Part I: Introduction, Background, and Findings

This year **Congress** faces important decisions about the future course of the Landsat land remote sensing satellite program and the experiment with commercialization that began in 1984. A consensus is emerging within the government that Landsat 7 will be funded and managed by the public sector.[1] While giving greater assurance that Landsat data will continue to be available for scientists and other users of the&@ returning Landsat operations to the public sector creates a new set of problems.

Among these problems, the immediate question facing Congress is what policies to set for distributing and pricing Landsat data Existing distribution and pricing policies are governed by the Land Remote Sensing Commercialization Act of 1984 (Public Law 98-365) and a contract between the U.S. Government and the private firm EOSAT. This contract gives EOSAT the right to set prices on data from Landsats 1-6, but establishes no data rights for Landsat 7.

Two bills now before Congress, H.R. 3614[2] and S. 2297, would transfer responsibility for managing and funding the Landsat program, beginning with Landsat 7,[3] jointly to the Department of Defense (DoD) and the National Aeronautics and Space Administration(NASA) from the National Oceanic and Atmospheric Administration (NOAA). However, the two bills differ in how they would handle pricing issues. S. 2297 would price the sale of all Landsat data at the cost of fufilling the user's order. H.R. 3614 allows for a two-tier pricing system in which Federal Government users would be charged the cost of fulfiling an agency's order and for-profit firms would be charged market prices.

How the United States chooses to address the issues of pricing and distributing Landsat data will prove important not only for land remote sensing, but also for the immense amount of data that the Federal Government intends to gather about the atmosphere, land, and oceans using NASA's Earth Observing System.

Users of Landsat data expect the data to find increased use among government agencies for a variety of beneficial applications, including environmental monitoring, surface change detection and evaluation of resources. Many hope the data will also be the basis for a diverse and profitable U.S. industry, which enhances and sells data products to a range of users in the United States and abroad. Policies adopted to govern the pricing and distribution of Landsat data will affect:

- how much data are available, for which applications;
- how the ultimate costs of providing land remote sensing data are divided between the public and private sectors;
- how the public costs and benefits of remotely sensed data mre divided among federal agencies;
- the extent to which private firms using Landsat data benefit from the system
- the competitive prospects of foreign systems, and the term.s and conditions under which similar data produced by foreign systems are available to U.S. public and private sectors;
- the prospect of future U.S privatelyfinanced and operated systems intended to seine "niche" markets;
- the pace of technological improvement in geographic information systems and the character of new applications; and
- technological development of future Landsat-type . satellites.

This short background paper summarizes the discussion concerning data pricing and distribution from a one-day workshop convened by OTA on May 20, 1992. It does not discuss the broader policy issues regarding commercialization of land remote sensing and the benefits and drawbacks of the decision to assign responsibility for the operation of Landsat 7 to DoD and NASA.

The workshop, which included data users from government, universities, the private sector, and nongovernmental organizations, registered a notable degree of consensus about the future level of prices for data relative to existing prices: lower data prices would stimulate data use. At the same time, several workshop participants noted that compared to the costs of gathering the necessary data from other sources, Landsat data are a bargain. Participants reached much less agreement on the proposed two-tier system where for-profit buyers are charged a higher price than government users, Most workshop participants, however, agreed that existing law-which mandates that all earth imaging data gathered from orbit, from any U.S. source, public or private, must

[1] For a detailed summary of the events and issues related to the Landsat commercialization decision, see U.S. Congress, Office of Technology Assessment, *Remote Sensing and the Private Sector*, OTA-ISC-TM-20 (Washington, DC: *Us.* Gov ernment Printing Office, April 1984).

[2] Passed by the House of Representatives, June 9, 1992.

[3] According to Bush Administration plans, DoD would procure the satellite and NASA would manage its operation and data distribution. The two congressional bills would codify this arrangement.

Box A—A Land Remote Sensing Satellite System

A land remote sensing satellite system consists of five major components, each of which is critical to producing useful data

1. ***Sensors: Optical systems gather*** **light in various spectral** (color) bands from Earth's surface and focus it on photosensitive surfaces that convert the light to digital electrical impulses that can be transmitted to Earth electronically. Landsats ***4*** and 5 **collect light m seven spectral** bands, ranging from the blue to the infrared. The thematic mapper sensor is capable of distinguishing **objects as small as** 30 meters across. Landsat 6, which will be launched in 1993, will also carry a higher resolution sensor, able to distinguish objects only 15 meters across.
2. ***Spacecraft and Transmitters: The*** spacecraft provides a stabilized platform and power for the sensors and their optics, the receiving and transmitting antennas, and the associated electronics necessary to control the spacecraft and to deliver data to Earth Some remote sensing spacecraft may also carry tape recorders to store data until the spacecraft is within sight of a receiving station.
3. ***Receiving Station and Other Communication Components:*** A ground station may receive data in digital form directly from the satellite as it passes overhead, or, if the satellite is not in a position to communicate with the ground **station,** through a **system** equivalent to NASA's Tracking and Data Relay Satellite System (TDRSS). In the latter case, data arc passed from the remote sensing satellite to a communication satellite m geosynchronous orbit and then retransmitted to a ground facility. From the ground facility, the data arc then passed directly to a processing laboratory.
4. ***Data Processing Facilities:*** Before the raw data can be converted into photographic images or computer tapes capable of being analyzed by the end user, they must be processed to remove geometric and other distortions inevitably introduced by the sensors. Data that have only had these distortions removed are generally referred to as unenhanced data. For remote sensing applications, large amounts of data manipulation are usually required
5. ***Interpretation of the Data: After the unenhanced data are processed*** and converted to computer tapes or photographs, they must be interpreted to provide information for the end user. Part of the interpretation process may involve merging or layering sets of data, usually done with computer image processing programs. A variety of advanced techniques are available to turn remotely sensed data into new products for different users.

