A RAND NOTE

U.S. Space-Based Remote Sensing: Challenges and Prospects

Dana J. Johnson, Max Nelson, Robert J. Lempert

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Published 1993 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
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U.S. Space-Based Remote Sensing: Challenges and Prospects

Dana J. Johnson, Max Nelson, Robert J. Lempert

Prepared for the
United States Air Force
United States Army
Office of the Secretary of Defense
U.S. space-based remote sensing programs and activities are facing a number of critical junctures in the coming decade. The U.S. government will have some critical decisions about its own requirements for exploiting remote sensing capabilities for environmental, meteorological, and national security uses, balanced against limited and decreasing budgets for those activities. Furthermore, there are ongoing debates within the Administration, in the Congress, and by the American public over the extent of the role government should play in fostering the commercial remote sensing sector. The explosion in geographical information system technologies for enhancing raw remote sensing data is also encouraging the development of a commercial market. These trends and others, such as expanding international capabilities, have combined to produce a dynamic remote sensing arena—an arena requiring a balanced approach to resource allocation and long-range planning.

This Note presents a survey of remote sensing policy issues for the 1990s, with the purpose of assisting in the development of a future space-related RAND research agenda. It was written under the guidance of RAND's Resource Management Department, which is responsible for planning RAND's studies in space policy. This research was supported by funds for exploratory research from Project AIR FORCE, the Arroyo Center, and the National Defense Research Institute (NDRI), RAND's federally funded research and development centers (FFRDCs) for national security studies. The three centers are sponsored, respectively, by the Air Force, the Army, and the Office of the Secretary of Defense and the Joint Staff. This survey should be of interest to those concerned with the development and implementation of U.S. space policy and the planning and acquisition of space-based remote sensing systems.
SUMMARY

During the last decade, unenhanced and value-added data from space-based remote sensing systems have become increasingly useful in many areas, from national security, emergency planning, and regional studies, to civil engineering, weather forecasting, media coverage, and environmental protection. Remote sensing from space has traditionally supported U.S. national objectives in providing meteorological data on a nondiscriminatory basis to other countries and in contributing critical information for national decisionmaking in crises and wartime. Other uses are evolving, such as the commercial exploitation of remote sensing data in developing geographic information systems (GIS). Furthermore, other nations are also pursuing independent satellite remote sensing programs for their own domestic and national security needs. The increasing diversity—and in some cases, duplication of systems and efforts—in the remote sensing field is creating tensions among civil, national security/military, scientific, and commercial sectors that must be considered in the formulation of U.S. government space policies.

Two questions for remote sensing in this vein are: (1) can certain functions and programs be combined without detracting from timeliness or access to data? and (2) are there legitimate political, economic, technological, or security reasons why certain programs should not be consolidated? While lengthy answers to these questions are not attempted in this Note (they would require detailed payload and cost tradeoff analyses), our objective here is to broadly survey the space-based remote sensing field and to provide guidance for further analyses of the issues.

The study begins by examining the historical record on U.S. activities in space-based remote sensing, from the first studies conducted at RAND in the late 1940s on the utility of satellites for reconnaissance, weather monitoring, and communications purposes, to the evolution of the “Open Skies” principle and its impact on current National Oceanic and Atmospheric Administration (NOAA) operations. It also addresses the evolution of Landsat and the emergence of an effort by the Reagan Administration to commercialize the program. The study argues that although commercialization of Landsat did not succeed as intended, that effort is not necessarily indicative of the commercial field as a whole and should be addressed in a “lessons learned” context.

The study illustrates the differences among the functions that remote sensing satellites perform by dividing the functions into four user communities, or sectors: civil, national security/military, scientific, and commercial. Foreign efforts are described in a
separate international sector. Section 2 describes each sector in terms of associated issues and programs. For example, the near-term crisis in the civil meteorological program—the degradation of the current orbiting GOES satellite and on-going problems with the development of GOES-Next—is discussed in the civil sector, and current policy developments with Landsat are found in the commercial sector. National security and military issues and programs are not included in this study; however, the importance of remote sensing support to the theater commander is highlighted. The scientific sector follows the Mission to Planet Earth (MPE) and Earth Observing System (EOS) programs.

As shown in Table S.1, individual users, whether they are federal agencies, state and local governments, or private entities, exploit remote sensing data for different reasons and objectives. These sectors do not exist in isolation from each other, nor are they of equal size or budget; rather, users will exploit systems primarily "belonging" to another sector, depending on their needs. But as the utility of remote sensing data is more widely understood and appreciated, greater efforts to exploit the data in unique ways will increase. This will have the corresponding effect of blurring the distinctions among sectors and of increasing congressional and public interest in consolidating sectors. It will then be up to the owners and operators of remote sensing systems to justify why their particular systems should remain unique.

Several courses of action for the U.S. government are suggested, some of which are already under way:

- Remote sensing policies should be developed from a more comprehensive perspective, derived from U.S. remote sensing goals, user needs, and the diverse organizations that can participate in meeting those needs.
- The government should determine where broadening needs or new technologies allow planned programs to be better coordinated or consolidated to avoid duplication of effort.
- The government should determine what areas are best pursued as public endeavors, which are best pursued as commercial or private endeavors, and the boundaries between them, while recognizing the valid needs of all actors involved.
- Finally, remote sensing systems need to be made more responsive to user needs.
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**N.B.:** See the list of acronyms on page xv of this Note for organizational titles.
ACKNOWLEDGMENTS

The authors wish to acknowledge the advice and support given by Morton Berman and Grace Carter. Their thanks also go to Bruno Augenstein, William Harris, and Daniel Gonzales for their valuable comments, suggestions, and historical insights into the development of space-based remote sensing. Richard DalBello of NASA's Office of Commercial Programs also provided extensive commentary on current policy debates as well as long-term trends. Other individuals in the U.S. government and aerospace industry were very helpful in providing information about specific systems and operations. These individuals include Gary Davis of NOAA/NESDIS, Steve Ockenden of General Electric, Carol Tevepaugh of the Hamilton Standard Division of United Technologies, Nate Boyer of the Earth Observation Satellite Company (EOSAT), and Margaret Roberts of The Harris Group. It is hoped that this Note rings true with their comments, but, needless to say, they are not responsible for the arguments and interpretations expressed herein.
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ACRONYMS

AID  Agency for International Development
ARPA  Advanced Research Projects Agency
AWS  Advanced Warning System
BSTS  Boost Surveillance and Tracking System
DEA  Drug Enforcement Agency
DMA  Defense Mapping Agency
DMSP  Defense Meteorological Satellite Program
DOC  Department of Commerce
DoD  Department of Defense
DOE  Department of Energy
DOI  Department of the Interior
DOS  Department of State
DOT  Department of Transportation
DSP  Defense Support Program
EOS  Environmental Observation Satellite
EOSAT  Earth Observation Satellite Company
EPA  Environmental Protection Agency
ESA  European Space Agency
FEMA  Federal Emergency Management Agency
FEWS  Follow-on Early Warning System
GIS  Geographic Information Systems
GOES  Geostationary Operational Environmental Satellite
HUD  Housing and Urban Development
MPE  Mission to Planet Earth
NASA  National Aeronautics and Space Administration
NASDA  National Space Development Agency (Japan)
NOAA  National Oceanic and Atmospheric Administration
NORAD  North American Aerospace Defense Command
NRC  Nuclear Regulatory Commission
NSF  National Science Foundation
NSPC  National Space Council
NSPD  National Space Policy Directive
POES  Polar Orbiting Environmental Satellite
SPOT  Satellite Probatoire d'Observation de la Terre
TIARA  Tactical Intelligence and Related Activities
USA  United States Army
USAF  United States Air Force
USCG  United States Coast Guard
USDA  United States Department of Agriculture
USGS  United States Geological Survey
USMC  United States Marine Corps
USN  United States Navy
1. INTRODUCTION

During the last decade, unenhanced and value-added data provided by space-based remote sensing systems have become increasingly useful in a variety of areas—anthropology, archaeology, environmental protection, earth science, surveying and mapping, urban development, civil engineering, resource exploration, disaster warning, weather forecasting, media coverage, and military operations. More broadly, remote sensing from space has historically supported U.S. national objectives, from providing meteorological data on a nondiscriminatory basis to other nations, to supporting national-level decisionmaking in crises and wartime operations (e.g., Operation Desert Storm). On the commercial side, the introduction of what is now called Landsat twenty years ago and the deployment of the French SPOT program in 1982 have contributed to the development of a multibillion dollar industry in geographic information systems (GIS). In addition, other nations are pursuing independent satellite remote sensing programs, not only for national security purposes, but also for gathering information necessary for their own domestic needs.

All in all, the remote sensing field is becoming extremely diverse, with certain inherent tensions among civil, national security/military, scientific, and commercial sectors as a result. It is these tensions and the interaction among sectors that is of interest to us, particularly how they influence the making of U.S. government space policies. Furthermore, given recent trends in other areas to consolidate systems and processes (notably the “joint forces” approach in the military services mandated by the Goldwater-Nichols Act and budgetary constraints), it is likely that satellite remote sensing will also be faced with similar pressures. (In fact, as this document is being written, the National Space Council is undertaking a review of U.S. space policies; it is expected to assess the traditional separation between civilian and military space programs and determine whether that separation remains in the national interest.) Two questions for remote sensing in this vein are: first, can certain functions and programs be combined without detracting from timeliness or access to data, and second, are there legitimate political, economic, technological, or security reasons why certain programs should not be consolidated? We will not attempt to answer

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these questions at great length in this document, as detailed payload tradeoff analyses would be required and the intent here is to broadly survey the field and to provide guidance for further analyses of the issues.

The focus of this study is on remote sensing, defined as

the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation. 4

Space-based remote sensing is emphasized; neither airborne nor ground-based remote sensing systems are discussed. 5 The study concentrates on U.S. activities, while acknowledging the broader context of international remote sensing developments and their implications for cooperation and competition among nations possessing or developing remote sensing capabilities.

To illustrate the different functions that space-based remote sensing systems perform, we have divided the functions into the following user communities, or sectors, and identify representative associated organizational entities:

- **Civil:** those agencies, organizations, or individuals who exploit remote sensing systems and data to promote the general welfare and provide for the public good, for example, weather forecasting, national security emergency preparation, urban planning, and environmental management (National Oceanic and Atmospheric Administration (NOAA), Federal Emergency Management Agency (FEMA)).

- **National security/military:** those who use remote sensing for the pursuit of national interests, for example, defense of the United States and its allies (Department of Defense).

- **Scientific:** those who use remote sensing systems and data for exploration and discovery, for example, climate change, environmental developments (NASA).

- **Commercial:** those who exploit remote sensing data to gain profit, either through the procurement and sale of data as an intermediate good, or through value-

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3Remote sensing systems such as planetary probes are also used to study other planets of the solar system. However, here we are concerned only with earth-observing systems.


5We recognize that a comparative analysis of all types of remote sensing systems should be conducted to assess the advantages and disadvantages of each approach for particular mission needs and types of data to be gathered.

6We recognize that these are distinct sectors in themselves, but we have combined them for classification reasons.
added analysis that uses remote sensing data as a production input (Department of Commerce, private industry).

The first two sectors are distinguished from the latter two by their operational nature; that is, the outcomes or products of the data they are gathering are known and predictable quantities, whereas with the latter two the course of a scientific experiment or the future development of a commercial market are not as predictable. Obviously many functions cross sectors, such as meteorological systems having utility not only on a daily basis for the general public (NOAA), but also for day-to-day and wartime military operations (Department of Defense (DoD)). However, this example demonstrates the key problem: the duplication of essentially the same systems (NOAA/Polar Orbiting Environmental Satellite (POES) and the Defense Meteorological Satellite Program (DMSP)) and technologies, and the inherent policy tensions: NOAA bound by a web of international obligations, and DMSP primarily dedicated to serving a single set of customers.

Although it is probably more appropriate to place international remote sensing users and programs in each of the four sectors, these are briefly discussed in a separate sector. U.S. remote sensing policies cannot realistically be developed in a vacuum, despite the analytical appeal of simplicity. However, several considerations are warranted: (1) what is the level of national or geopolitical interest in space exhibited by other nations possessing or developing remote sensing capabilities; (2) will the political will in each country support space-based remote sensing programs, particularly when those programs compete for scarce fiscal resources; and (3) does each nation have the requisite technological capabilities to act independently of other space powers, or is it in its own national interest to undertake joint programs, perhaps justified in the interests of regional unity.\footnote{Adapted from Dana J. Johnson, \textit{Trends in Space Control Capabilities and Ballistic Missile Threats: Implications for ASAT Arms Control}, RAND, P-7635, March 1990, p. 30.}

2. THE UTILITY OF REMOTE SENSING DATA

Before discussing the utility of space-based remote sensing for each of the four sectors identified earlier, we will briefly review the antecedents to current programs. Remote sensing from space has its roots in historical efforts to gain information from afar, whether it be monitoring an enemy’s movements in the field to help determine his intentions or studying the foraging habits of a species to learn more about its migratory patterns. Here, the concern is with the development of U.S. remote sensing capabilities in the postwar period, the devolution of a single military-sponsored space program into today’s civil and military space programs, and the foundation laid for the complex environment of the future.

HISTORICAL OVERVIEW

The strong impetus to pursue space technologies and satellites for military and civilian purposes in the United States grew out of postwar interest in German rocketry efforts both before and during World War II. Both the Navy and the Army Air Forces conducted independent studies addressing the feasibility of long-range rockets and satellites, but differed over which service should retain the lead responsibility. In the spring of 1946, General Curtis LeMay, USAAF, requested that Project RAND (the forerunner to RAND and then a part of the Douglas Aircraft Company) undertake a study of the feasibility of a space satellite. The result was SM-11827, Preliminary Design of an Experimental World-Circling Spaceship (May 2, 1946); it addressed not only propulsion, multi-stage launch vehicles, and recovery, but also potential missions: guiding missiles, satellites as the missiles themselves, satellites as “observation aircraft,” and attack assessment, weather reconnaissance, and communications. However, the authors recognized the inherent limitations of their views of the potential of satellites, saying they could “see no more clearly all the utility and implications of spaceships than the Wright brothers could see fleets of B-29s bombing Japan and air transports circling the globe.”

