Remotely Sensed Data From Space: Distribution, Pricing, and Applications

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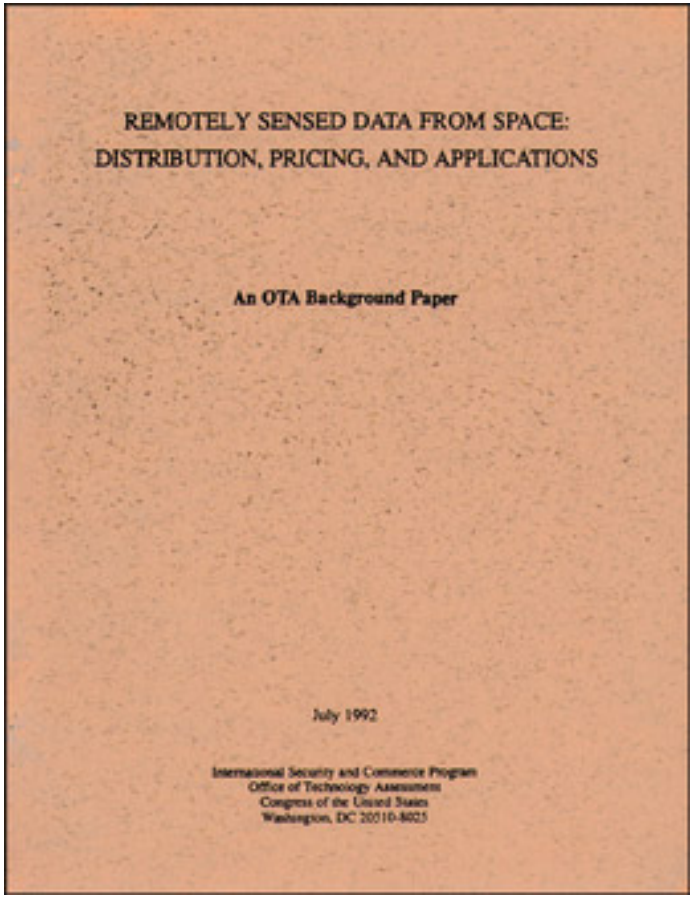

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Part I: Introduction, Background, and Findings

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 ' ' n o * - q tory 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'' sensors from space. Daratech, Cambridge, MA, 1991. Markets and Opportunities, 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.

Part II: Workshop Summary

WORKSHOP SUMMARY

Participant's comments revolved around five major topics affecting data pricing and distribution:

(1) Federal government needs and low, cost-of-service pricing;

(2) The relationship between LandSat commercialization and two-tier, or multiple-tier, pricing;

(3) The chances for developing an internationally competitive U.S.-based industry in space-based earth imaging; and

(4) Foreign policy, and price and distribution policies to support "open-skies" policy.

(5) Academic research and instructional needs.

1. Federal Government Needs and Low, Cost-of-Service Pricing

The Federal Government considers the provision of earth imagery an important public service. Since NASA launched the first Landsat satellite in 1972, users have applied its data to a wide variety of problems, including natural and cultural resource management, agriculture, land use planning, mapping, and resource exploitation (table 1). In the 1970s and early 1980s, U.S. users received data either directly from the satellite at no cost or at very low cost from NASA or the USGS EROS Data Center.[46] NASA charged foreign ground stations an access fee of $200,000 per year to collect data directly from the satellite as it passed over.[47]

In 1982, because of the commercialization process, NOAA began to raise prices of Landsat data in anticipation of a transfer to the private sector. By 1985, it was charging users $4,400 (in 1985 dollars) per digital Thematic Mapper (TM) scene (up from $2,000 in 1982); this was NOAA's estimate of the market price of the data. When EOSAT assumed control of data sales in 1985, it initially lowered the price for a TM scene to $3,300, but over time has raised the price again to $4,400 (in 1992 dollars) to keep up with its costs of operations.

A wide variety of users have complained since data prices were raised arguing that higher prices inhibit use of the data for research and other activities supporting the public good.[48] The government's case for low prices for data from Landsats 6 and 7 is strengthened by increasing evidence of global change. Scientists will need a large number of Landsat scenes to track the various elements of global change; the existing price structure would make assembling those data sets extremely expensive, over and above paying for the satellite system in orbit. Use of data from both Landsat 6 and 7 would be a key element of any U.S. government plan to assert international leadership on global environmental issues. Currently "we have no institution taking its global change responsibilities seriously" said one participant. However, if the "federal establishment steps up to its responsibilities, " Landsat data--distributed to international organizations and Cooperating foreign government~would be a major part of the effort.