SOURCE: U.S. **Congress, Office** of Technology **Assessment,** 1992.

be sold on a nondiscriminatory basis[4]--could be liberalized to allow private satellite system owners to set their **own price structures. They also** generally agreed that means should be found to make Landsat data available more cheaply to the academic community, which will use the data to conduct scientific research or to train students in data techniques.

This paper is the first publication of an assessment of Earth observation systems requested by the House Committee on Science, Space, and Technology; the Senate Committee on Commerce, science, and Transportation; the House and Senate Appropriations Subcommittees on Veterans Affairs, Housing and Urban Develop ment, and Independent Agencies; and the House Permanent Select Committee on Intelligence. OTA will issue a detailed report on data issues in 1993.

BACKGROUND

The united States initiated the Landsat program in 1969 as a research activity. NASA launched Landsat 1 in 1972.[5] Data from the Landsat system (box A) soon proved capable of serving a wide variety of government and private sector needs for spatial information about the land surface and coastal areas (table 1). NASA designed, built, and operated Landsats 1-3. The perceived potential economic value of Landsat imagery led the Carter Administration to consider commercial operation of the system During the late 1970s it began a process of transferring control of Landsat operations and data distribution from NASA to the private sector. The first step in the transition gave operational control of the Landsat system to NOAA in 1981, because of NOAA's extensive experience in operating remote sensing satellites for weather and climate observations. Landsat 4 was

4 "The term "nonrotatory basis" means Without **preference, bias,** or any other **special** arrangement. . . **regarding delivery, format, financing,** or **technical considerations which** would favor one buyer or class of buyers over **another**." Public **Law** *98-365,* **Sec. 104** (3)(A)—(15 USC 4204).

5 **Initially** called the Earth Resources Technology **Satellite,** NASA changed its name to **Landsat** in 1975.

6 **Landsats 4** and 5 were **designed and built by** NASA but operated by NOAA.

Table l-Summary of Landsat Applications

A. Agriculture	**D. Fish and wildlife**	**F. Water resources**
Crop inventory	Wildlife habitat inventory	Planning and management
Irrigated crop inventory	Wetlands location, monitoring, and analysis	Surface water inventory
Noxious weeds assessment	Vegetation classification	Flood control and damage assessment
Crop yield prediction	Precipitation/snow pack monitoring	Snow/lee cover monitoring
Grove surveys	salt exposure	irrigation demand estimates
Assessment of flood damage	**E. Environmental management**	Monitor runoff and pollutlon
Disease/drought monitoring	Water quality assessment and planning	Water circulation, turbidity, and sediment
B. Forestry and rangeland	Environmental and pollution analysis	Lake eutrophication survey
Productivity assessment	Coastal zone management	Soil salinity
Identification of crops, timber and range	Surface mine inventory and monitoring	Ground water Location
Forest habitat assessment	Wetlands mapping	**G Geological mapping**
Wildlife range assessment	Lake water quality	Lineament mapping
Fire potential/damage assessment	Shoreline delineation	Mapping/identification of rock types
C. Land resource management	Oil and gas iease sales	Mineral surveys
Land cover inventory	Resource inventory	Siting/surveying for public/private facilities
Comprehensive planning	Dredge and fill permits	Radioactive waste storage
Corridor analysis	Marsh salinization	**H. Land use and planning**
Facility siting		Growth trends and analysis
Flood plain delineation		Land use planning
Solid waste management		Cartography
Lake shore management		Assess land capabilities

SOURCE: Office of Technology Assessment, 1992.

launched in 1982; Landsat 5[6] became operational in 1984.[7]