Subsequent efforts by Project RAND in 1946–1947 to expand on the ideas developed in SM-11827 led to the concept of the use of satellites for reconnaissance missions, while recognizing that their feasibility was dependent upon advancements in high resolution

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1Much of the historical overview is drawn from Merton E. Davies and William R. Harris, R-3692-RC, and Bruno W. Augenstei\n\nP-6814.
2Davies and Harris, pp. 7–9.
3Douglas Aircraft Company, Santa Monica Plant, Engineering Division, Preliminary Design of an Experimental World-Circling Spaceship, SM-11827, May 2, 1946, quoted in Davies and Harris, p. 9.
photography. Other concepts developed at this time included the use of a polar orbit for recurring reconnaissance coverage and the use of geostationary orbits for communications.

In the early 1950s, RAND undertook analysis of the feasibility of balloons for strategic reconnaissance and meteorology. This helped to lay the foundation for the use of space-based systems for those missions. Another RAND study recognized the problem of data management and retrieval—how to display the vast amount of data which would be transmitted by reconnaissance satellites. Finally, RAND R-218, *Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle*, by Stanley M. Greenfield and William W. Kellogg (1951), was instrumental in laying the foundation for the first TIROS-1 meteorological satellite, launched by NASA in 1960. These studies were undertaken against the backdrop of an increasing awareness of Soviet military developments and pressures for monitoring those activities. This led to a landmark RAND study, *Project Feed Back* (March 1954), which became the cornerstone for an Air Force operational reconnaissance satellite system.

Another event that helped to shape the “open” nature of the civilian space program was the proposal in July 1955 by President Eisenhower at the first Geneva summit for a system of arms control verification with the Soviet Union. Called “Open Skies,” the proposal suggested photographic overflights of each other’s military sites by aircraft. Eisenhower and others believed it was preferable to have legal overflights by U-2s as a confidence-building measure than to provoke the Soviets with violations of their airspace. However, this was viewed by the Soviets as solely an intelligence ploy by the United States, and they denounced the proposal. The principle behind “Open Skies” became a consistent theme of the U.S.

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4Davies and Harris, p. 10.
5Davies and Harris, p. 15. As Davies and Harris note, Arthur C. Clarke first was the originator of the geostationary orbit concept in 1944; however, the RAND analysis represented the first engineering feasibility study.
6As of November 1948, Project RAND was transferred by Douglas Aircraft to The RAND Corporation, founded on May 14, 1948.
7Professor Louis N. Ridenour (MIT), in “the Ridenour Memorandum of [August] 1960,” quoted in Davies and Harris, p. 23.
8Davies and Harris, p. 25.
9Bruno W. Augenstein, P-6814, pp. 5–6.
10Augenstein, p. 7.
12The concept of “Open Skies” was resurrected by President Bush in May 1989, again as a confidence-building measure (but this time between NATO and the Warsaw Pact rather than solely the United States and the Soviet Union), and again using aircraft. However, this time the Soviets pushed the concept of “an international monitoring system [in which] everybody would have access to everybody’s sensors, and everybody’s resources,” which would make it more difficult to protect sensitive national technical means (NTM) of verification. “U.S. Sees Sensors, Information-Sharing as Key Open
civil space program insofar as U.S. remote sensing policy championed open access to the products of civil remote sensing systems by all nations and users on a nondiscriminatory basis. Furthermore, since then the United States has consistently rejected efforts by other nations, primarily those in the developing world, for restrictions on access to national resources surveyed from space and on open dissemination of such information.

On February 7, 1958, the Advanced Research Projects Agency was established within the Department of Defense. ARPA was responsible for research and development activities and assigned them to the services, other government agencies, or civilian organizations. Until the establishment of the National Aeronautics and Space Administration with the signing of the National Aeronautics and Space Act (P.L. 85-568) on July 20, 1958, the President designated ARPA as the manager of all civil and military space projects. Thus, ARPA acted as the “national” space agency for about eight months (February 7–October 1, 1958). In October, ARPA transferred its programs in space technology applications and advanced scientific research to NASA; other programs, such as man-in-space (which became Project Mercury), satellite tracking, meteorology, navigation, and communications, were also transferred. ARPA maintained the advanced reconnaissance and ICBM defense programs. In 1959, the Project Discoverer, Midas, and Samos reconnaissance programs were transferred to the Air Force, the Navy got the Transit navigation program, and the Notus communications program went to the Army.

The separation between military and civil programs received further reinforcement with the promulgation of a National Security Council statement on space on July 3, 1958. This statement recognized the importance of space systems to the operational needs of the

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13Discrimination could occur in many forms, but the results would be to create economic, political, or technical barriers to countries, organizations, or individuals wishing to use the remote sensing system. See the discussion in Glenn H. Reynolds and Robert P. Merges, Outer Space: Problems of Law and Policy, Westview Press, Boulder, Colorado, 1989, pp. 178–183.

14Reynolds and Merges, p. 186. The principle is also consistent with the theme expressed in the 1967 Outer Space Treaty: "Outer space . . . shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies." See Article I of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, signed at Washington, London, Moscow, January 27, 1967.

15Augenstein, p. 11.

16Augenstein, pp. 11–13.

17Augenstein, pp. 13–14.

military forces. It was eventually signed by the President in August 1958 and became official policy that is still in effect.\textsuperscript{19}

In the early 1960s, pictures taken by the Gemini astronauts inspired NASA and the Department of the Interior to request funding for an Earth resources observation satellite.\textsuperscript{20} This led to the establishment of the Landsat program under NASA in 1965. It was expected at that time that Landsat technology would be useful for a broad range of agencies and other customers.

In 1972–1973, President Nixon established a Federal Mapping Task Force that considered means of sharing remotely sensed reconnaissance data with civil agencies. A report of the Office of Management and Budget, in 1973, recommended extended utilization of remotely sensed data. This resulted in the increased utilization of space-based remote sensing for environmental monitoring and map-making by civilian agencies. But it did not resolve questions of commercialization.

In a review of the program by the Carter Administration in 1978, it was concluded that commercialization would not be feasible at that time because of market uncertainties, the development of foreign systems, and the expense of the Landsat system.

However, because of escalating Landsat costs, the incoming Reagan Administration took another look at the commercialization question, and, in 1983, elected to commercialize the program. The Administration argued that: a commercial operation could be more efficient, thus lowering system and operational costs; could encourage market growth and stimulate new applications; and could reduce the need for federal funding—unless commercialization failed, at which point the government could recover its costs by taking over the system. Accordingly, under the terms of the Land Remote Sensing Commercialization Act of 1984, the government turned over the Landsat system to the Earth Observation Satellite Company (EOSAT), a quasi–private partnership between General Electric and Hughes. Although a large market for Landsat data did develop and operational costs dropped somewhat, the attempt to commercialize Landsat data did not develop as extensively as was expected.

The 1970s and 1980s saw an expansion of U.S. remote sensing activities into military surveillance, early warning, and meteorology programs. On the military side, a successor to the Midas missile detection program called Integrated Missile Early Warning Satellite, or

\textsuperscript{19}Augenstein, pp. 12–13.
\textsuperscript{20}The system was an experimental program called Earth Resources Technology Satellite–1 (ERTS–1) until shortly after its launch. Its data were so useful that NASA quickly changed its status to an operational system and adopted the name Landsat 1.
IMEWS, began operation in 1970, and led to the Defense Support Program (DSP), first launched in 1976. There have been a series of ongoing efforts to develop a follow-on surveillance/early warning system to DSP since the early 1980s, with names such as the Advanced Warning System (AWS), the Boost Surveillance and Tracking System (BSTS), and Follow-On Early Warning Satellite (FEWS), with varying levels of capability of missile detection and supporting defense against ballistic missiles. The Defense Meteorological Support Program (DMSP), as it is known now, was deployed in 1971; however, military meteorological satellites have been launched since the mid-1960s.\textsuperscript{21} Other surveillance systems that have been considered for years and have recently been incorporated into SDI focus on space object surveillance, specifically, “cold body tracking,” which tracks targets in their midcourse phase if they are ballistic missiles or satellites in orbit. This is a very different problem technically for remote sensing and represents a critical phase in ICBM defense. Such a system also tracks orbital debris and satellites in general.

Other recent efforts have focused on developing smaller and cheaper satellites and launchers as ways to help cut the historically high costs associated with satellites and launch vehicles. Miniaturization of computer technologies and advancements in spacecraft materials, among other developments, are having an impact on all aspects of space, including remote sensing. In the policy arena, the Bush Administration established an organization for remote sensing services. William Lackman, former deputy director of the Intelligence Community Staff, became the first Director of the Central Imagery Office in the spring of 1992.

Within the latter half of 1992, the National Space Council will be conducting a reassessment of U.S. space policy. One aspect of the reassessment will be to consider the traditional partition of the space program into military and civil sectors.\textsuperscript{22} Several factors are influencing this interest: existing budgetary constraints that are expected to continue into the future, foreign competition, the versatility of space technologies and programs in supporting multiple users, and concern about maintaining a viable industrial base. Remote sensing has amply demonstrated its versatility, and the question becomes one of determining whether it would be prudent to merge several programs, not only from a cost-effectiveness standpoint, but also in view of national objectives. The issue remains to be decided, but


assuming efforts are undertaken to increase the connectivity among military and civil programs, the U.S. space program will have come full circle since its inception in the 1940s.

REMOTE SENSING SECTORS

As was discussed in the Introduction, the different functions that remote sensing systems perform and the users they support were divided into four sectors: civil, national security/military, scientific, and commercial. To further illustrate the utility of remote sensing data, Table 2.1 provides selective examples of remote sensing applications by sectors and users. It is intended to be illustrative, not comprehensive. The point to be made is that individual users (whether they are federal agencies, state and local governments, or private entities) exploit remote sensing data for different reasons and objectives. Furthermore, these sectors do not exist in isolation from each other; experience has shown that users from one sector will exploit systems primarily “belonging” to another sector, often in ways that are unexpectedly beneficial. Another observation is that not all sectors, as portrayed in the table, are equal in terms of importance, budget, or size. Certainly the national security/military sector is far greater in size and budget compared to the commercial sector, at least at this time. Nevertheless, as the utility of remote sensing data becomes more widely understood and appreciated, greater efforts will be made to exploit that data. These efforts in turn will blur distinctions between sectors and, in a budget-constrained environment, increase congressional and public interest in eliminating redundancies among systems. The onus will then be on system owners and operators to elucidate why their particular system should remain unique.

Civil Sector

This sector was defined earlier as those agencies, organizations, or individuals who exploit remote sensing systems and data to promote the general welfare and provide for the public good. Remote sensing data are gathered to support such activities as weather forecasting, disaster relief, urban planning, storage of radioactive waste, flood plain mapping and management, drug law enforcement, and hurricane prediction. We next discuss the contribution of (primarily civil) meteorological systems to these and other activities.

Meteorological data are provided by both a civilian agency, NOAA, through its geostationary and polar orbiting satellites, and the Department of Defense (DoD), through the Defense Meteorological Satellite Program. NOAA is responsible for the U.S. civilian
<table>
<thead>
<tr>
<th>Remote Sensing Applications</th>
<th>Civil Sector</th>
<th>National Security/Military Sector</th>
<th>Scientific Sector</th>
<th>Commercial Sector</th>
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<tr>
<td>Agriculture, forestry, range resources</td>
<td>Assessment of flood damage (FEMA)</td>
<td>Determination of soil, vegetation conditions (USA)</td>
<td>Crop diseases analysis (USDA, academia)</td>
<td>Identification of vegetation, crops, timber, range vegetation (USDA, farmers, GIS industry)</td>
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<td></td>
<td>Grove surveys (Forestry Service)</td>
<td>Assessment of foreign agricultural output (DOS, AID)</td>
<td>Global change research (NASA, international research organizations)</td>
<td>Solid waste management (state and local governments, private industry)</td>
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<tr>
<td>Land use and planning</td>
<td>Urban planning (DOT, state and local governments)</td>
<td>Terrain analysis (USA, USMC)</td>
<td>Wetlands monitoring (EPA)</td>
<td>Transportation networks planning (state and local governments, private industry)</td>
</tr>
<tr>
<td></td>
<td>Base siting (DoD)</td>
<td>Base siting (DoD)</td>
<td>Wetlands monitoring (EPA)</td>
<td>Transportation networks planning (state and local governments, private industry)</td>
</tr>
<tr>
<td>Mapping</td>
<td>Siting/surveying for public/private facilities (HUD, state and local governments)</td>
<td>Position locating (all services)</td>
<td>Environmental impact assessments (EPA, scientific research organizations)</td>
<td>Regional planning (state and local governments, private industry)</td>
</tr>
<tr>
<td></td>
<td>Emergency planning (FEMA, state and local governments)</td>
<td>Monitoring of support equipment movement (all services)</td>
<td>Forest, grove monitoring (DOI)</td>
<td>Search for surface guides to mineralization (private industry)</td>
</tr>
<tr>
<td>Geology</td>
<td>Radioactive waste storage (DOE, NRC)</td>
<td>Threat analysis (DIA)</td>
<td>Mapping linear (fractures) (USGS)</td>
<td>Ground water location (state and local governments, private developers)</td>
</tr>
<tr>
<td>Water resources</td>
<td>Floods and flood plains mapping and assessment (DOT, state and local governments, Water Resources Council)</td>
<td>Soil compaction (USA, USMC)</td>
<td>Pollution monitoring (EPA, academia)</td>
<td>Ground water location (state and local governments, private developers)</td>
</tr>
<tr>
<td></td>
<td>Ice, water surface analysis (USN)</td>
<td>Disaster relief (FEMA, many federal agencies, state and local governments)</td>
<td>Soil salinity (local governments, scientific researchers)</td>
<td>Ground water location (state and local governments, private developers)</td>
</tr>
<tr>
<td>Coastal resources</td>
<td>Mapping of shoals and shallow areas (USCG)</td>
<td>Base and port siting, closing (DoD, USN)</td>
<td>Wildlife habitat monitoring (NSF, EPA, Fish and Wildlife Service)</td>
<td>Ice floe mapping for shipping (USCG, private shipping companies)</td>
</tr>
<tr>
<td>Environmental monitoring</td>
<td>Drug law enforcement (DEA)</td>
<td></td>
<td>Atmospheric research (NASA)</td>
<td>Drought impact assessment (agricultural industry)</td>
</tr>
<tr>
<td></td>
<td>Civil weather forecasting (NOAA)</td>
<td></td>
<td>Global climate change (NASA, international research organizations)</td>
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<tr>
<td></td>
<td>Hurricane prediction (National Hurricane Center, FEMA, state and local governments)</td>
<td>Weather monitoring for air, ground operations (all services)</td>
<td></td>
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</tr>
</tbody>
</table>


N.B.: See the list of acronyms on page xv of this Note for organizational titles.
operational meteorological system.\textsuperscript{23} It operates a series of polar orbiting systems and geostationary satellites to support its primary mission of weather forecasting. \textit{GOES}\textsuperscript{24} is the geostationary satellite series for weather monitoring, whereas POES (or NOAA\textsuperscript{25}) is the polar orbiting series, used primarily for long-range weather forecasting. The GOES system is intended to have two satellites that provide pictures every half hour (one over the West Coast, one over the East Coast); however, only one is currently operational. When tracking weather for emergency purposes, such as a hurricane, data can be provided every seven minutes. The POES series consists of a constellation of four satellites that provide the data for long-range weather forecasting as well as search and rescue equipment, ozone data collection sensors, and other experimental sensors.\textsuperscript{26} POES/NOAA's data are distributed in near-real-time at reproduction cost to any organization or individual who requests them.