DoD shares an interest with NASA and other federal agencies in the lowest-possible data prices. Its experience in using Landsat (and SPOT) data in the Persian Gulf War convinced DoD that Landsat was an important unclassified military resource.[49] As Defense Intelligence Agency official Brian Gordon noted in a 1991 Congressional Hearing:

> Certainly DoD would be using Landsat and Spot [imagery]. We recognize that it's very important to get a wide area of coverage over our areas of interest, and we'll use everything we can get our hands on--any and all imagery data-because of the very, very strong technical tradeoffs between resolution and a broad area of Coverage.[50]

Landsat's usefulness for national security purposes seems to argue for distribution of Landsat data to the military at a low price as a public good.

Entities other than federal agencies also argue for low data prices. Since the discovery of the Antarctic ozone hole in 1987, there has been a marked growth in demand for remotely sensed data that bear on aspects of global

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46 Prior to 1982, when Landsat 4 became operational, the o@ data available were multispectral sensor (MSS) images, which have a resolution of 80 meters.

47 EOSAT now charges a fee Of $600,000 per terminal.

48 See us. congress, House of Representatives, *The Landsat Program: Management, Funding, and Policy Decisions, Hearing* before the Committee on Science, Space, and Technology, Nov. 26, 1991, Sect. IV: "Solicited Comments on H.R. 3614; U.S. congress, Senate, Hearing before the Senate Committee on Commerce, Science, and Transportation May 6, 1992.

49 DoD spent $5.$6 million on Landsat and SPOT imagery for the Persian Gulf War.

50 Brian Gordon, statement in ''Sci~~lc, Military, and Commercial Applications Of the Landsat Program,'' a Joint Hearing before the Committee on Science, Space, and Technology, and the Permanent Select Committee on Intelligence of the U.S. House of Representatives, June 26, 1991 (Washington, DC: U.S. Government Priming Office, 1991), p. 28.

change. These include requests from foreign government agencies and public interest nonprofit groups, both of which contend they should have the data at a low, cost-of-service price. Representatives of conservation and internati onal groups at the workshop pointed at that Landsat data are an important tool for managing and monitoring development. They endorsed a single-tier pricing policy in which data are priced at the marginal cost of fulfilling a user request. Alternatively, they favored a two-tier policy in which groups such as theirs can obtain data at the lower (i.e., first-tier) price.

The issue of data pricing is at the intersection **of several competing and unresolved national goals (box** B). If the Congress were to resolve that a single price, set as low as possible, be charged to all users, it would uphold a longstanding commitment to a principle of broad access to data it acquires at public expense for the public good Examples include weather, census, and economic data Proponents of low data prices argue that such prices would assist governments, **private groups, and individu**als in the study of global change.

The Administration's present management plan for Landsat 7, and both House and Senate bills, recognize commercialization of unenhanced data as a policy goal. However, some workshop participants, especially those from private industry, contended that the NASA management plan for Landsat 7 goes beyond the appropriate role of the public sector and is "a gigantic step in the wrong direction in terms of the future of this technology." They argued that leaving the distribution of unenhanced data in government hands would in effect stifle the evolution of a viable commercial industry. Several of them suggested that commercialization could work if the system were designed as a commercial system from the start Pricing would then be an integral part of the system design. Orbital Sciences Corporation's Seastar satellite, which carries the Seawifs sensor, provides one example of how this could work (box. C).

Other participants disagreed with the entire thrust toward commercialization, contending that a single-tier, low price would most effectively stimulate the value--added industry. One participant noted that the government had successfully developed new products that are finding new markets, citing as an example the U.S. "Census Bureau's TIGER files.

OMB Circular A-130 (appendix B) governs the pricing of publicly owned data, such as that acquired from Landsat 7. The general debate over A-130 has revealed conflicts between users of inexpensive government data and those who would supply competing data products. Thus, the debate over the pricing of Landsat data exists within a larger context, in which government-created data and information can affect the marketplace.