In late 1983, the Reagan Administration took steps to transfer Landsat **4 and 5 operations to private hands** because it did not want to continue public funding for the system. A few proponents of commercialization expected that industry could soon build a sufficient data market to support a land remote sensing system.[8] Soon thereafter, Congress began consideration of the Land Remote Sensing Commercialization Act of 1984, which was intended to provide legislative authority for the transfer process. Public Law 98-365 was signed into law on July 17, 1984. During deliberations over the Landsat Act, the Administration issued a request for proposal (RFP) for industry to operate Landsat and any follow-on satellite system. After competitive bidding,[9] NOAA transferred control of operations and marketing of data to EOSAT in 1985.[10] At present, EOSAT operates Landsats **4** and **5 under contract to the Department** of Commerce,[11] and manages distribution and sales of data from Landsats 1-5. EOSAT will operate Landsat 6 at its expense.[12]

Although EOSAT and its primary competitor,[13] SPOT Image, S.& which markets data from the French (SPOT) satellite system have developed a market for unenhanced data[14] by the late 1980s, EOSAT'S yearly sales income was apparently not suffficient to enable it to finance future satellites. Although the Federal Government has provided most of the funding for Landsat 6, and had initially agreed to subsidize a substantial portion of Landsat 7, in the late 1980s it withdrew its support for Landsat 7. The Landsat program was in danger of failing.

Hence, in 1991 Congress, the National Space Council, NASA, NOAA, and DoD reviewed their options for continuing the LandSat program. Policymakers reached

6 Landsats 4 and 5 were designed and built by NASA but operated by NOAA.

8 However, moat analysts were extremely pessimistic about such prospects. See Us. Congress, Congressional Budget Office, *Encouraging Private Investment in Space Activities* (Washington, DC: Us. Government Printing Office, Feb. 1991), ch. 3.

9 Seven firms responded to the RFP, from which two were selected for further negotiations—EOSAT and Kodak/Fairchild. After a series of negotiations, during which the government changed the ground rules of the RFP, Kodak dropped out, leaving EOSAT to negotiate with the Department of Commerce.

10 EOSAT was established as a joint venture by RCA (now part of GE) and Hughes Aircraft (now part of General Motors) for this purpose.

11 Subsystems in both satellites have failed, but together they function as a nearly complete satellite system. EOSAT has taken great care to nurse these tWO satellites along, in order to maintain continuity Of data delivery until Landsat 6 is operational.

12 Landsat 6 is scheduled for launch in 1993.

13 Although for some applications EOSAT and SPOT Image, S.A., compete for customers, the data they sell are sufficiently different that they serve different customer needs. For some applications, for example, where both high spatial resolution (SPOT's strength) and high spectral resolution (Landsat's strength) arc needed, customers use both to produce a find image containing much more information than either alone can display.

14 Unenhanced data have been subjected only to the spectral and geometric correcti Ons necessary to use them.

the conclusion that maintaining continuity[15] of the Landsat program important to the national interest.[16] They also wished to provide in some form for the **continued commercialization** of land remote sensing from space. The argument for continuing to acquire Landsat-type data for use by government agencies was strengthened by the observation that these data could be a major contributor to understanding and monitoring the effects of global change.[17] For this application, especially, continuity of the data stream is very important. The usefulness of the Landsat program received further impetus from the Persian Gulf War, when DoD made extensive use of Landsat and SPOT imagery to create maps of the region to support operations by the U.S.-led multinational force.[18] Afterward, LandSat and SPOT images were **used to evaluate the environmental consequences of the War.**[19] Thc rapid growth of the geographic information systems (GIS) industry supports continuation of the Landsat program because these systems have facilitated growth of the value-added industry (firms that process and add interpretive information to Landsat data). The ease with which it is possible to incorporate other spatial information with remotely sensed data[20] has led to a broadly diversified market for these data and has significantly increased their market potential

The government has three broad options for continuing to provide data compatible with data collected by Landsats 1-5, each of which has numerous possible variations of detail. It could:

1. ***Release an RFP requiring the provision of data of specified character, quality, and amount over a specified number of years, leaving the satellite system design, ownership, and operation to private industry.*** Under this option, the government would purchase data for its needs as a commodity, much like the arrangement NASA has with Orbital Sciences Corporation (OSC) for the purchase of ocean color data from the SeaWiFS sensor aboard the SeaStar satellite.[21] The selected firm would then be free to offer data to other customers on mutually agreeable terms.
2. ***Release an RFP requiring the provision of a satellite system for government operation with specifications designed to meet specified data requirements.*** Under this arrangement, the government would reclaim responsibility for providing a satellite system and operating it.
3. ***Release an RFP requiring the provision of a satellite system designed to meet the government's data requirements. Release a second RFP for a private firm to operate the government's system. This*** arrangement is similar to the current one with EOSAT.