The Air Force operates two DMSP satellites in polar orbits that gather data for U.S. military weather analysis. These data are also made available to qualified scientific researchers 45 to 90 days after acquisition. Both DMSP and POES are built by the same contractor (GE AstroSpace, who is also the prime contractor for Landsat) but have different on-board sensors, slightly different orbits (in the 820–865 km range), but similar inclinations (98+ degrees).

The United States faces a near-term crisis in its meteorological program. Following a 1986 launch failure of GOES-G and the failure in orbit of GOES-6, only one geosynchronous operational GOES satellite is left from the usual fleet of two. The remaining satellite passed its planned lifetime in February 1992, and barring failure on orbit, will definitely begin losing useful data by February 1993, probably before its replacement (GOES-Next) can be launched.

As a result of a decision made by the Office of Management and Budget (OMB) in 1981 to streamline NASA spending, the responsibility for the development of new weather satellites was transferred from NASA to NOAA. NOAA decided that the next satellite series would incorporate improved sensors and image registration (the precise location of images on the Earth), and proposed to NASA in 1982 that the space agency assist them in monitoring satellite development by a contractor.\textsuperscript{27} However, over time problems developed in reaction

\textsuperscript{23}Under the traditional division of space programs into research and operations, NASA is responsible for developing and launching civilian meteorological satellites while NOAA is responsible for determining the system requirements and for operating the system after launch. Discussions with officials of NOAA/National Environmental Satellite, Data, and Information Service (NESDIS), summer 1991.

\textsuperscript{24}Its official name is the Geostationary Operational Environmental Satellite.

\textsuperscript{25}In this case NOAA is both the name of the governmental agency and the satellite.

\textsuperscript{26}Two of the four POES satellites provide data at 7:30 a.m., two at 2:30 p.m. The newest and oldest spacecraft are morning and afternoon systems, respectively.

to schedule slips, contractor inexperience, technological challenges, and inadequate budgets; these problems were exacerbated by schedule pressures imposed by NASA (similar to the Hubble Telescope fiasco) without adequate contractor supervision. Compounding the problems was a lack of oversight by NOAA, and despite NOAA and NASA statements to the contrary, congressional concerns over the course of the program led to recommendations for delay of the launch of the first GOES-Next satellite until instrument and other problems were fixed.\textsuperscript{28} These events have led to the current shortfall in geosynchronous weather satellite coverage. Fortunately, improvements in program management and technical quality are being made,\textsuperscript{29} and the European Space Agency was able to reposition a backup European weather satellite to allow the U.S. weather service to track two tropical storms and a hurricane in 1991 when the lone U.S. GOES system was unable to provide coverage. This prevented potentially severe storm damage.

The GOES-Next example illustrates the differences in perspectives and objectives among federal agencies and potential problems to be considered when undertaking joint agency programs in the future. Both NASA and NOAA were under pressure to reduce costs while maintaining schedules, a combination that typically has led to problems in other programs that require substantial technological or scientific advances. In the longer term, there are likely to be continued pressures to reduce redundancy among meteorological programs; however, policy differences, security concerns, and potentially incompatible mission and technical requirements will have to be resolved prior to making decisions to undertake joint efforts. NOAA operates under the open and nondiscriminatory access rule, and flies other nations’ sensors aboard GOES and POES, whereas DMSP is dedicated primarily to serving one set of customers. The main arguments, however, are those relating to the ability to meet user needs and the differences in mission data. Both NOAA and the DoD are concerned that a joint program would diminish their ability to satisfy user sensor, continuity, and access needs. Furthermore, both programs use the data differently. The military has historically exploited weather data for operational needs such as weapons targeting, aircraft range planning, and terrain analysis, whereas NOAA has gathered data for civil and scientific purposes. However, policy and procedural mechanisms are in place to facilitate NOAA systems support to national authorities in case of national disasters. Recently, in Operation Desert Storm, civilian meteorological satellites provided highly detailed weather information that was used by U.S. planes providing support and cover for

\textsuperscript{28}Lerner, pp. 24–25.

\textsuperscript{29}A reorganized contractor team is in place, and programmatic schedules will be allowed to slip if problems in sensor performance are encountered. Lerner, pp. 24–25.
ground troops. The Air Force Space Command stated that “We can see the sand storms as they are building on the Arabian peninsula.” Such information provided critical assistance for planning air operations.30

In addition, the distinction between meteorological data and environmental data is diminishing as the environmental research agenda grows. In the past, environmental data were provided by relatively short-lived NASA research satellite programs dedicated to making particular measurements, or as a byproduct of the continuous daily data collection for weather prediction by NOAA's operational satellites. In the 1990s, the need to map long-term environmental changes at both large and small scales will blur the distinction between these research and operational missions. Over the next several years, NOAA satellites may be able to gather much useful scientific data as instrument calibration improves and as better algorithms are developed to process the raw data. To the extent that policymakers concerned with problems such as global warming or stratospheric ozone depletion require scientific answers quickly, existing NOAA systems may be viable competitors to accelerating work on NASA's Mission to Planet Earth. However, past the turn of the century, an operational system of dedicated environmental research satellites may provide much of the data needed for weather prediction. Whether such a system can effectively meet such requirements for this task as timeliness (i.e., near-real-time transmission) and high daily reliability is not certain.

National Security/Military Sector

This sector was defined earlier as those who use remote sensing for the pursuit of national interests, such as the defense of the United States and its allies. This would include but not be limited to such agencies as the Department of Defense, the Department of State, and the intelligence community.

The scope and nature of multispectral imagery for military and national security needs are expanding because of a greater operational role for space systems on the battlefield and a recognition of the dual-use nature of strategic systems such as DSP. Desert Storm's demonstration of the tactical utility of remote sensing data has reinforced calls for remote sensing systems designed with tactical users' needs in mind. This is not new: recall the Eisenhower Administration National Security Council's (NSC's) recognition of the importance of satellites to the needs of the operational military forces.31 These tactical needs are quite different from those for which the U.S. surveillance systems were designed,

31See discussion on page 6.
particularly where timeliness is an issue. In addition, the end of the Cold War has diminished concerns about large-scale war with the former Soviet Union, but conversely has increased concerns over ballistic missile proliferation among small regional powers and the extent of potential U.S. involvement in regional conflicts. Thus, the dynamic international environment has created both new opportunities and new dangers for surveillance systems.

Additionally, budget constraints are forcing a need to diminish redundancy and enhance the justification for systems, which leads planners to seek dual-use applications for their systems. Beyond this need for additional justification of national security missions, DoD is mandated by law and policy to enhance its role in civilian remote sensing efforts by the U.S. Global Change Research Program and Senator Sam Nunn's Strategic Environmental Research and Development Program (SERDP). One proposal under SERDP recently discussed would encompass the development of an unclassified encyclopedic listing of the kinds of imagery now resident in government collections. It would be part of a broader effort to make imagery from classified sources available for environmental research, and to develop policies and procedures for allowing access to classified imagery.\textsuperscript{32} Whereas some programs will probably continue to maintain unique missions, many of the DoD programs share common functions with NASA and other civil programs; the issues in many cases are those of policy, bureaucracy, and national interests.

The increasing demands for military remote sensing systems reflect the strong support for assets that can provide continuous, near-real-time, all-weather, day-night coverage directly to combat forces.\textsuperscript{33} Martin Faga, Assistant Secretary of the Air Force for Space, argues that land-use remote sensing is an area of broad interest within our government, and around the world. . . . The defense department needs multispectral data for such things as terrain analysis and mission planning; can we drive tanks and trucks or drop airborne troops in a given region? Many agencies need these data to estimate crop yields. NASA needs it as a fundamental element of global change research. Commercial users need it for environmental compliance, for monitoring, mineral prospecting, forestry, agricultural applications, map-making and geographic information, and so on.\textsuperscript{34}

Although recognition of the importance of space systems to theater commanders antedated the Gulf War, it was the first instance in which space systems were actively


\textsuperscript{34}M. Faga, p. 10.
integrated (whether planned or "kluged" together) into campaign planning. For example, DMSP provided data for weather and sandstorm predictions that optimized force deployment, weapon loads, laser-guided munitions, and the application of aircraft, and provided data critical to the timing of the ground offensive. DMSP also helped program cruise missiles for effective deployment and assisted in the determination of appropriate surveillance platform configurations.

To compensate for critical gaps in imagery, the services exploited commercially available satellite imagery. During the Gulf War, the U.S. Air Force became the single largest consumer in the world of commercial satellite imagery. Although most of the images purchased (222) were from the French satellite imagery provider, SPOT Image, they also used Landsat and even Soviet Soyuzkarta 5-meter imagery for planning special operation missions. SPOT, and to a lesser extent, Landsat data were used for mission planning to reduce U.S. forces' exposure to hostile fire, to plan routes and aim points, and to provide animated pilot's-eye fly-throughs of planned missions. Landsat's multi-spectral capabilities enabled scene-change detection, traffic and terrain analysis, and concealment and deception detection information. The Defense Mapping Agency used Landsat for interim special-purpose and crisis support products, and in support of several bathymetric, hydrographic, and terrain categorization products. DMA produced 122 Landsat image maps of the Gulf War theater to support operations until more standard maps could be produced. DMA also used Landsat to provide information about water depth and shallow water hazards. Furthermore, DMA used Landsat to supplement information about soil composition and moisture content, vegetation data, and more. Although Landsat was found to be of great use during the Gulf War, its utility was diminished by its relatively low spatial resolution, its lack of stereoscopic coverage to produce three-dimensional mapping products, its lack of precise metric positioning data, and its long revisit times.

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40Representative D. McCurdy, statements at the joint hearing before the House of Representatives' Committee on Science, Space, and Technology, and the Permanent Select Committee on Intelligence, June 26, 1991.
The official DoD report, *Conduct of the Persian Gulf Conflict: Final Report to Congress*, concluded that tactical commanders considered intelligence support at the division, wing and lower levels insufficient, because of overreliance on national and theater systems, lack of adequate tactical imagery systems, and limited imagery production. Although better dissemination of national and theater intelligence can meet some intelligence requirements, commanders need more and better organic assets. [emphasis added]

Furthermore, a Senate Armed Services committee report told the Defense Support Program Office to examine approaches for using national intelligence systems for tactical wide-area surveillance. The DoD has had a program called Tactical Intelligence and Related Activities (TIARA) in place for a number of years to accomplish much of this; however, most of the details remain classified. A bill submitted by Senator David L. Boren (D-OK) to amend the National Security Act of 1947 to reorganize U.S. intelligence organizations and activities argues that the existing framework for the conduct of United States intelligence activities, established by the National Security Act of 1947, has evolved largely without changes to the original statutory framework, but rather as a matter of Executive order or directive. In large part, this evolution has been prompted by advances in technology or by ad hoc developments in mission and circumstance, rather than reflecting an overall scheme, design, or purpose.

The bill goes on to state that while the intelligence community has served the nation well, it has not performed as well as it might: “civilian and military intelligence are not well integrated; unwarranted duplication remains a problem; and intelligence remains too isolated from the governmental process it was created to serve.” Among the changes proposed by the Boren bill include moving TIARA under a new Tactical Intelligence Program, placing signals intelligence under the purview of the National Security Agency, and establishing a National Imagery Agency to procure and operate “overhead reconnaissance systems as may be required to satisfy the imagery collection requirements of the Intelligence Community.” Some of the terms of the Boren bill are being adopted now; the implementation of the rest remains to be seen.

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44DoD Learns Wartime Satellite Lessons,” p. 5.
46Boren, p. 5.
47Boren, pp. 28, 30–32.
Scientific Sector

This sector encompasses those who use remote sensing systems and data for exploration and discovery, in topics such as global climate change and environmental developments.