Box B-A Selection of Goals Identified by the Workshop

- l ***Maximizing*** access to data by ***all*** users, as a pure public good;
- l Ensuring maximum data access by government users;
- l Spurring research:
- l Partial or full cost recovery for Landsat system investment;
- l Meeting foreign policy goals, including 'open skies; ''
- l Maintaining data control for national security purposes;
- l Fostering U.S. industrial competitiveness;
- l Fostering development of the value-added industrial and
- l Fostering development of greater private investment in supply of unenhanced data.

SOURCE: Office of Technology Assessment, 1992.

2. The Relationship Between Commercialization and Two-Tier, or Multiple-Tier, Pricing

The United States is m a period of transition, participants agreed between the second phase—attempted commertialization --of the Landsat program and an undefined future. In the first stage of Landsat's history in the 1970s and early 1980s, the system and its data were a U.S. government monopoly. In those early days, NASA viewed development and testing of the sensors and operation of the system more as an exploratory research and development. (R&D) activity than as a routine operational service. Data were used primarily by federal agencies and a small group of researchers. A value-added industry gradually developed to support government applications and to assist extractive industries such as oil gas, and minerals. Under these circumstances, most policymakers agreed that a federal agency (first NASA and then NOAA) should operate the system archive and distribute data, and encourage research and federal agency use through uniform, cost-of-service pricing.

As use of these data by private industry grew, some analysts suggested that the Landsat system could eventually **become self-supporting by marketing unenhanced data to a wider range of users. As a result, beginning with** passage of the LandSat Commercialization Act of 1984[51] the United States began an experiment designed to encourage the growth of a private earth-sensing industry

[51] The Reagan Administration had **initiated the process of transfer by** issuing an **Executive Order in late 1983.**

in the United States that would eventually enable the marketplace to pay for the satellite system, including launch, and the marketing of Landsat data The implicit goal of commercialization was to create a new industry that would offset the costs of Landsat launch and operation to the Federal Government, and pay for future satellites in the Landsat series.

Some workshop participants commended the progress EOSAT has made towards the goal of commercialization. Several noted that EOSAT had created "a worldwide marketing system" for LandSat imagery, which, although underutilized is a prerequisite for market growth. However, EOSAT had not been aggressive enough in marketing, some said. Opinions differed on whether EOSAT's distribution and pricing policy had hindered EOSAT's growth. One participant pointed out that the prerequisite for market growth is identifying existing products or services that can be improved by using Landsat imagery, which leads to lower data prices and an increase in demand for imagery. An aggressive marketing system would then help in identifying new products.[52]

Most participants agreed that the circumstances of 1992 are very different from those of 1986, when EOSAT assumed control of data distribution. Today a growing value-added industry is developing new products and markets and cheaper, user-friendly technology. In addition, other countries (table 2) are providing remotely sensed data

The idea of moving to a two-tier or multiple-tier pricing structure arose in order to preserve part of the commercialization process begun in 1984 and to avoid outright termination of the existing contract with EOSAT, which would likely be required in order to implement other proposed pricing structures.[53] In theory it could allow a private operator to earn a profit by selling higher-priced data while also supplying data to government users at cost-of-service prices. Alternatively, it would allow a government-operated system *to* offset some of the costs **of** building, launching, and operating a satellite system.

Some workshop participants expressed concern about the workability of a two-tier arrangement, others insisted that a multi-tier pricing system would be practical. There appeared to be differences in perspective between those participants for whom charging prices according to market demand is the key to profitability and a viable business, and participants who are managers in the federal sector. One federal manager at the workshop contended that dual-tier pricing would be "an administrative nightmare. " In rebuttal, a participant from the private sector said that offering different prices is "not a problem. It is in the noise" of running a business. He noted that many businesses charge different prices for different types of service. However, *another* participant noted that discriminating according to product or service is very different from discriminating according to type of client, adding, "Only a monopoly can afford to discriminate according

Box C—The SeaStar Satellite System

The commercial market for remotely sensed data has not grown as fast as early predictions once heralded The data remain too expensive for many of the smaller users such as farmers and the fishing industry. In the future, the Federal Government may purchase quantities of data from private systems, allowing these firms to earn a profit marketing data to other users. The Federal Government and the Orbital Sciences Corporation (OSC) have recently entered into an experimental data purchase agreement that may provide valuable lessons for possible future agreements of a similar character.