Each of these arrangements has benefits and drawbacks relating to cost, technical risks, potential for furthering the commercialization of data acquired from space, and amount of government involvement and control. The Administration, with the support of Congress, has chosen the second option, in part because it seemed to promise the least risk for maintaining continuity of the provision of data compatible with previously acquired LandSat data. It is not necessarily the choice that would promise the greatest involvement of private industry, except as providers of the satellite system under contract to the U.S. Government Discussion and analysis of the benefits and drawbacks of these options is well beyond the scope of this background paper, however, the choice of Option 2 for providing Landsat-type data necessitates a decision regarding data pricing and distribution policies. Option 1, in contrast, would not; with the exception of the contract price for delivery to government, pricing of data would be determinedly the market This background paper takes as a given that the government will proceed with a variant of Option 2 If it were to choose a different option, for example, for a future LandSat 8, other data pricing and distribution policies would likely be possible.

In addition to the large user community within the federal government, the number of existing and potential users of remotely sensed data is also large: farmers planting or besting crops, cities and states monitoring "

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15 As the House Committee *on* Science, Space, and Technology Report to accompany H.R. 3614 points out (pp. 32-3), the tam 'continui ty" can be used in at least three different ways: 1) continuity of the Landsat program 2) continuity of the data stream from the Landsat satellites, and 3) continuity of data format, scale, and spectral response. The latter is especially important to earth scientists attempting to study global change.

16 The Committee has decided that one of the bill's principal goals should be to "enhance the use of Landsat data for public - applications." Report of the House Committee on Science, Space, and Technology to accompany H.R. 3614, May 28, 1992, p. 43.

17 J. Roughgarden, et al., "What Does Remote Sensing Do for Ecology?" *Ecology*, vol. 72, No. 6, 1991, pp. 1918-21; U.S. Executive Office of the President, Office of Science and Technology Policy, Committee on Earth Sciences. Our *Changing Planet: A U.S. Strategy for Global Change Research. A Report by the Committee on Earth Sciences to Accompany the U.S. President's Fiscal Year 1990 Budget* (Washington, DC: Office of Science and Technology Policy, 1989).

18 OTA discussions with Defense Mapping Agency personnel; see also Ian Parker, "Spacecraft in the Balance." *Space*, April-May 1S92, pp. 35-37.

19 National Geographic *Society, Committee* for Research and Exploration, "Environmental Consequences of the Gulf War: 19901991," *Research and Exploration*, Vol. 7 *(special issue)*, 1991.

20 Such as maps delineating ownership boundaries and data on soils, hydrology, and ecology.

21 under this arrangement, OSC agreed to provide data of specified quality, format, and spatial and spectral coverage for a specified price, which allowed the firm to secure additional private financing.

water tables or planning sewage treatment, environmental firms monitoring land use. Even McDonald's Corp. uses Landsat data to study suburban growth to find locations for new franchises. Private firms have created a growing market for information created from Landsat and other data by enhancing images for specific users.

Finally, land remote sensing has become an international activity. During the lifetimes of Landsats 6 and 7, foreign earth observing systems, including Canada's Radarsat, France's SPOT, the European Space Agency's ERS-1, Japan's JERS-1, and Russia's ALMAZ are expected to contribute to a growing global market for remotely sensed earth images collected from space (table 2). Hence, while these systems, which provide data from different regions of the electromagnetic spectrum at different spatial resolutions, broaden the overall market for remotely sensed data they also provide increased international competition to the United States in an arena it once monopolized.[22]

FINDINGS

Finding 1: Landsat data may generate sufficient public benefit to justify continuation of the program even if costs **of design, construction, and launch of the spacecraft are not recovered by the " revenues generated by data sales.**

It was clear from the workshop that the social value of Landsat data is potentially immense:[23] they can be used for a number of socially beneficial applications, from management of domestic resources to plannin g for sustainable development. The pricing policy selected should thus include as a goal, fostering the social benefits provided by applications of the data while also nurturing the growth of a U.S.-based, value-added industry.

Finding 2: The prices charged **for imagery collected from space are pivotal in deciding who will have access to this information source and on what** terms. Therefore, **data pricing policy is a key factor in how widely remotely sensed data are applied by the public and private sectors.**

The Landsat system is a publicly funded U.S. monopoly with benefits that seine both public and private interests. Under existing policy, codified in the Landsat Act of 1984 (P.L. 98-365), data from the Landsat system are sold by the system operator (EOSAT). The system operator sets data prices, which are intended to enable an operating company to earn a profit after subtracting system operating, marketing, and distribution costs from gross sales. By mandating nondiscriminatory access to Landsat data the Landsat Act of 1984 essentially mandated a single price for the same data for all Landsat data customers. Experts disagree on what kind of pricing policy is fair and will best nurture the industry's growth while serving the government's needs. However, they generally agree that if the public sector pays for satellites and their operation, government and many not-for-profit users should pay much lower prices than currently charged.

Some argue for a two-tier, or more generally a multiple-tier, pricing structure that makes data available for federal government use at the cost of fulfilling a user request, and allows the data distributor to charge market rates to all other users. H.R. 3614 permits, but does not mandate, **a two-tier pricing structure** (appendix A).[24]

A two-tier pricing structure might also make it possible to reach agreement with EOSAT over changes to the existing contract between the Federal Government and EOSAT. H.R 3614 requires the Landsat Program Management (DoD and NASA) to negotiate with EOSAT to secure modified terms for pricing, distribution, acquisition, archiving, and access to data from Landsats 1-6. In particular, it instructs the Landsat program Management to seek agreement that EOSAT would provide unenhanced data to "the United States and its affiliated users at the cost of fulfilling user requests, on the condition that such data is used solely for noncommercial purposes.