Remote sensing for environmental science will clearly be a central part of U.S. remote sensing efforts in the 1990s. The national program in which space-based remote sensing plays a critical role is Mission to Planet Earth (MPE), begun in the spring of 1989 (although portions of MPE had been going on for a number of years). Viewed as an umbrella program for a wide range of activities, MPE exploits environmental data gathered by surveillance and meteorological satellites on Earth-related phenomena to monitor global change; it cuts across a dozen federal agencies and is also a major theme of the 1992 International Space Year (ISY). MPE consists of two phases: Phase I incorporates an extensive period of observations by a wide variety of U.S. and international spacecraft, whereas Phase II is characterized by the Earth Observing System (EOS) program.

To better understand the planned scope of Mission to Planet Earth and EOS, it is worthwhile to quote NASA at length:

The goal of the EOS science mission is to advance understanding of the entire Earth system on the global scale, by developing a deeper comprehension of the components of that system, the interactions among them, and how the Earth system is changing. To quantify changes in the Earth system, EOS will provide systematic, continuing observations from low Earth orbit for a minimum of 15 years. Mission objectives in support of this goal are: 1) To create an integrated scientific observing system that will enable multidisciplinary study of the Earth's critical, life-enabling, interrelated processes involving the atmosphere, oceans, land surface, polar regions, and solid Earth, and the dynamic and energetic interactions between them. 2) To develop a comprehensive data and information system, including a data retrieval and processing system, to serve the needs of scientists performing an integrated multidisciplinary study of planet Earth. 3) To acquire and assemble a global database for remote sensing measurements from space over a decade or more to enable definitive and conclusive studies of Earth system science attributes, including (but not limited to): a) Global distribution of energy input and energy output from the Earth; b) Structure, state variables, composition, and dynamics of the atmosphere from the ground to the mesopause; c) Physical and biogeochemical structure, state composition, and dynamics of the land surface, including terrestrial and inland water ecosystems; d) Rates, important sources and sinks, and key components and processes of the Earth's biogeochemical cycles; e) Circulation, surface temperature, wind stress and sea state, and the biological activity of the oceans; f) Extent, type, state, elevation, roughness, and dynamics of glaciers, ice sheets, snow, and sea ice; g) Global rates, amounts, and distribution of precipitation; h) Dynamic motions of the Earth as a whole, including both rotational dynamics and the kinematic motions of the tectonic plates.\textsuperscript{48}

MPE also involves extensive international cooperation with the European Space Agency (ESA) and Japan's National Space Development Agency (NASDA). The former Soviet Union was also invited to participate. Until the summer of 1991, the NASA program

was built around two series (EOS-A and EOS-B) of three very large satellites, an unparalled data and information system, and a number of smaller Earth Probes and precursor missions. In the fall of 1991, the EOS Engineering Review Panel, deliberating under the auspices of the National Space Council and NASA, rejected NASA's concept for EOS-A and EOS-B, leaving the EOS program without an agreed-upon system architecture.

The panel favored reconfiguring the large EOS platforms into smaller clusters of instruments on medium-sized satellites, arguing that this approach would allow EOS to address the major scientific questions about climate change, while making the program more resilient to budget fluctuations, technical innovation, changing requirements, and system failure.\textsuperscript{49} The panel also found that a reexamination of scientific needs has lessened requirements for simultaneity\textsuperscript{50} and reduced the need for co-located instruments that drove the design toward the very large EOS platforms.

Besides being able to fulfill the relaxed simultaneity requirements, the panel found that small platforms can provide more rapid acquisition of the information needed by policymakers to inform their decisions through earlier satellite launch. Furthermore, they found that the large EOS satellites lack sufficient budget resiliency to handle future congressional actions and that architectures relying on smaller platforms provide greater flexibility for both budget increases and budget decreases. Finally, the panel found that smaller satellite architectures provide quicker development and flight, protection against launch vehicle failure, and easier optimization of science needs, since each set of instruments to fly can have a narrower focus and faster technical evaluation, and can incorporate innovation because instruments can be tried without jeopardizing the full program.\textsuperscript{51}

In response to the panel's report, NASA developed an alternative architecture for EOS that has 18 satellites sized for launch by Atlas IIAS class boosters and the same sensors as the original EOS architecture. The new architecture consists of a series of six satellites "repeated twice on five-year centers for at least fifteen year coverage."\textsuperscript{52} The spacecraft, launch dates and vehicles, and their purposes, are:


\textsuperscript{50}Requirements for "simultaneity" occur when different scientific instruments must make observations of the earth together at the same time and place to achieve the best scientific results.


\textsuperscript{52}NASA, \textit{Report to Congress}, pp. 5–6.
• COLOR (1998, Pegasus-class) — Oceanic biomass and productivity.
• AERO (2000, Pegasus-class) — Atmospheric aerosols.
• EOS-PM (2000, Atlas IIA-class) — Clouds, precipitation, and radiation balance; terrestrial snow and sea ice; sea-surface temperature and ocean productivity.
• ALT (2002, Delta-class) — Ocean circulation and ice sheet mass balance.
• CHEM (2002, Atlas IIA-class) — Atmospheric chemical species and their transformations; ocean surface stress.\textsuperscript{53}

As NASA notes, these EOS program satellites will follow the deployment of a number of other spacecraft and Shuttle missions by the United States and other nations to observe climate change. In addition, Mission to Planet Earth will utilize long-term monitoring by military and civil weather satellites.\textsuperscript{54} MPE is a long-term, evolutionary program, incorporating the data collection by many satellites whose primary functions may not necessarily be climate change research but that will nevertheless prove beneficial to the goals of MPE and EOS.

Some analysts outside NASA have put forth more radical proposals, based on both technology-push and user-pull efforts, for small satellites, commonly called “lightsats.” For example, Dr. James Hansen, of the Goddard Institute of Space Science, has proposed an architecture called Climsat. In his proposal, two small satellites would be launched in 1997 to provide the measurements needed to determine global warming feedbacks, forcings, and diagnostics.\textsuperscript{55} The JASON Summer Study (1991) also argued that small satellites can be used for parametric global change research in a timely manner, and that advanced technologies outside of NASA (i.e., DoD and DoE) have utility for such missions.\textsuperscript{56}

There is also political interest in parametric user-pull architectures. Congressman Lamar Smith’s Global Warming Response Act of 1991 stated that decisionmakers require global warming data quickly and need a first launch by 1995. A 1995 launch date would rule out NASA’s revised EOS architecture for a small satellite alternative. This legislation noted the role of DoE and DoD’s advanced technologies by requiring the decision on mission

\textsuperscript{53}NASA, Report to Congress, pp. 4–5.
\textsuperscript{56}N. Fortson, JASON Summer Study 1991: Uses of Remotely Piloted Vehicles and Small Satellites in Global Change Studies, a presentation to the EOS Engineering Review Advisory Committee, Scripps Institution of Oceanography, La Jolla, California, July 1991.
architecture to be made jointly by the Secretary of Defense, the Secretary of Energy, and the Administrator of NASA. The White House has also expressed a desire for faster and cheaper measurement of global change parameters.\textsuperscript{57}

The technology-push proposals originated at various agencies and contractors who seek to use sensors and spacecraft developed for other national missions, primarily military, in a dual-use capacity for global change research. Technology-push proposals have been made by Lawrence Livermore National Laboratories (Brilliant Eyes); a Tri-Lab satellite proposal by Sandia, Los Alamos, and Lawrence Livermore National Laboratories; Defense Advanced Research Project Agency (DARPA) (Joint Remote Sensing Demonstration); TRW and Rockwell (EOS B Alternatives); and a Sandia/TRW joint proposal for Radiation Budget Measurements (Climsat). Lawrence Livermore’s Brilliant Eyes proposal, originally developed for the Strategic Defense Initiative, takes a radical approach to remote sensing that incorporates very small, highly distributed satellites in a global constellation. Other dual-use proposals, such as Sandia/TRW’s Climsat and the DOE Tri-Lab satellite\textsuperscript{58} also try to increase investment return through dual-use technologies, but they do not attempt to minimize measurement overlap between remote sensing sectors and organizations.

\textbf{Commercial Sector}

This sector is defined as those organizations or individuals who exploit remote sensing data to gain profit, either through the procurement and sale of data as an intermediate good, or through value-added analysis that uses remote sensing data as a production input. The former can be considered as data providers, such as EOSAT, and the latter as data analyzers, such as the value-added community. In the case of the value-added community, remote sensing data provided by satellites may be only one of several sets of data that are manipulated to build a composite representation of a particular topic, such as a geographical region or city, to be used for regional or urban planning purposes. The “commercialization” of remote sensing systems then becomes a question of the government enacting policies that support commercialization of data providers, data analyzers, or both communities.

The predominant issue (albeit not the only one) in this sector today is the debate over the fate of Landsat and the future of an emerging commercial remote sensing market. Although the government’s attempts to privatize Landsat have not proven as successful as

\textsuperscript{57}D. Quayle, “Statement by the Vice President: Press Conference at the University of New Hampshire,” Office of the Vice President, July 17, 1991.

\textsuperscript{58}A. Boye and D. Otten, “Sandia and TRW have developed a Climsat concept to support climate research and monitoring,” presentation to the JASON Summer Study, La Jolla, California, June 21, 1991.
originally hoped, it is not necessarily indicative that the entire commercial market will also be a failure. The Department of Commerce states that "the U.S. remote sensing industry will likely continue to grow at an annual rate of 15 to 20 percent a year in 1992, with revenues reaching $200 million." Much of that growth is due to Geographic Information Systems (GIS), which is a "broad term covering systems that use computer hardware and software to manipulate and analyze a wide variety of data organized geographically." The expansion in GIS services and products is largely a result of the declining costs of computers and digital processing, and the overall shift in mapping technology from photography to digital data. This area presents a key strength of U.S. leadership in remote sensing technologies that many in Congress and the Administration are reluctant to relinquish to foreign competitors, primarily SPOT.

The most recent effort to "decommercialize" Landsat, under way simultaneously in the Administration and the Congress, focused on several critical issues: which government agency should build the next satellite in the series, Landsat 7; whether Landsat 7 should be a clone of Landsat 6 or whether there are cheaper ways of building an effective and competitive remote sensing system; and what should be the pricing structure for the new Landsat.

Early in 1992 the National Space Council undertook a review of Landsat policy and issued a National Space Policy Directive (NSPD), Landsat Remote Sensing Strategy, on February 13, 1992. The NSPD acknowledges the importance of a remote sensing capability to U.S. national interests and the maintenance of continuity of Landsat-type data. The Landsat Remote Sensing Strategy is composed of seven elements:

1. Ensuring that Landsat satellites 4 and 5 continue to provide data as long as they are technically capable of doing so, or until Landsat 6 becomes operational.
2. Acquiring a Landsat 7 satellite with the goal of maintaining continuity of Landsat-type data beyond the projected Landsat 6 end-of-life.
3. Fostering the development of advanced remote sensing technologies, with the goal of reducing the cost and increasing the performance of future Landsat-type satellites to meet U.S. government needs, and, potentially, enabling substantially greater opportunities for commercialization.

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59Economics and Statistics Administration and the Office of Space Commerce, Space Business Indicators, June 1992, Department of Commerce, Washington, D.C., p. 6. These figures include "revenues from sales of unenhanced satellite data, and from consulting firms and service providers."
61Space Business Indicators, p. 6.
(4) Seeking to minimize the cost of Landsat-type data for U.S. government agencies and to provide data for use in global change research in a manner consistent with the Administration’s Data Management for Global Change Research Policy Statements.

(5) Limiting U.S. government regulations affecting private sector remote sensing activities to only those required in the interest of national security, foreign policy, and public safety.

(6) Maintaining a U.S.-based archive of existing and future Landsat-type data.

(7) Considering the alternatives for maintaining continuity of data beyond Landsat 7.62

This Directive assigns NASA and the DoD to manage and fund Landsat 7 and define alternatives for maintaining data continuity beyond Landsat 7. They are directed to “develop and launch a Landsat 7 satellite of at least equivalent performance to replace Landsat 6,” which opens the door to alternative concepts other than the existing Landsat design.63 The Commerce Department is directed to complete and launch Landsat 6, and maintain the operation of Landsats 4 and 5 until 6 becomes operational.64

Two bills were submitted by Rep. George E. Brown, Jr. (D–CA), chairman of the House Science, Space and Technology Committee, and Sen. Larry Pressler (R–SD) in 1992 and led to the passage of Public Law 102-555, “Land Remote Sensing Policy Act of 1992,” signed by President Bush on October 28, 1992 (see Appendix). The Act moves Landsat management from the Department of Commerce to a program office managed jointly by NASA and the Department of Defense. That office is charged with the responsibility for Landsat 7 procurement, launch, and operations, as well as for negotiating with EOSAT an arrangement for pricing, distribution, acquisition, archiving, and availability of unenhanced data for Landsats 4 through 6. A two-tier pricing structure for Landsat data is established, one for industry and the other for researchers, scientists, and other nonprofit users. Enhancement of the use of such data for environmental research was sought by offering it to domestic

62The Vice President’s Office, Office of the Press Secretary, “Vice President Announces Landsat Policy,” February 13, 1992, and attachment, Landsat Remote Sensing Strategy, pp. 1–2.

63As it turns out, General Electric was the only company that responded to a request for proposals (RFP) for Landsat 7 system development. According to Aerospace Daily (August 5, 1992, p. 210), GE’s primary associate contractor is Santa Barbara Research Center, which will provide the multi-spectral imaging payload. GE’s proposal includes the Landsat 6 Enhanced Thematic Mapper and “a number of optional system performance improvements.” Contract award was expected by October 1, 1992, and Landsat 7 launch about 1997.

64The Vice President’s Office, Office of the Press Secretary, “Vice President Announces Landsat Policy,” February 13, 1992, and attachment, Landsat Remote Sensing Strategy.
nonprofit entities for noncommercial uses at the marginal cost of acquisition, reproduction, and transmission. The Act also includes provisions for a technology demonstration program that seeks to demonstrate an advanced land remote sensing system design and components that would be less expensive to procure and operate than the current Landsat system. Finally, the Secretary of Commerce is authorized to license private sector organizations to operate private remote sensing space systems.