The Sea Wide Field of view Sensor (SeaWiFS) is a multi-band (8) imager that operates in the very near infrared portion of the spectrum SeaWiFS will be used to observe chlorophyll, dissolved organic matter, and pigment concentrations in the ocean. The sensor will contribute to monitoring and understanding the health of the ocean and concentration of life forms in the ocean. Data will have significant commercial potential for fishing, ship routing, and aquaculture, and will be important for understanding the effects of changing ocean content and temperatures on the health of aquatic plants and animals.

Under the arrangement with NASA, the company's SeaStar satellite will collect ocean color data for primary users (including NASA), who then have the option to sell both unenhanced and enhanced data to other users. NASA has agreed to purchase $43.5 million of data from Orbital Sciences. This arrangement allowed OSC to seek private financing for design and construction of the satellite. OSC has developed a virtually identical sensor for the EOS-Color satellite, one of the Earth Probes included under the vast umbrella of EOS. EOS-Color, to be launched in 1998, will measure oceanic biomass and productivity.

[52] The market for telecommunication services from satellites provides an instructive example of this process. When satellite communication services were introduced in the 1 %0s, they entered a telecommunications market that was already well-established. Communications by satellite soon became much cheaper than by copper undersea cable. Hence, satellite communications quickly gained market share and forced the cost of international communications services down See Office of Technology Assessment, op. cit., footnote 22, ch. 6.

[53] Terminating the contract with EOSAT could cost the government millions of dollars and jeopardize data distribution from Landsat 6.

to client type." H.R. 3614 proposes to distinguish prices on the basis of client type, rather than service delivered

The heart of the issue is whether any entity--a private group like EOSAT or NASA for Landsat 7--can help bring **a new industry (for unenhanced data) into being with a single-tier pricing policy.** Several participants argued that a larger market for Landsat data would materialize only with a two-or multi-tier pricing system and an organization devoted to building a market for Unenhanced data According to this argument, low, single-tier pricing will inhibit the ability of the system operator (whether the government or the private sector) to offset investment and operating costs. In addition, when data are provided only at prices that reflect only the costs of reproduction and distribution, no feedback is possible between users of the data and suppliers regarding the intrinsic value of the data compared to the system costs. Such feedback is needed to guide future investment, such as choice of spacecraft operating parameters, or the choice of new sensors. In other words, users of data provided on a single-tier, low-cost basis may undervalue the data. In addition, there is the danger of encouraging the develop ment of a larger bureaucracy for data distribution purposes.

In sum, during this period of transition, when a major U.S. market for Landsat imagery is still forming, proponents of two-tier or multi-tier pricing argued that this policy may be the only way providers of uncaha.need earth imagery can earn sufficient revenues to grow. In addition, it was argued the perception of an unreliable federal or private monopoly would discourage the growth of the industry. Shifts in federal Landsat policy may have already inhibited the growth of a U.S.-based industry.

Government-gathered meteorological data are-in some sense analogous to LandSat data.[54] Weather data are essential to two federal government functions: civil aviation safety and the armed forces. But satellite weather data is now also down-linked at "spigots" around the country, from which commercial users, such as television news stations, can draw. These commercial users then ''enhance" the weather da@ for example, to display it on news broadcasts. Given the large number of commercial users who can enhance and resell such public goods--i.e., weather or Landsat data-for profit, should not the Federal Government charge a royalty for such commercial use, asked one workshop participant He suggested that some of the value of unenhanced data could be captured charging royalties and licenses on the use of data. Under this approach, a value-added firm would pay a royalty on its profit when it buys unenhanced data, adds value to them, and resells them.

One participant offered an alternative to a single-tier pricing policy, m the form of a hypothetical private firm that would contract to distribute Landsat data using two-tier pricing. Users entitled to data at the lowest, 'Tier One," prices would be "all Federal Government users, plus "authorized" academic, nonprofit research users." "Tier Two" users would be "everyone who is not a member of Tier One. The firm would be free to establish internal use and commercial resale fees, in the form of up front payments or those made "downstream" for later or repeated use. This was one of several suggestions for meeting the needs for low-cost pricing for public service uses of Landsat da@ and giving the managing entity enough freedom with all other prices to develop the industry.