Most researchers and some value-added firms contend that data should be sold at the cost of fulfilling the order. They argue that such a price structure would allow broader use of the data, and uphold a principle that these data, acquired by government satellite systems and paid for through taxes, are a public good. S. 2297, which is under consideration by the Senate, generally adopts this view.[25]

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22 U.S. Congress, Office of Technology Assessment, *International Cooperation and Competition in Civilian Space Activities,* OTA-ISC-239 (Washington, DC: Us. Government Printing Office, July 1985), ch. 7.

23 A Congressional Budget Office assessment, in examining policy options for encouraging private investment in remote sensing, suggests an examination of the social value of Landsat is appropriate before evaluating the role of government in funding such satellites. See Congressional Budget office, op. cit., footnote *8.*

24 "The Congress *finds that--to* increase the *value* of the Landsat program to the American Public, Landsat data should be made available to United states Government agencies, to global change researchers, and to other researchers who arc financially supported by the united states Government, at the cost of fulfilling user requests. ' '—Sec. *2.* (12) Findings.

25 "The Congress f@ and declares that—to maximize the value of Federal satellite land remote sensing programs to the American public, data generated from all land remote sensing satellites funded by the United States Government should be made available to users at prices that do not exceed the marginal cost of filling a specific user request. ' S. *2297,* "Land Remote Sensing Policy Act of 1992," Sec. 101 (8).

Table 2-Operational and Proposed Earth Remote Sensing Satellites

satellite	LANDSAT 5	LANDSAT 6	SPOT 3-4	MOS 1,16	JERS-1	ALMAZ-1	ERS 1-2'	RADARSAT
Owner	Us.	Us.	France	Japan	Japan	Russia	ESA	Canada
Repeat Coverage	18 days	18 days	26 days	17 days	41 days	1-3 days	3 days	16 days
Launch Date	1905	1993	(3) 1994, (4) 1998	1967; 1990	1992	1991	1991, 1994	1995
Blue								
Spectral Coverage (microns)	.45-.52	.45-.52						
Resolution	30 m	30 m	NA	NA	NA	NA	NA	NA
Swath Width	185 km	185 km						
Green								
Spectral Coverage	.52-.6	.52-.6	.5-.59	.5-.59;.5-.7	.52-.56			
Resolution	30 m	30 m	20 m	50 m ; 9 m	18 m x 24 m	NA	NA	NA
Swath Width	185 km	185 km	60 km	100 km; 1500 km	75 km			
Red								
Spectral Coverage	.63-.89	.63-.89	.61-.68	.61-.69	.63-.69			
Resolution	30 m	30 m	5 m SPOT	50 m	18 m x 24 m	NA	NA	NA
Swath Width	185 km	185 km	60 km	100 km	75 km			
Near-Infrared								
Spectral Coverage	.76-.9	.76-.9	.79-.89	.73-1.1	.76 x .86			
Resolution	30 m	30 m	20 m	50 m	18 m x 24 m	NA	NA	NA
Swath Width	185 km	185 km	60 km	100 km	75 km			
Mid-Infrared								
Spectral Coverage	1.55-1.75/ 2.08-2.35	1.55-1.75/ 2.08-2.35	1.58-1.75	NA	I.6-I.71/2.01-2.4	NA	1.6	NA
Resolution	30 m	30 m	20 m		18 m x 24 m		1 km	
Swath Width	185 km	185 km	60 km		75 km		500 km	
Thermal Infrared								
Spectral Coverage	10.4-12.5	10.4-12.5		6.0-7 .010.5-12.5			3.7/11-12	
Resolution	120 m	120 m	NA	2.7 km	NA	NA	1 km	NA
Swath Width	185 km	185 km		IWO km			500 km	
Microwave								
Frequency				23 GHz/31 GHz	1275 GHz	3 GHz/37 GHz	5.3 GHz/23.8-36.5 GHz	5.3 GHz
Resolution	NA	NA	NA	23 km	18m x 18m	15-30 m	30 m-50 km 20 m	2.5 m
Swath Width				320 km	75 km	20 x 240 km	100 km-500 km	
Panchromatic								
Resolution		15 m	10 m					
Swath Width	NA	185 km	60 km	NA	NA	NA	NA	NA

a 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.

SOURCE: NASA, MaPeat Market Review, 1992; *World Space Industry Survey, 10-year Outlook*, Euroconsult, 1991.