Both the Land Remote Sensing Policy Act of 1992 and the Landsat Remote Sensing Strategy are consistent with the Administration’s U.S. Commercial Space Policy Guidelines, issued on February 12, 1991. The latter directive mandates that federal agencies will “utilize commercially available space products and services to the fullest extent feasible.”65 However, Landsat’s fate is not yet sealed. There is some congressional concern over future DoD management of Landsat—a traditional civilian program—despite the fact that the DoD is Landsat’s biggest customer.66 Questions of funding levels were being debated as this document is being written, and the final outcome remains to be seen.

International Sector

An increasing number of nations either have or are developing space-based remote sensing systems in support of national interests. While bilateral and international cooperation in space activities is growing, fundamental national interests dictate individual courses of action. Therefore, a number of questions are useful in analyzing foreign motivations and capabilities:

1. What is the level of national or geopolitical interest in space exhibited by other nations possessing or developing remote sensing capabilities?
2. What is the extent of political will resident in each country to support space-based remote sensing programs, particularly when those programs compete for scarce fiscal resources?
3. Does each nation have the requisite technological capabilities to act independently of other space powers, or is it in its own national interest to undertake joint programs, perhaps justified in the interests of regional unity?67

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67 Adapted from Dana J. Johnson, Trends in Space Control Capabilities and Ballistic Missile Threats: Implications for ASAT Arms Control, RAND, P-7635, March 1990, p. 30.
Whereas an in-depth analysis of existing and emerging spacefaring nations and their remote sensing capabilities is not possible here, a brief summary of selected countries and key factors involved in this sector is provided. Each nation's remote sensing capabilities should be placed within the context of the contribution that remote sensing is making or can make to achieving its national interests, protecting its national security, and promoting its people's welfare.

Like the United States, the USSR saw the reconnaissance potential of satellites and instituted its first remote sensing system in 1962. However, the Soviets never had a clear division between military and civilian activities, and their program was largely driven by political objectives. This meant that the Soviet military forces were responsible for the training of cosmonauts, and the launch and recovery of manned and unmanned payloads. As Nicholas L. Johnson has noted,

The integration of military and civilian objectives within the Soviet programme and the need to maintain party control over all aspects of space utilisation require an organisation which bears little resemblance to its American DoD and NASA counterparts.

In 1969, the Soviet Union began its own meteorological efforts with the launch of Meteor 1—a system used for both military and civilian meteorological needs as well as technology development for other remote sensing systems. By the 1980s, the Soviets were using their military systems for land-use and commercial purposes. KFA-1000, Resurs, Okean, and Almaz, primarily military systems, all produce data used for internal civilian purposes and sold commercially overseas.

The Soviets launched their fifth-generation reconnaissance satellite in 1982 and the first of a new series of ocean reconnaissance satellites in 1983. The 1984 launch of Meteor 3 began the upgrade of the Soviet weather system. Soviet land-use efforts were invigorated in the late 1980s with the launch of the Resurs series beginning in 1987 and the Okean 1 and Prognoz satellites beginning in 1988. The Resurs-O satellites, first launched in 1988, are the Soviet multi-spectral digital equivalent to the U.S. Landsat and French SPOT systems. But with the breakup of the Soviet Union and the great political instability and enormous economic problems faced by its successor republics, it is uncertain whether many of these programs will continue. The Russians, as well as some of the other republics, have begun to

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69This is not meant to imply that the U.S. program was not influenced by political objectives—witness the reaction to Sputnik.

expand their commercial space activities in order to gain hard currency, but many Western
governments and companies are reluctant to deal with them until some measure of political
and economic stability is instituted.

During the 1980s, advances in remote sensing technologies and space-related
capabilities coupled with individual national objectives led other nations to begin to deploy
their own space systems. Most of these new programs began with relatively simple
meteorological platforms, although some later expanded to more complex civilian land use
and military systems. Most nations justify their remote sensing programs as civilian, while
often expecting to gain military benefits as well.

In 1974, the People's Republic of China became the first country other than the United
States and the Soviet Union to launch its own remote sensing satellite, the FYW-X, an
experimental version of their photo-optical satellite series. The Chinese program slowed,
however, and after the launch of FYW-1 in 1975, the Chinese did not launch a new satellite
system until 1988 (though the FYW series continued). In 1977, Japan launched its GMS-1
weather satellite, followed in 1981 by the European Space Agency's (ESA) Meteosat 2
weather satellite and a second Japanese meteorological system, GMS-2. In 1982, India
entered the arena with the launch of the multi-purpose Insat 1a satellite, used for
communications as well as weather data.

More advanced systems began appearing in 1986 with France's launch of SPOT 1.
France has been the primary motivator behind European space activities, largely because of
its independent military stance. Similarly to its pursuit of its nuclear force de frappe, it has
supported the development of a force d'espace that would reduce European reliance on the
United States for space activities.\(^{71}\) As one French official stated,

Strategic decision making will be based more and more on refined analysis, supported by
a large quantity of processed information. [Space] is the hinge for the conventional and
nuclear balances. Space is also becoming a place of growing strategic importance. It is
possible that the first—and perhaps the only—battle waged in the next war will be one of
information, and this battle may unfold over access to space.\(^{72}\)

Although France pursues an official policy of independence in space-related matters,
that has not prevented it from initiating cooperative programs with members of the NATO
alliance (in addition to taking an active leadership role in the European Space Agency). One
prominent program is Helios, a joint effort with Italy and Spain to develop a reconnaissance
capability based on SPOT remote sensing technology. Initial talks were conducted in the

\(^{71}\) "France calls for Euro 'space mastery'," *Military Space*, October 24, 1988, p. 2.

\(^{72}\) Statement by Vice Admiral Jean Chabaud, in "France calls for Euro 'space mastery'," *Military
Space*, October 24, 1988, p. 1; also quoted in D. J. Johnson, pp. 31–32.
early to mid-1980s with the Federal Republic of Germany on the joint development of a reconnaissance satellite, but differing national priorities and technological approaches ultimately doomed the talks.\textsuperscript{73}

SPOT was developed as a commercial competitor to Landsat and as a national technology effort. SPOT 1 quickly demonstrated its competitiveness with Landsat, and cemented its role with the launch of SPOT 2 in 1990. The Japanese entered the space-based remote sensing field in 1987 with MOS 1a, Japan’s first domestic Earth resources satellite, and continued its mission with the launch of MOS 1b in 1990. The Europeans spun off their meteorological role to a separate operational organization, EUMETSAT, and continued development with Meteosat 3 in 1988 and MOP-1 in 1989. ESA also entered the civil research sector with the recent launch of the ERS-1 environmental research satellite, the first civilian system with a high-resolution synthetic aperture radar (SAR) since the U.S. Seasat program in 1978. ERS-1 data is slated to be sold commercially through Spot Image and used by the Western European Union Security Organization.

The British and Canadians have long conducted cooperative efforts in remote sensing with the United States. Great Britain’s “special relationship” with the United States has extended to the sharing of imagery and has had beneficial economic effects in its space program.\textsuperscript{74} Canada has both contributed to and benefited from joint surveillance efforts with the United States; examples are its role in the North American Aerospace Defense Command (NORAD) and its long involvement in the Shuttle program.

Other nations, such as South Korea, Israel, and Brazil, are currently preparing to become spacefaring nations by developing their own launch systems and satellites, based on their national interests and objectives. These developments have important national security, economic, and political implications for the United States and its allies. Selected operational and proposed remote sensing satellites are shown in Table 2.2.

\textsuperscript{73}D. J. Johnson, pp. 32–34.
\textsuperscript{74}D. J. Johnson, p. 35.
### Table 2.2
Selected Operational and Proposed Remote Sensing Satellites

<table>
<thead>
<tr>
<th>Satellite</th>
<th>LANDSAT 5</th>
<th>LANDSAT 6</th>
<th>SPOT 3-4</th>
<th>MOS 1,1B</th>
<th>JERS-1</th>
<th>ALMAZ-1</th>
<th>ERS 1-2&lt;sup&gt;a&lt;/sup&gt;</th>
<th>RADARSAT&lt;sup&gt;b&lt;/sup&gt;</th>
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<tr>
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<td>U.S.</td>
<td>France</td>
<td>Japan</td>
<td>Japan</td>
<td>Russia</td>
<td>ESA</td>
<td>Canada</td>
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<td>18 days</td>
<td>26 days</td>
<td>17 days</td>
<td>41 days</td>
<td>1-3 days</td>
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<td></td>
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<td>Green</td>
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<tr>
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<td>.5–.59,.5–.7</td>
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<td>.61–.69</td>
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<td>100 km</td>
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<td>75 km</td>
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<td>Mid-infrared</td>
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<td></td>
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<tr>
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<td>1.55–1.75/2.08–2.35</td>
<td>1.58–1.75</td>
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<tr>
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<td>30 m</td>
<td>20 m</td>
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<td>1.6–1.7/2.01–2.4</td>
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<td>500 km</td>
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<td>Thermal infrared</td>
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<td></td>
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<td>3.7,11–12</td>
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</tr>
<tr>
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<td>NA</td>
<td>23 GHz,81 GHz</td>
<td>1275 GHz</td>
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<td>15 m</td>
<td>10 m</td>
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<td>NA</td>
<td>185 km</td>
<td>60 km</td>
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</table>


<sup>a</sup>ERS-2 will carry the Global Ozone Monitoring Experiment, which will have some capabilities in the ultraviolet to visible regions of the spectrum. Actual coverage is not yet known.
3. ISSUES FOR THE FUTURE

After examining the four sectors—civil, national security/military, scientific, and commercial—a set of issues was developed. This set is by no means comprehensive, nor are all the answers presented. Rather, the issues are representative of the debate over the future course of the U.S. government’s role in remote sensing and the government’s relationship to other actors, such as the domestic and international commercial remote sensing industry. As such, these issues might be appropriate subjects for further RAND research.

Issue 1a: What are the competing needs for remote sensing data by interested government agencies and private organizations and individuals? Which of these activities should logically be undertaken by the government, and which should be encouraged for commercialization?

Issue 1b: How should the U.S. government mediate among competing requirements for remote sensing data from interested governmental agencies? Should programs or individual agency efforts be consolidated, or are there valid reasons arguing for their separate existence? How can those programs meet budgetary, programmatic, risk, schedule, and competitiveness and commercialization goals and constraints?

These two issues are related and descriptive of the fundamental issues facing the U.S. government and its development of remote sensing policies. The first issue represents the larger community of remote sensing sectors and users, and the second emphasizes a subset of that community, those federal agencies and organizations that use remote sensing data or are interested in using data to support future plans and policies. A payload and cost tradeoff analysis should be undertaken to assess programmatic priorities and to determine which programs can be consolidated and which should remain unique or independent. This tradeoff analysis could be used to support the effort by the National Space Council to reassess U.S. space policy in late 1992 and subsequently.

Issue 2: Can—and should—the United States remain the leader in space-based remote sensing? What does “leadership” mean? Which technologies should the U.S. government pursue to maintain global competitiveness in remote sensing from space?

Particularly in this election year (as well as in past ones), the phrase “American leadership in space” has become a cliche subject to many interpretations and not necessarily
with much substance. In this case, the terms “leadership” and “global competitiveness” must be carefully defined. Technologies associated with spacecraft and sensor performance, data collection and analysis, data management, and ground station operations would be assessed against analyses of the strengths and weaknesses of the U.S. economic competitive posture versus its international industrial competitors.

This issue might be appropriate for RAND’s Critical Technologies Institute to address as a part of its larger effort of assessing technology trends in the United States and foreign countries.

**Issue 3: What is an appropriate approach for pricing of remote sensing data (e.g., one-tier vs. two-tier pricing)?**

Examining this issue requires addressing several other fundamental questions. First, what is the value of remote sensing information, given that it supports both public and private goods (for which value is itself difficult to determine) and that it is time-dependent, which in turn affects its value (i.e., information has high value if it is timely enough to support a policymaking decision; on the other hand, to the scientific sector, timeliness may not be as critical a factor)? Second, what is an appropriate level and combination of investment in remote sensing systems? Furthermore, how much of that investment should involve public monies, and how much can be privately financed? Third, which system is most cost-effective for the kinds of information required for particular purposes? The latter question necessitates developing measures of merit by which to evaluate not only space systems with differing characteristics, but also airborne and ground-based systems that may be more suitable for the particular task and objective. Competing sectors, each with goals and objectives, are likely to have equally valid reasons for one form of pricing versus another; however, pricing decisions should be guided by higher-order objectives, such as encouraging the competitiveness of the U.S. remote sensing industry in the world market.

**Issue 4: What is the appropriate approach for releasing remote sensing data from national technical means so as to preserve national security and yet foster other national goals such as global change research and commercialization?**

Despite the demise of the former Soviet Union, the international security environment remains extremely complex and unstable, and the U.S. government still needs to protect sensitive space-related technologies and systems. However, commercially available remote

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sensing technologies are advancing so rapidly that it may no longer be realistic or feasible for the government to maintain security restrictions on U.S. firms attempting to market or even discuss state-of-the-art technologies and systems. The question becomes one of the need to balance valid security concerns with potentially great economic and scientific gains, all in support of U.S. national and economic security. It is also one of internal agency-to-agency sharing of sensitive information in pursuit of higher-order government objectives, such as during wartime operations when timely surveillance of the enemy and speedy dissemination of that information are critical. Some of this has already been initiated, such as the establishment in May 1992 of the Central Imagery Office, an organization for remote sensing services. However, the policies and procedures of the CIO remain to be worked out. This is potentially an area for detailed tradeoff analysis and research and assistance in organizational planning.