Although the workshop reached no consensus regarding which policy would best serve the public interest, the discussion did lead to the following insights:

- Most workshop participants agreed that lower prices would result in wider use of data.[26] A single low price might encourage market growth, especially among users already familiar with the applications of Landsat imagery. A low price would be unlikely to reduce costs associated with the collection, processing, distribution, maintenance, and archiving of data.[27]
- Two-tier pricing would allow for smaller overall losses (some cost recovery) by charging profit-making enterprises prices that reflect the cost of operating the system. It would thus spur the government to continue the the experiement in commercialization by supporting the development of a commercial market for unenhanced data.
- Two-tier pricing would allow for greater cost recovery in the face of small or diminished demand. However, it might depress demand compared to low, single-tier prices.
- Two-tier pricing could be harder to administer and difficult to enforce because it would discriminate on the basis of client type rather than service or product. As an example of the difficulty of enforcement, some researchers in universities or nonprofit organizations who might be entitled to lower prices for data used in research also consult for commercial interests. Similarly, some for-profit, value-added firms frequently work under contract with federal state, and local governments. Firms may also conduct rerearch, the results of which are published in publicly available journals.

Under current Administration plans, data from LandSat **7 will be** publicly owned data the distribution of which will be governed by OMB Circular A-130. This circular sets pricing for other Federal Government data products such as census data, economic statistics, and government-created software (appendix B) "so as to recover costs of disseminating the products or services through user charges. " Circular A-130 is flexible enough to allow for two-tier pricing.

Finding 3: **Changing the existing policy of nondiscriminatory access** to **data from** *privately funded* **satellite systems to a policy that allows owners to determine their own pricing policies may encourage growth of private satellite systems. However, in view of the continued importance of the "open skies" principle to the** U.S. use **of space *and to* foreign policy, nondiscriminatory access to data from** *publicly funded* **satellite systems should be retained.**

Existing law requires that all data from all U.S. land remote sensing systems be sold to all purchasers, U.S. or foreign, on a nondiscriminatory basis, in part to allay fears among some countries that other countries would seek to use these superior information sources to gain economic advantage.[28] Some U.S. data users also express concern that allowing companies to follow sales policies giving exclusive access to data might trigger retaliatory restrictions on important data acquired from space by other countries.

Nevertheless, proponents of private remote sensing systems have complained that this policy impedes entry of privately financed U.S. remote sensing systems into the market for unenhanced data. For example, potential private satellite systems could, perhaps, fill a market niche for specialized products. However, if the system owners were prevented from charging higher prices for, say, mom timely or even exclusive access to data, they would lose their market advantage and their ability to service the market niche.

Proponents of private systems suggest that as the number of international sources of earth-imaging data grow, the fears of countries concerning exclusive access and resource exploitation would likely diminish. Indeed many argue that global competition in remotely sensed data is already sufficient to allow the United States to relax previous restrictions. Hence, in order to encourage operation of private remote sensing systems, recent Administration proposals, H.R 3614, and S. 2297 would allow pricing and access discrimination for data acquired by *privately funded* systems. All however, would retain the nondiscriminatory policy for Landsat 7 and other *publicly funded* systems on grounds that the policy supports the full and open exchange of information that has been a cornerstone of U.S. policy for space and international environmental research.[29]

The opportunity to use Landsat imagery to help developing countries manage their own resources is an important opportunity for the United States in the post-Cold War world. Continued provision of Landsat imagery by the U.S. government for the development of local and regional economies could also help undercut

[26] This finding, based on data purchase information provided by value-added companies, is corroborated by sales data from EOSAT and the U.S. Geological Survey, EROS Data Center, Annual Report of Landsat Sales for Fiscal Year 1986 (1987).

[27] Congressional Budget Office, op. cit., footnote 8, p. 69.

[28] Office of Technology Assessment, op. cit. footnote 1, ch. 3, for a discussion of the foreign policy implications of a discriminatory data policy.

[29] The importance of this policy has been recently underscored by Science Adviser D. Alan Bromley.

criticism of any move to allow discriminatory data distribution for privately funded satellite systems.

Finding 4: The experiment to commercialize the Landsat system has been only partially successful EOSAT has streamlined the operations and data distribution system, and achieved sufficient income to support its efforts without government support. However, revenues from data sales do not appear sufficient to enable a system operator to finance the entire Landsat system for many years.

when the Landsat Commercialization Act of 1984 was passed proponents argued that the best **way to create a strong market** for remotely sensed data was to transfer the operation of the Landsat system and the marketing function to the private sector. At recent congressional hearings some members of **Congress have called com**mercialization a failure.[30]

EOSAT has apparently lowered the costs of collecting data from the satellite and putting scenes into usable form.[31] Yet EOSAT has been faced with operating and marketing data from a system that was designed to meet government requirements rather than the marketplace. Hence this experiment does ***not*** provide the most effective test of the Commercial prospects for unenhanced remotely sensed data *What the **United States has tested since EOSAT'S formation is not whether private management can work in general, but whether a private system operator with a single pricing policy is anymore effective than the public system operator that predated EOSAT.***

Landsat 6 will **cost the U.S. Government about** $220 million data sales, even ***if all*** **customers were charged the single** price of $4,400 per digital Thematic Mapper (TM)[32] image, would not reccover these costs over ***5*** **years** of operation. DoD and NASA have estimated that procuring, launchings and operating Landsat 7 for 5 years, and constructing a large, new data processing facility, will cost about $880 million.[33] However, if the costs of a different satellite system could be reduced sufficiently, a private firm might be able to establish a viable business selling unenhanced data.[34] A few firms, for example, have developed preliminary designs for small lightweight satellites that show promise in eventually reducing the costs of the system?[35] Some experts nevertheless remain doubtful that even with the likely future **system cost reductions, sufficient market for** unenhanced data would develop to support a commercial satellite system within the next decade.[36]

Finding 5: The pricing and distribution policies arrived at now for U.S. earth-sensing activity will set precedents for NASA's planned Earth Observing System (EOS).

Although the-decision before this Congress concerns the pricing and distribution policy for Landsats 1-6 and Landsat 7, the debate over LandSat data has parallels for other publicly funded remote seining systems that will generate data with economic value. EOS sensors are experimental and will require considerable effort to evaluate before the full commercial potential of the data can be assessed yet several of these sensors will collect data having economic potential (table 3).[37] The pricing policies for EOS and Landsat should be consistent, since the data will be used by many of the same institutions and the issues of public versus private good are the same in both cases.

Finding 6: Stability and continuity in the acquisition of data over time and enhanced customer access to data will contribute to the further development of the data market.. Aggressive, innovative marketing will also be important.

Commercial and other users, in order to plan for the orderly development of their businesses or long-term research, need to know that the satellite system will provide continuous data for a specified period of time. Researchers, particularly those interested in global change, need data sets that are consistent, can be cross referenced and reflect repeated observations of various phenomena (e.g., land change) over time. Failure to provide such data sets will be detrimental to our understanding of global change and to other environmental research It will also be detrimental to the

30 Statements *of* Senators Gore and Pressler, Senate Committee on commerce, Science, and Transportation, Subcommittee on Science, Technology and Space, Hearing on S. 229'7, the Land Remote Sensing Policy Act of 1992, May 6,1992. Also see testimony of David Thibault, John R. Jensen, and Charlotte Black Elk at the same hearing.

31 Congressional Budget Office, op. at-, footnote 8.

32 = - instrument on the Landsat satellite. It carries seven spectral bands with aground resolution of 30 meters (except for the thermal infrared ban& which possesses a resolution of 120 meters). On Landsat 6, the Enhanced Thematic Mapper will also collect data in a p anchromatic baud of 15 meters.

33 Management Plan for the Landsat Program, Mar. *20,* 1992, Attachment 1.

34 See KPMG Peat Marwick, *Mapsat Market Review* (Stennis Space *Center, Mississippi:* ITD/Space Remote Sensing center, 1992), for a detailed review of the market potential for remotely sensed data suitable for gemming maps, as well as the characteristics of foreign remote sensing systems.

35 A future report in this assessment will address the benefits and drawbacks of using innovative, small remote sensing satellites.

36 Comments of several reviewers on the first draft.

37 For example, ASTER (provided by Japan), SeaWiFS, and MODIS.

Table 3--Potential Commercial Applications for Selected and Proposed EOS Instruments

	Potential Commercial use
Selected EOS Instruments	
ASTER (High Resolution Visible)	Mineral/petroleum exploration
AIRS (Infrared Sounder)	Commercial weather forecasting
AMSV (Microwave Radiometers)	Commercial weather forecasting
MODIS-N (Imaging Spectrometer)	Fisheries, ocean production
STICKSCAT (Scatterometer)	Maritime forecasts, maritime industry
SEAWIFS (Ocean Color Sensor)	Shipping industry Fishing, other maritime industries
Proposed EOS Instruments	
EOS SAR	Soil moisture, canopy monitoring, ice measurement, mapping
HIRIS (Imaging Spectrometer)	Environmental surveys, oil/gas/mineral industries

SOURCE: Office of Technology Assessment and Susan L. Ustin, et. al., "Opportunities for Using the EOS Imaging Spectrometers and Synthetic Aperture Radar in Ecological Models," *Ecology*, 72 (6), 1991, p. 1935.

continued development of the U.S. value-added industry. Previous, inconsistent support for Landsat has hurt market development.

Those entrusted with marketing unenhanced remotely sensed data have an important role in defining new applications and products. SPOT Image corporation, for example, has developed an entire series of image maps and 'theme" maps that have proved popular with certain customers .38 The entry of SPOT Image into the marketplace has helped to stimulate the overall market for remotely sensed data. EOSAT now offers TM digital data on small 8 mm ''Exabyte' cartridges, which promise to make the storage and handling of Landsat data more efficient.