**Issue 5: What are the effects of increased international access to remote sensing systems and data on U.S. national security?**

The aspects of this issue that would be explored would include: increasing international capabilities in remote sensing technologies, potential “turn-key” sales of inexpensive remote sensing systems to potential aggressors, increased access to commercial sources of data, and increased access to environmental research data. The effect on military actions of increased potential aggressor access to surveillance information and the inability to directly deny access to such information should also be addressed.
4. CONCLUSIONS

As we have seen, U.S. space-based remote sensing programs and activities are facing a number of critical junctures in the coming decade that call for a reasoned, interdisciplinary, and interdepartmental approach. The U.S. government is faced with some critical decisions about its requirements for exploiting remote sensing capabilities for environmental, meteorological, and national security uses, balanced against limited and decreasing budgets for those activities. Furthermore, the debate about governmental support and encouragement of a nascent commercial space sector will continue, and the viability of that sector will continue to be dependent upon the government's ability to influence the market through its regulatory activities and support of private capital investment in new technological ideas for data exploitation. These trends and others, such as expanding international capabilities, have combined to make for a dynamic remote sensing arena requiring a balanced approach to resource allocation and long-range planning.

These junctures suggest several courses of action, some of which are now being undertaken by the U.S. government. First, the U.S. government ought to develop its remote sensing policies from a more comprehensive viewpoint, based not on the traditional remote sensing sectors, but derived directly from overall U.S. remote sensing goals, the needs of the user communities, and the diverse organizations that can participate in meeting those needs. A key example of this is commitment on the part of NASA, NOAA, and the DoD to conduct separate weather monitoring programs. While there are mission- and user-related reasons for maintaining unique systems, surely some of the aspects of these programs could be consolidated without detriment to current mission performance. As discussed earlier, recent trends in Landsat policy and in utilization of remote sensing systems and their products during the Gulf War would seem to indicate that the United States is moving in that direction, at least in an operational sense.

Second, the government should determine where broadening needs or new technologies allow planned programs to be better coordinated or consolidated to avoid the duplication of effort. This will be particularly important in the future when, for example, EOS's scientific satellites transition from prototype to operational status. At that point they will be competing for scarce resources with many NOAA satellites, which provide some of the same data for environmental research. Third, the government should determine what areas are best pursued as public endeavors, what areas under government authority would be better pursued as commercial or private endeavors, and how to handle the boundaries
between the two while recognizing the valid needs of all the actors involved. The experience of Landsat should not be interpreted as typical of future government forays into the commercial sector, but rather, as a case of "lessons learned" on when, how, and to what degree the government should be involved in a similar venture. However, whatever data pricing policy is adopted will have broad implications for the remote sensing industry, not just Landsat, and so those implications must be carefully considered prior to enactment of policy and regulations. Concurrently, the government should also determine how to best provide encouragement to Americans engaged in commercial space endeavors to help them compete effectively in the international marketplace.

Finally, it should make remote sensing systems more responsive to user needs; in the case of military operations, procedures and mechanisms for the use of imagery in support of accomplishing operational objectives are underway by the DoD and the intelligence community. The policies and procedures of the Central Imagery Office are still being formulated; however, the establishment of this organization may have far-reaching ramifications beyond its immediate purview. Much remains to be accomplished in other areas of remote sensing policies, assignment of priorities, and resource allocations. It will be interesting to see the outcome of the National Space Council's effort to assess the separation between military and civil space programs and the effect of that assessment on U.S. remote sensing activities.

In the last thirty years, U.S. remote sensing has made important contributions to national security, military operations, scientific endeavors, meteorology, and emerging commercial applications. The next decades should be as successful, but the vitality of U.S. activities may depend on the government's ability to restructure its programs to fit the new budgetary, military, and economic environment and yet still achieve its national interests in space.
Appendix

PUBLIC LAW 102-555—OCTOBER 28, 1992:
"LAND REMOTE SENSING POLICY ACT OF 1992"

PUBLIC LAW 102-555—OCT. 28, 1992  106 STAT. 4163

Public Law 102-555
102d Congress
An Act

To enable the United States to maintain its leadership in land remote sensing
by providing data continuity for the Landsat program, to establish a new national
land remote sensing policy, and for other purposes.

Be it enacted by the Senate and House of Representatives of
the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.
This Act may be cited as the "Land Remote Sensing Policy
Act of 1992".

SEC. 2. FINDINGS.
The Congress finds and declares the following:
(1) 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 planning and conducting
many other activities of scientific, economic, and social
importance.

(2) The Federal Government's Landsat system established
the United States as the world leader in land remote sensing
technology.

(3) The national interest of the United States lies in
maintaining international leadership in satellite land remote
sensing and in broadly promoting the beneficial use of remote
sensing data.

(4) The cost of Landsat data has impeded the use of such
data for scientific purposes, such as for global environmental
change research, as well as for other public sector applications.

(5) Given the importance of the Landsat program to the
United States, urgent actions, including expedited procurement
procedures, are required to ensure data continuity.

(6) Full commercialization of the Landsat program cannot
be achieved within the foreseeable future, and thus should
not serve as the near-term goal of national policy on land
remote sensing; however, commercialization of land remote
sensing should remain a long-term goal of United States policy.

(7) 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.

(8) Recognizing the importance of the Landsat program
in helping to meet national and commercial objectives, the
President approved, on February 11, 1992, a National Space
Policy Directive which was developed by the National Space
Council and commits the United States to ensuring the continuity
of Landsat coverage into the 21st century.
(9) Because Landsat data are particularly important for national security purposes and global environmental change research, management responsibilities for the program should be transferred from the Department of Commerce to an integrated program management involving the Department of Defense and the National Aeronautics and Space Administration.

(10) Regardless of management responsibilities for the Landsat program, the Nation's broad civilian, national security, commercial, and foreign policy interests in remote sensing will best be served by ensuring that Landsat remains an unclassified program that operates according to the principles of open skies and nondiscriminatory access.

(11) Technological advances aimed at reducing the size and weight of satellite systems hold the potential for dramatic reductions in the cost, and substantial improvements in the capabilities, of future land remote sensing systems, but such technological advances have not been demonstrated for land remote sensing and therefore cannot be relied upon as the sole means of achieving data continuity for the Landsat program.

(12) A technology demonstration program involving advanced remote sensing technologies could serve a vital role in determining the design of a follow-on spacecraft to Landsat 7, while also helping to determine whether such a spacecraft should be funded by the United States Government, by the private sector, or by an international consortium.

(13) To maximize the value of the Landsat program to the American public, unenhanced Landsat 4 through 6 data should be made available, at a minimum, to United States Government agencies, to global environmental change researchers, and to other researchers who are financially supported by the United States Government, at the cost of fulfilling user requests, and unenhanced Landsat 7 data should be made available to all users at the cost of fulfilling user requests.

(14) To stimulate development of the commercial market for unenhanced data and value-added services, the United States Government should adopt a data policy for Landsat 7 which allows competition within the private sector for distribution of unenhanced data and value-added services.

(15) Development of the remote sensing market and the provision of commercial value-added services based on remote sensing data should remain exclusively the function of the private sector.

(16) It is in the best interest of the United States to maintain a permanent, comprehensive Government archive of global Landsat and other land remote sensing data for long-term monitoring and study of the changing global environment.

SEC. 2. DEFINITIONS.

In this Act, the following definitions apply:

(1) The term "Administrator" means the Administrator of the National Aeronautics and Space Administration.

(2) The term "cost of fulfilling user requests" means the incremental costs associated with providing product generation, reproduction, and distribution of unenhanced data in response to user requests and shall not include any acquisition, amortiza-
tion, or depreciation of capital assets originally paid for by the United States Government or other costs not specifically attributable to fulfilling user requests.

3) The term "data continuity" means the continued acquisition and availability of unenhanced data which are, from the point of view of the user—

(A) sufficiently consistent (in terms of acquisition geometry, coverage characteristics, and spectral characteristics) with previous Landsat data to allow comparisons for global and regional change detection and characterization; and

(B) compatible with such data and with methods used to receive and process such data.

4) The term "data preprocessing" may include—

(A) rectification of system and sensor distortions in land remote sensing data as it is received directly from the satellite in preparation for delivery to a user;

(B) registration of such data with respect to features of the Earth; and

(C) calibration of spectral response with respect to such data, but does not include conclusions, manipulations, or calculations derived from such data, or a combination of such data with other data.

5) The term "land remote sensing" means the collection of data which can be processed into imagery of surface features of the Earth from an unclassified satellite or satellites, other than an operational United States Government weather satellite.

6) The term "Landsat Program Management" means the integrated program management structure—

(A) established by, and responsible to, the Administrator and the Secretary of Defense pursuant to section 101(a); and

(B) consisting of appropriate officers and employees of the National Aeronautics and Space Administration, the Department of Defense, and any other United States Government agencies the President designates as responsible for the Landsat program.

7) The term "Landsat system" means Landsats 1, 2, 3, 4, 5, and 6, and any follow-on land remote sensing system operated and owned by the United States Government, along with any related ground equipment, systems, and facilities owned by the United States Government.

8) The term "Landsat 6 contractor" means the private sector entity which was awarded the contract for spacecraft construction, operations, and data marketing rights for the Landsat 6 spacecraft.

9) The term "Landsat 7" means the follow-on satellite to Landsat 6.

10) The term "National Satellite Land Remote Sensing Data Archive" means the archive established by the Secretary of the Interior pursuant to the archival responsibilities defined in section 502.

11) The term "noncommercial purposes" refers to those activities undertaken by individuals or entities on the condition, upon receipt of unenhanced data, that—

(A) such data shall not be used in connection with any bid for a commercial contract, development of a
commercial product, or any other non-United States Government activity that is expected, or has the potential, to be profitmaking;

(B) the results of such activities are disclosed in a timely and complete fashion in the open technical literature or other method of public release, except when such disclosure by the United States Government or its contractors would adversely affect the national security or foreign policy of the United States or violate a provision of law or regulation; and

(C) such data shall not be distributed in competition with unenhanced data provided by the Landsat 6 contractor.

(12) The term "Secretary" means the Secretary of Commerce.

(13) The term "unenhanced data" means land remote sensing signals or imagery products that are unprocessed or subject only to data preprocessing.

(14) The term "United States Government and its affiliated users" means—

(A) United States Government agencies;

(B) researchers involved with the United States Global Change Research Program and its international counterpart programs; and

(C) other researchers and international entities that have signed with the United States Government a cooperative agreement involving the use of Landsat data for non-commercial purposes.


TITLE I—LANDSAT

SEC. 101. LANDSAT PROGRAM MANAGEMENT.

(a) ESTABLISHMENT.—The Administrator and the Secretary of Defense shall be responsible for management of the Landsat program. Such responsibility shall be carried out by establishing an integrated program management structure for the Landsat system.

(b) MANAGEMENT PLAN.—The Administrator, the Secretary of Defense, and any other United States Government official the President designates as responsible for part of the Landsat program, shall establish, through a management plan, the roles, responsibilities, and funding expectations for the Landsat Program of the appropriate United States Government agencies. The management plan shall—

(1) specify that the fundamental goal of the Landsat Program Management is the continuity of unenhanced Landsat data through the acquisition and operation of a Landsat 7 satellite as quickly as practicable which is, at a minimum, functionally equivalent to the Landsat 6 satellite, with the addition of a tracking and data relay satellite communications capability;

(2) include a baseline funding profile that—
(A) is mutually acceptable to the National Aeronautics and Space Administration and the Department of Defense for the period covering the development and operation of Landsat 7; and

(B) provides for total funding responsibility of the National Aeronautics and Space Administration and the Department of Defense, respectively, to be approximately equal to the funding responsibility of the other as spread across the development and operational life of Landsat 7;

(3) specify that any improvements over the Landsat 5 functional equivalent capability for Landsat 7 will be funded by a specific sponsoring agency or agencies, in a manner agreed to by the Landsat Program Management, if the required funding exceeds the baseline funding profile required by paragraph (2), and that additional improvements will be sought only if the improvements will not jeopardize data continuity; and

(4) provide for a technology demonstration program whose objective shall be the demonstration of advanced land remote sensing technologies that may potentially yield a system which is less expensive to build and operate, and more responsive to data users, than is the current Landsat system.

(c) RESPONSIBILITIES.—The Landsat Program Management shall be responsible for—

(1) Landsat 7 procurement, launch, and operations;

(2) ensuring that the operation of the Landsat system is responsive to the broad interests of the civilian, national security, commercial, and foreign users of the Landsat system;

(3) ensuring that all unenhanced Landsat data remain unclassified and that, except as provided in section 506 (a) and (b), no restrictions are placed on the availability of unenhanced data;

(4) ensuring that land remote sensing data of high priority locations will be acquired by the Landsat 7 system as required to meet the needs of the United States Global Change Research Program, as established in the Global Change Research Act of 1990, and to meet the needs of national security users;

(5) Landsat data responsibilities pursuant to this Act;

(6) oversight of Landsat contracts entered into under sections 102 and 103;

(7) coordination of a technology demonstration program, pursuant to section 303; and

(8) ensuring that copies of data acquired by the Landsat system are provided to the National Satellite Land Remote Sensing Data Archive.

(d) AUTHORITY TO CONTRACT.—The Landsat Program Management may, subject to appropriations and only under the existing contract authority of the United States Government agencies that compose the Landsat Program Management, enter into contracts with the private sector for services such as, but not limited to, satellite operations and data preprocessing.

(e) LANDSAT ADVISORY PROCESS.—

(1) ESTABLISHMENT.—The Landsat Program Management shall seek impartial advice and comments regarding the status, effectiveness, and operation of the Landsat system, using existing advisory committees and other appropriate mechanisms. Such advice shall be sought from individuals who represent—
(A) a broad range of perspectives on basic and applied science and operational needs with respect to land remote sensing data;
(B) the full spectrum of users of Landsat data, including representatives from United States Government agencies, State and local government agencies, academic institutions, nonprofit organizations, value-added companies, the agricultural, mineral extraction, and other user industries, and the public, and
(C) a broad diversity of age groups, sexes, and races.

(2) REPORTS.—Within 1 year after the date of the enactment of this Act and biennially thereafter, the Landsat Program Management shall prepare and submit a report to the Congress which—
(A) reports the public comments received pursuant to paragraph (1); and
(B) includes—
(i) a response to the public comments received pursuant to paragraph (1);
(ii) information on the volume of use, by category, of data from the Landsat system; and
(iii) any recommendations for policy or programmatic changes to improve the utility and operation of the Landsat system.