Finding 7: A worldwide, "value-added" industry, closely tied to the application of geographic information systems (GIS), is now evolving, offering enhanced imagery and other information products for specific users and applications.

The value-added, geographic information services industry may top **$2** billion in yearly sales by 1993.[39] Unlike 1985, when EOSAT was formed the United States appears to be on the verge of having a U.S.-based, internationally competitive GIS industry, supported in part by remotely sensed data aquired from space. This is a result of the simultaneous growth of GIS sales and computing technologies. These technologies have the unique **advantage** of being able to handle data in many different formats and integrate them into usable files. Products include maps, inventories of crops, forests, and other renewable resources, and assessments of urban growth, cultural resources and nonrenewable resources. The growth of the GIS industry will be aided by the extensive archives of unenhanced Landsat data, which now includes some 210,000 multispectral TM scenes (maintained at the U.S.G.S. EROS Data Center, Sioux Falls, SD).

It is important to differentiate between sales of value-added information and unenhanced data. Because value-added firms can add so much extra value to imagery, the former will **always** outstrip the latter in terms of gross sales and tax revenues returned to the U.S. treasury, just as the return from applications of commercial communications satellites far outstrips the market for the satellites themselves.[40] Hence, if the value-added industry grows sufficiently strong, the return of indirect revenues in the form of taxes could outsweigh the direct return of income from unenhanced data sales.

A key factor driving the evolution of the market is the importance of timely data to many different users, such as farmers making weekly decisions on when to plant crops. Another key factor is the evolution of technology, in which the price of hardware and software for manipulating earth-sensing data has dropped dramatically so that small groups and even private individuals can use it. The

38 KPMG Peat Marwick, op. cit., footnote 34, p. 11.

39 These figures include all GIS applications, not only those that use ''GIS-only'' data from space. See Markets and Opportunities, 1991, Daratech, Cambridge, MA, 1991.

40 Note, however, that communications satellites became commercially viable rather quickly because they were introduced into a vibrant international telecommunications market.

small user, whether a New **England coastal environmental** institute[41] or a southwestern Indian tribe concerned with forest management,[42] represents an enormous potential market, which is now largely untapped Value-added firms are well positioned to reach this market.

Finding 8: Congress may wish to consider alternative means of commercializing the space remote sensing industry.

Some workshop participants suggested alternative means of commercialization to the present operating structure, which, they said, could build on the lessons of the EOSAT experiment. They argue that while EOS~ has thus far not succeeded in commercialization as envisioned in the mid-1980s, other approaches to commercialization may work such as offering incentives to cut costs and finding ways to be more responsive to users. Pricing policy will nevertheless be a key determinant of failure or success.

In the future, for a Landsat 8, for example, the government may wish to promote the commercialization of land remote sensing by adopting Option 1 of the previous section in which the government issues an RFP asking for the provision of specified quantities of remotely sensed land data Some participants worried that the present plan to put **NASA back in charge of managing data distribution from Landsat 7 may** halt the **trend** towards commercialization and hinder the growth of this new industry. Others felt that any emphasis on the commercialization of unenhanced data was misplaced that the **value-added sector was the most important Commercial area to protect.**

Finally, a few workshop participants questioned the fundamental concept of turning over publicly funded assets to a single private operator and giving it exclusive rights to distribute publicly funded data. One participant suggested that the government might consider allowing several private firms to collect unenhanced data and sell a variety of products from them in much the same way that the weather satellites now distribute unenhanced data to a variety of firms that add value to the data

Finding 9: Academic institutions can play an important role in broadening the market for remotely sensed data by developing new applications and by training graduates who will make careers using the data in government private industry, nonprofit groups, and international institutions.

Participants agreed that the U.S. academic research community has the potential to uncover new uses for remotely sensed data[43] Some suggested that to facilitate academic use of LandSat images, the government could set prices of present and/or archived data at the cost of fulfilling a user's order, or subsidize purchases by giving researchers data grants to support purchases at the "market price."[44] For many academic users, archived data could be sufficient for research and to train graduate students, because these uses generally do not require time-critical data[45]

41 Richard Podolsky and Philip Conkling, "Satellite Imagery Aids Analysis of Rare Coastal Ecosystems," *Geo Info Systems*, VOL 2, No. 8, June 1992, pp. 56-59.

42 R@ Fule and Scott Bradshaw, "Wildfire Management for New Mexico's Native American Lands," Geo *Info Systems*, vol. 2, No. 8, June 1992, pp. *3443.*

43 Private firms also assist in developing new applications. In addition, some publish research results in the open literature. one reviewer suggested that private firms should also receive discounts for conducting bona fide research.

44 Recently, EOSAT offered to extend qualified researchers about $1 million in data grants to facilitate purchases of thematic mapper data.

45 One reviewer suggested, however, that because the universities do a lot of vahn?-added work on Landsat data, they should not be allowed to acquire current da@ which would give them a competitive advantage over private firms.