SEC. 102. PROCUREMENT OF LANDSAT 7.

(a) CONTRACT NEGOTIATIONS.—The Landsat Program Management shall, subject to appropriations and only under the existing contract authority of the United States Government agencies that compose the Landsat Program Management, expeditiously contract with a United States private sector entity for the development and delivery of Landsat 7.

(b) DEVELOPMENT AND DELIVERY CONSIDERATION.—In negotiating a contract under this section for the development and delivery of Landsat 7, the Landsat Program Management shall—
(1) seek, as a fundamental objective, to have Landsat 7 operational by the expected end of the design life of Landsat 6;
(2) seek to ensure data continuity by the development and delivery of a satellite which is, at a minimum, functionally equivalent to the Landsat 6 satellite; and
(3) seek to incorporate in Landsat 7 any performance improvements required to meet United States Government needs that would not jeopardize data continuity.

(c) NOTIFICATION OF COST AND SCHEDULE CHANGES.—The Landsat Program Management shall promptly notify the Congress of any significant deviations from the expected cost, delivery date, and launch date of Landsat 7, that are specified by the Landsat Program Management upon award of the contract under this section.

(d) UNITED STATES PRIVATE SECTOR ENTITIES.—The Landsat Program Management shall, for purposes of this Act, define the term “United States private sector entities”, taking into account the location of operations, assets, personnel, and other such factors.

SEC. 103. DATA POLICY FOR LANDSAT 4 THROUGH 6.

(a) CONTRACT NEGOTIATIONS.—Within 30 days after the date of enactment of this Act, the Landsat Program Management shall
enter into negotiations with the Landsat 6 contractor to formalize an arrangement with respect to pricing, distribution, acquisition, archiving, and availability of unenhanced data for which the Landsat 6 contractor has responsibility under its contract. Such arrangement shall provide for a phased transition to a data policy consistent with the Landsat 7 data policy (developed pursuant to section 106) by the date of initial operation of Landsat 7. Conditions of the phased arrangement should require that the Landsat 6 contractor adopt provisions so that by the final phase of the transition period—

(1) such unenhanced data shall be provided, at a minimum, to the United States Government and its affiliated users at the cost of fulfilling user requests, on the condition that such unenhanced data are used solely for noncommercial purposes;

(2) instructional data sets, selected from the Landsat data archives, will be made available to educational institutions exclusively for noncommercial, educational purposes at the cost of fulfilling user requests;

(3) Landsat data users are able to acquire unenhanced data contained in the collective archives of foreign ground stations as easily and affordably as practicable;

(4) adequate data necessary to meet the needs of global environmental change researchers and national security users are acquired;

(5) the United States Government and its affiliated users shall not be prohibited from reproduction or dissemination of unenhanced data to other agencies of the United States Government and other affiliated users, on the condition that such unenhanced data are used solely for noncommercial purposes;

(6) nonprofit, public interest entities receive vouchers, data grants, or other such means of providing them with unenhanced data at the cost of fulfilling user requests, on the condition that such unenhanced data are used solely for noncommercial purposes.

(7) a viable role for the private sector in the promotion and development of the commercial market for value added and other services using unenhanced data from the Landsat system is preserved; and

(8) unenhanced data from the Landsat system are provided to the National Satellite Land Remote Sensing Data Archive at no more than the cost of fulfilling user requests.

(b) Failure To Reach Agreement.—If negotiations under subsection (a) have not, by September 30, 1993, resulted in an agreement that the Landsat Program Management determines generally achieves the goals stated in subsection (b) (1) through (8), the Administrator and the Secretary of Defense shall, within 30 days after the date of such determination, jointly certify and report such determination to the Congress. The report shall include a review of options and projected costs for achieving such goals, and shall include recommendations for achieving such goals. The options reviewed shall include—

(1) retaining the existing or modified contract with the Landsat 6 contractor;

(2) the termination of existing contracts for the exclusive right to market unenhanced Landsat data; and
(3) the establishment of an alternative private sector mechanism for the marketing and commercial distribution of such data.

SEC. 104. TRANSFER OF LANDSAT 6 PROGRAM RESPONSIBILITIES.

The responsibilities of the Secretary with respect to Landsat 6 shall be transferred to the Landsat Program Management, as agreed to between the Secretary and the Landsat Program Management, pursuant to section 101.

SEC. 105. DATA POLICY FOR LANDSAT 7.

(a) LANDSAT 7 DATA POLICY.—The Landsat Program Management, in consultation with other appropriate United States Government agencies, shall develop a data policy for Landsat 7 which should—

(1) ensure that unenhanced data are available to all users at the cost of fulfilling user requests;
(2) ensure timely and dependable delivery of unenhanced data to the full spectrum of civilian, national security, commercial, and foreign users and the National Satellite Land Remote Sensing Data Archive;
(3) ensure that the United States retains ownership of all unenhanced data generated by Landsat 7;
(4) support the development of the commercial market for remote sensing data;
(5) ensure that the provision of commercial value-added services based on remote sensing data remains exclusively the function of the private sector; and
(6) to the extent possible, ensure that the data distribution system for Landsat 7 is compatible with the Earth Observing System Data and Information System.

(b) In addition, the data policy for Landsat 7 may provide for—

(1) United States private sector entities to operate ground receiving stations in the United States for Landsat 7 data;
(2) other means for direct access by private sector entities to unenhanced data from Landsat 7; and
(3) the United States Government to charge a per image fee, license fee, or other such fee to entities operating ground receiving stations or distributing Landsat 7 data.

(c) LANDSAT 7 DATA POLICY PLAN.—Not later than July 15, 1994, the Landsat Program Management shall develop and submit to Congress a report that contains a Landsat 7 Data Policy Plan. This plan shall define the roles and responsibilities of the various public and private sector entities that would be involved in the acquisition, processing, distribution, and archiving of Landsat 7 data and in operations of the Landsat 7 spacecraft.

(d) REPORTS.—Not later than 12 months after submission of the Landsat 7 Data Policy Plan, required by subsection (c), and annually thereafter until the launch of Landsat 7, the Landsat Program Management, in consultation with representatives of appropriate United States Government agencies, shall prepare and submit a report to the Congress which—

(1) provides justification for the Landsat 7 data policy in terms of the civilian, national security, commercial, and foreign policy needs of the United States; and
(2) provides justification for any elements of the Landsat 7 data policy which are not consistent with the provisions of subsection (a).

TITLE II—LICENSING OF PRIVATE REMOTE SENSING SPACE SYSTEMS

SEC. 201. GENERAL LICENSING AUTHORITY.

(a) LICENSING AUTHORITY OF SECRETARY.—(1) In consultation with other appropriate United States Government agencies, the Secretary is authorized to license private sector parties to operate private remote sensing space systems for such period as the Secretary may specify and in accordance with the provisions of this title.

(2) In the case of a private space system that is used for remote sensing and other purposes, the authority of the Secretary under this title shall be limited only to the remote sensing operations of such space system.

(b) COMPLIANCE WITH THE LAW, REGULATIONS, INTERNATIONAL OBLIGATIONS, AND NATIONAL SECURITY.—No license shall be granted by the Secretary unless the Secretary determines in writing that the applicant will comply with the requirements of this Act, any regulations issued pursuant to this Act, and any applicable international obligations and national security concerns of the United States.

(c) DEADLINE FOR ACTION ON APPLICATION.—The Secretary shall review any application and make a determination thereon within 120 days of the receipt of such application. If final action has not occurred within such time, the Secretary shall inform the applicant of any pending issues and of actions required to resolve them.

(d) IMPROPER BASIS FOR DENIAL.—The Secretary shall not deny such license in order to protect any existing licensee from competition.

(e) REQUIREMENT TO PROVIDE UNENHANCED DATA.—(1) The Secretary, in consultation with other appropriate United States Government agencies and pursuant to paragraph (2), shall designate in a license issued pursuant to this title any unenhanced data required to be provided by the licensee under section 202(b)(3).

(2) The Secretary shall make a designation under paragraph (1) after determining that—

(A) such data are generated by a system for which all or a substantial part of the development, fabrication, launch, or operations costs have been or will be directly funded by the United States Government; or

(B) it is in the interest of the United States to require such data to be provided by the licensee consistent with section 202(b)(3), after considering the impact on the licensee and the importance of promoting widespread access to remote sensing data from United States and foreign systems.

(3) A designation made by the Secretary under paragraph (1) shall not be inconsistent with any contract or other arrangement entered into between a United States Government agency and the licensee.
SEC. 302. CONDITIONS FOR OPERATION.

(a) License Required for Operation.—No person who is subject to the jurisdiction or control of the United States may, directly or through any subsidiary or affiliate, operate any private remote sensing space system without a license pursuant to section 201.

(b) Licensing Requirements.—Any license issued pursuant to this title shall specify that the licensee shall comply with all of the requirements of this Act and shall—

(1) operate the system in such manner as to preserve the national security of the United States and to observe the international obligations of the United States in accordance with section 506;

(2) make available to the government of any country (including the United States) unenhanced data collected by the system concerning the territory under the jurisdiction of such government as soon as such data are available and on reasonable terms and conditions;

(3) make unenhanced data designated by the Secretary in the license pursuant to section 201(e) available in accordance with section 501;

(4) upon termination of operations under the license, make disposition of any satellites in space in a manner satisfactory to the President;

(5) furnish the Secretary with complete orbit and data collection characteristics of the system, and inform the Secretary immediately of any deviation; and

(6) notify the Secretary of any agreement the licensee intends to enter with a foreign nation, entity, or consortium involving foreign nations or entities.

(c) Additional Licensing Requirements for Landsat 6 Contractor.—In addition to the requirements of paragraph (b), any license issued pursuant to this title to the Landsat 6 contractor shall specify that the Landsat 6 contractor shall—

(1) notify the Secretary of any value added activities (as defined by the Secretary by regulation) that will be conducted by the Landsat 6 contractor or by a subsidiary or affiliate; and

(2) if such activities are to be conducted, provide the Secretary with a plan for compliance with section 501 of this Act.

SEC. 303. ADMINISTRATIVE AUTHORITY OF THE SECRETARY.

(a) Functions.—In order to carry out the responsibilities specified in this title, the Secretary may—

(1) grant, condition, or transfer licenses under this Act;

(2) seek an order of injunction or similar judicial determination from a United States District Court with personal jurisdiction over the licensee to terminate, modify, or suspend licenses under this title and to terminate licensed operations on an immediate basis, if the Secretary determines that the licensee has substantially failed to comply with any provisions of this Act, with any terms, conditions, or restrictions of such license, or with any international obligations or national security concerns of the United States.

(3) provide penalties for noncompliance with the requirements of licenses or regulations issued under this title, including civil penalties not to exceed $10,000 (each day of operation
in violation of such licenses or regulations constituting a separate violation;

(4) compromise, modify, or remit any such civil penalty;

(5) issue subpoenas for any materials, documents, or records, or for the attendance and testimony of witnesses for the purpose of conducting a hearing under this section;

(6) seize any object, record, or report pursuant to a warrant from a magistrate based on a showing of probable cause to believe that such object, record, or report was used, is being used, or is likely to be used in violation of this Act or the requirements of a license or regulation issued thereunder; and

(7) make investigations and inquiries and administer oaths or take from any person an oath, affirmation, or affidavit concerning any matter relating to the enforcement of this Act.

(b) REVIEW OF AGENCY ACTION.—Any applicant or licensee who makes a timely request for review of an adverse action pursuant to subsection (a)(1), (a)(3), (a)(5), or (a)(6) shall be entitled to adjudication by the Secretary on the record after an opportunity for any agency hearing with respect to such adverse action. Any final action by the Secretary under this subsection shall be subject to judicial review under chapter 7 of title 5, United States Code.

SEC. 204. REGULATORY AUTHORITY OF THE SECRETARY.

The Secretary may issue regulations to carry out this title. Such regulations shall be promulgated only after public notice and comment in accordance with the provisions of section 553 of title 5, United States Code.

SEC. 205. AGENCY ACTIVITIES.

(a) LICENSE APPLICATION AND ISSUANCE.—A private sector party may apply for a license to operate a private remote sensing space system which utilizes, on a space-available basis, a civilian United States Government satellite or vehicle as a platform for such system. The Secretary, pursuant to this title, may license such system if it meets all conditions of this title and—

(1) the system operator agrees to reimburse the Government in a timely manner for all related costs incurred with respect to such utilization, including a reasonable and proportionate share of fixed, platform, data transmission, and launch costs; and

(2) such utilization would not interfere with or otherwise compromise intended civilian Government missions, as determined by the agency responsible for such civilian platform.

(b) ASSISTANCE.—The Secretary may offer assistance to private sector parties in finding appropriate opportunities for such utilization.

(c) AGREEMENTS.—To the extent provided in advance by appropriation Acts, any United States Government agency may enter into agreements for such utilization if such agreements are consistent with such agency's mission and statutory authority, and if such remote sensing space system is licensed by the Secretary before commencing operation.

(d) APPLICABILITY.—This section does not apply to activities carried out under title III.

(e) EFFECT ON FCC AUTHORITY.—Nothing in this title shall affect the authority of the Federal Communications Commission pursuant to the Communications Act of 1934 (47 U.S.C. 151 et seq.).
PUBLIC LAW 102-555—OCT. 28, 1992

TITLE III—RESEARCH, DEVELOPMENT, AND DEMONSTRATION

SEC. 301. CONTINUED FEDERAL RESEARCH AND DEVELOPMENT.

15 USC 5631. (a) ROLES OF NASA AND DEPARTMENT OF DEFENSE.—(1) The Administrator and the Secretary of Defense are directed to continue and to enhance programs of remote sensing research and development.

(2) The Administrator is authorized and encouraged to—

(A) conduct experimental space remote sensing programs (including applications demonstration programs and basic research at universities);

(B) develop remote sensing technologies and techniques, including those needed for monitoring the Earth and its environment; and

(C) conduct such research and development in cooperation with other United States Government agencies and with public and private research entities (including private industry, universities, non-profit organizations, State and local governments, foreign governments, and international organizations) and to enter into arrangements (including joint ventures) which will foster such cooperation.

(b) ROLES OF DEPARTMENT OF AGRICULTURE AND DEPARTMENT OF INTERIOR.—

(1) In order to enhance the ability of the United States to manage and utilize its renewable and nonrenewable resources, the Secretary of Agriculture and the Secretary of the Interior are authorized and encouraged to conduct programs of research and development in the applications of remote sensing using funds appropriated for such purposes.

(2) Such programs may include basic research at universities, demonstrations of applications, and cooperative activities involving other Government agencies, private sector parties, and foreign and international organizations.

(c) ROLE OF OTHER FEDERAL AGENCIES.—Other United States Government agencies are authorized and encouraged to conduct research and development on the use of remote sensing in the fulfillment of their authorized missions, using funds appropriated for such purposes.

SEC. 302. AVAILABILITY OF FEDERALLY GATHERED UNEHANCED DATA.

15 USC 5632. (a) GENERAL RULE.—All unenhanced land remote sensing data gathered and owned by the United States Government, including unenhanced data gathered under the technology demonstration program carried out pursuant to section 303, shall be made available to users in a timely fashion.

(b) PROTECTION FOR COMMERCIAL DATA DISTRIBUTOR.—The President shall seek to ensure that unenhanced data gathered under the technology demonstration program carried out pursuant to section 303 shall, to the extent practicable, be made available on terms that would not adversely affect the commercial market for unenhanced data gathered by the Landsat 5 spacecraft.

SEC. 303. TECHNOLOGY DEMONSTRATION PROGRAM.

15 USC 5633. (a) ESTABLISHMENT.—As a fundamental component of a national land remote sensing strategy, the President shall establish,
through appropriate United States Government agencies, a technology demonstration program. The goals of such programs shall be to—

(1) seek to launch advanced land remote sensing system components within 5 years after the date of the enactment of this Act.

(2) demonstrate within such 5-year period advanced sensor capabilities suitable for use in the anticipated land remote sensing program; and

(3) demonstrate within such 5-year period an advanced land remote sensing system design that could be less expensive to procure and operate than the Landsat system projected to be in operation through the year 2000, and that therefore holds greater potential for private sector investment and control.

(b) EXECUTION OF PROGRAM.—In executing the technology demonstration program, the President shall seek to apply technologies associated with United States National Technical Means of intelligence gathering, to the extent that such technologies are appropriate for the technology demonstration and can be declassified for such purposes without causing adverse harm to United States national security interests.

(c) BROAD APPLICATION.—To the greatest extent practicable, the technology demonstration program established under subsection (a) shall be designed to be responsive to the broad civilian, national security, commercial, and foreign policy needs of the United States.

(d) PRIVATE SECTOR FUNDING.—The technology demonstration program under this section may be carried out in part with private sector funding.

(e) LANDSAT PROGRAM MANAGEMENT COORDINATION.—The Landsat Program Management shall have a coordinating role in the technology demonstration program carried out under this section.

(f) REPORT TO CONGRESS.—The President shall assess the progress of the technology demonstration program under this section and, within 2 years after the date of enactment of this Act, submit a report to the Congress on such progress.

TITLE IV—ASSESSING OPTIONS FOR SUCCESSOR LAND REMOTE SENSING SYSTEM

SEC. 401. ASSESSING OPTIONS FOR SUCCESSOR LAND REMOTE SENSING SYSTEM.

(a) ASSESSMENT.—Within 5 years after the date of the enactment of this Act, the Landsat Program Management, in consultation with representatives of appropriate United States Government agencies, shall assess and report to the Congress on the options for a successor land remote sensing system to Landsat 7. The report shall include a full assessment of the advantages and disadvantages of—

(1) private sector funding and management of a successor land remote sensing system;

(2) establishing an international consortium for the funding and management of a successor land remote sensing system;

(3) funding and management of a successor land remote sensing system by the United States Government; and
(4) a cooperative effort between the United States Government and the private sector for the funding and management of a successor land remote sensing system.

(b) GOALS.—In carrying out subsection (a), the Landsat Program Management shall consider the ability of each of the options to—

(1) encourage the development, launch, and operation of a land remote sensing system that adequately serves the civilian, national security, commercial, and foreign policy interests of the United States;

(2) encourage the development, launch, and operation of a land remote sensing system that maintains data continuity with the Landsat system; and

(3) incorporate system enhancements, including any such enhancements developed under the technology demonstration program under section 303, which may potentially yield a system that is less expensive to build and operate, and more responsive to data users, than is the Landsat system projected to be in operation through the year 2000.

(c) PREFERENCE FOR PRIVATE SECTOR SYSTEM.—If a successor land remote sensing system to Landsat 7 can be funded and managed by the private sector while still achieving the goals stated in subsection (b) without jeopardizing the domestic, national security, and foreign policy interests of the United States, preference should be given to the development of such a system by the private sector without competition from the United States Government.

TITLE V—GENERAL PROVISIONS

15 USC 5651.

SEC. 501. NONDISCRIMINATORY DATA AVAILABILITY.

(a) GENERAL RULE.—Except as provided in subsection (b) of this section, any unenhanced data generated by the Landsat system or any other land remote sensing system funded and owned by the United States Government shall be made available to all users without preference, bias, or any other special arrangement (except on the basis of national security concerns pursuant to section 506) regarding delivery, format, pricing, or technical considerations which would favor one customer or class of customers over another.

(b) EXCEPTIONS.—Unenhanced data generated by the Landsat system or any other land remote sensing system funded and owned by the United States Government may be made available to the United States Government and its affiliated users at reduced prices, in accordance with this Act, on the condition that such unenhanced data are used solely for noncommercial purposes.

15 USC 5652.

SEC. 502. ARCHIVING OF DATA.

(a) PUBLIC INTEREST.—It is in the public interest for the United States Government to—

(1) maintain an archive of land remote sensing data for historical, scientific, and technical purposes, including long-term global environmental monitoring;

(2) control the content and scope of the archive; and

(3) assure the quality, integrity, and continuity of the archive.

(b) ARCHIVING PRACTICES.—The Secretary of the Interior, in consultation with the Landsat Program Management, shall provide for long-term storage, maintenance, and upgrading of a basic, global,
land remote sensing data set (hereinafter referred to as the "basic data set") and shall follow reasonable archival practices to assure proper storage and preservation of the basic data set and timely access for parties requesting data.

(c) Determination of Content of Basic Data Set.—In determining the initial content of, or in upgrading, the basic data set, the Secretary of Interior shall—

1. use as a baseline the data archived on the date of enactment of this Act;
2. take into account future technical and scientific developments and needs, paying particular attention to the anticipated data requirements of global environmental change research;
3. consult with and seek the advice of users and producers of remote sensing data and data products;
4. consider the need for data which may be duplicative in terms of geographical coverage but which differ in terms of season, spectral bands, resolution, or other relevant factors;
5. include, as the Secretary of the Interior considers appropriate, unenhanced data generated either by the Landsat system, pursuant to title I, or by licensees under title II;
6. include, as the Secretary of the Interior considers appropriate, data collected by foreign ground stations or by foreign remote sensing space systems; and
7. ensure that the content of the archive is developed in accordance with section 506.

(d) Public Domain.—After the expiration of any exclusive right to sell, or after relinquishment of such right, the data provided to the National Satellite Land Remote Sensing Data Archive shall be in the public domain and shall be made available to requesting parties by the Secretary of the Interior at the cost of fulfilling user requests.

SEC. 503. NONREPRODUCTION.

Unenhanced data distributed by any licensee under title II of this Act may be sold on the condition that such data will not be reproduced or disseminated by the purchaser for commercial purposes.

SEC. 504. REIMBURSEMENT FOR ASSISTANCE.

The Administrator, the Secretary of Defense, and the heads of other United States Government agencies may provide assistance to land remote sensing system operators under the provisions of this Act. Substantial assistance shall be reimbursed by the operator, except as otherwise provided by law.

SEC. 505. ACQUISITION OF EQUIPMENT.

The Landsat Program Management may, by means of a competitive process, allow a licensee under title II or any other private party to buy, lease, or otherwise acquire the use of equipment from the Landsat system, when such equipment is no longer needed for the operation of such system or for the sale of data from such system. Officials of other United States Government civilian agencies are authorized and encouraged to cooperate with the Secretary in carrying out this section.

SEC. 506. RADIO FREQUENCY ALLOCATION.

(a) Application to Federal Communications Commission.—

To the extent required by the Communications Act of 1934 (47
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U.S.C. 151 et seq.), an application shall be filed with the Federal Communications Commission for any radio facilities involved with commercial remote sensing space systems licensed under title II.

(b) DEADLINE FOR FCC ACTION.—It is the intent of Congress that the Federal Communications Commission complete the radio licensing process under the Communications Act of 1934 (47 U.S.C. 151 et seq.), upon the application of any private sector party or consortium operator of any commercial land remote sensing space system subject to this Act, within 120 days of the receipt of an application for such licensing. If final action has not occurred within 120 days of the receipt of such an application, the Federal Communications Commission shall inform the applicant of any pending issues and of actions required to resolve them.

(c) DEVELOPMENT AND CONSTRUCTION OF UNITED STATES SYSTEMS.—Authority shall not be required from the Federal Communications Commission for the development and construction of any United States land remote sensing space system (or component thereof), other than radio transmitting facilities or components, while any licensing determination is being made.

(d) CONSISTENCY WITH INTERNATIONAL OBLIGATIONS AND PUBLIC INTEREST.—Frequency allocations made pursuant to this section by the Federal Communications Commission shall be consistent with international obligations and with the public interest.

SEC. 507. CONSULTATION.

(a) CONSULTATION WITH SECRETARY OF DEFENSE.—The Secretary and the Landsat Program Management shall consult with the Secretary of Defense on all matters under this Act affecting national security. The Secretary of Defense shall be responsible for determining those conditions, consistent with this Act, necessary to meet national security concerns of the United States and for notifying the Secretary and the Landsat Program Management promptly of such conditions.

(b) CONSULTATION WITH SECRETARY OF STATE.—(1) The Secretary and the Landsat Program Management shall consult with the Secretary of State on all matters under this Act affecting international obligations. The Secretary of State shall be responsible for determining those conditions, consistent with this Act, necessary to meet international obligations and policies of the United States and for notifying promptly the Secretary and the Landsat Program Management of such conditions.

(2) Appropriate United States Government agencies are authorized and encouraged to provide remote sensing data, technology, and training to developing nations as a component of programs of international aid.

(3) The Secretary of State shall promptly report to the Secretary and Landsat Program Management any instances outside the United States of discriminatory distribution of Landsat data.

(c) STATUS REPORT.—The Landsat Program Management shall, as often as necessary, provide to the Congress complete and updated information about the status of ongoing operations of the Landsat system, including timely notification of decisions made with respect to the Landsat system in order to meet national security concerns and international obligations and policies of the United States Government.

(d) REIMBURSEMENTS.—If, as a result of technical modifications imposed on a licensee under title II on the basis of national security
concerns, the Secretary, in consultation with the Secretary of Defense or with other Federal agencies, determines that additional costs will be incurred by the licensee, or that past development costs (including the cost of capital) will not be recovered by the licensee, the Secretary may require the agency or agencies requesting such technical modifications to reimburse the licensee for such additional or development costs, but not for anticipated profits. Reimbursements may cover costs associated with required changes in system performance, but not costs ordinarily associated with doing business abroad.

SEC. 508. ENFORCEMENT.

(a) IN GENERAL.—In order to ensure that unenhanced data from the Landsat system received solely for noncommercial purposes are not used for any commercial purpose, the Secretary (in collaboration with private sector entities responsible for the marketing and distribution of unenhanced data generated by the Landsat system) shall develop and implement a system for enforcing this prohibition, in the event that unenhanced data from the Landsat system are made available for noncommercial purposes at a different price than such data are made available for other purposes.

(b) AUTHORITY OF SECRETARY.—Subject to subsection (d), the Secretary may impose any of the enforcement mechanisms described in subsection (c) against a person who—

(1) receives unenhanced data from the Landsat system under this Act solely for noncommercial purposes (and at a different price than the price at which such data are made available for other purposes); and

(2) uses such data for other than noncommercial purposes.

(c) ENFORCEMENT MECHANISMS.—Enforcement mechanisms referred to in subsection (b) may include civil penalties of not more than $10,000 (per day per violation), denial of further unenhanced data purchasing privileges, and any other penalties or restrictions the Secretary considers necessary to ensure, to the greatest extent practicable, that unenhanced data provided for noncommercial purposes are not used to unfairly compete in the commercial market against private sector entities not eligible for data at the cost of fulfilling user requests.

(d) PROCEDURES AND REGULATIONS.—The Secretary shall issue any regulations necessary to carry out this section and shall establish standards and procedures governing the imposition of enforcement mechanisms under subsection (b). The standards and procedures shall include a procedure for potentially aggrieved parties to file formal protests with the Secretary alleging instances where such unenhanced data has been, or is being, used for commercial purposes in violation of the terms of receipt of such data. The Secretary shall promptly act to investigate any such protest, and shall report annually to the Congress on instances of such violations.

TITLE VI—PROHIBITION OF COMMERCIALIZATION OF WEATHER SATELLITES

SEC. 601. PROHIBITION.

Neither the President nor any other official of the Government shall make any effort to lease, sell, or transfer to the private sector, or commercialize, any portion of the weather satellite sys-
tems operated by the Department of Commerce or any successor agency.

SEC. 603. FUTURE CONSIDERATIONS.

Regardless of any change in circumstances subsequent to the enactment of this Act, even if such change makes it appear to be in the national interest to commercialize weather satellites, neither the President nor any official shall take any action prohibited by section 601 unless this title has first been repealed.

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