Most participants agreed that the role of the Federal Government during this period of transition is not well defined and that different pricing policies can lead to different outcomes in shaping the future of U.S. remote sensing in the early 21st century.

The workshop discussed another suggestion for resolving the question of data pricing and retaining a private sector supplier of unenhanced data If EOSAT or any other commercial seller of unenhanced data were free to improve its unenhanced data--i.e., allowed into the "value added' business--the seller would have an additional market **from which to recoup** investment and operating expenses. Several participants countered that although existing law does not prohibit EOSAT from entering the value-added business, such a step would give it an unfair competitive advantage because of EOSAT's inside knowledge of demand based on requests for raw data[55] (this information is not available to value-added firms). Yet if other firms were also given the right to collect and distribute unenhanced data from the satellite, EOSAT would lose this competitive advantage. To date, EOSAT has chosen not to enter the value-added business.

3. Chances for Developing an Internationally Competitive, U.S.-Based Industry

Most workshop Participants agreed that the goal of commercialization is not presently being met through the existing arrangement with EOSAT While participants noted that the value-added markct is moving toward a wider variety of products, and growing fast because of smaller, cheaper, user-friendly technology, they differed over which pricing policy would stimulate the market and improve the chances of fully commercializing the provision of unenhanced data.

As mentioned some participants felt that continuing a single-tier pricing policy at existing prices and service

[54] See Office of Technology Assessment, op. cit., footnote 1, ch. 4, for a discussion of weather data as they relate to data collected by Landsat.

[55] I.e., knowledge of the data purchasing habits and customer base of competing value-added firms, and the ability to delay or deny data delivery.

would fail to encourage commercialization of the sale of unenhanced data. 'There is a bigger market so long as we get better performance' from suppliers, said one participant, apparently referring to more timely service and better quality of data.

However, the private sector representatives at the workshop did not agree regarding two-tier pricing. At least one representative of a private firm argued that the revenues would increase if prices were lowered more, or kept at a relatively low rate. This participant noted that when EOSAT offered special "sales" of data, the firm had gone out and bought more data. For value-added firms, data costs can be a key business expense; being able to buy popular scenes (at lower cost) that can be utilized in many projects gives them a price advantage over value-added firms that cannot afford to maintain a library of scenes. But this has a greater impact on which value-added firms receive a contract and not whether a client will undertake a project in the first place. Ultimately, it is the number of projects purchased that influence data sales.

Private sector representatives differed in their outlook for the future of the industry. Some were gloomy that the Federal Government would not understand how to nurture a viable new segment of the U.S. economy. Participants agreed however, that taken together, the Landsat system, research community, and innovative private firms represent a potentially large national economic resource. One participant offered the following view:

> Remote sensing is part of the country's strategy for recovering world economic leadership, to make the country more important and successful. How well industry and government work together will determine whether a major U.S. industry comes into being, and how successful it is internationally while helping U.S. public and foreign-policy goals.

The health of the value-added industry is key both to enhancing a new and potentially large element of the economy and to building up a market for unenhanced data. Spokesmen for the maturing-and growing—industry of firms who "add value' to unenhanced Landsat data from EOSAT argue that the data and techniques to enhance it amount to a "strategic technology" akin to the Nation's former leadership m TVs and VCRs. The vast majority of potential buyers of remotely sensed data cannot use the unenhanced data that EOSAT (and after 1997, NASA) offer. In this they are like the average citizen who cannot use the raw data from a weather satellite, but regularly watches the television weather reports that display and interpret these raw data. Even if a self-sustaining market for unenhanced data were to develop, the value-added industry will still provide the greatest return to the Nation's tax base, because the value added to the data will generally far exceed the original cost of the data. A strong value-added industry would also indirectly assist governmental uses for the data by continuing its development of innovative ways of manipulating, displaying, and analyzing them and creating low-cost computer hardware and software.

4. Foreign Policy and Data Price and Distribution Policies

For the balance of the century, several participants argued, Landsat could be an increasingly important component of U.S. foreign policy. The United States, as a good global citizen and leader, could exploit its past investment m Landsat by offering imagery to foreign governments and international entities, such as the World Bank, that need information about desertification, water supply, patterns of settlement, wildlife habitat, forest cover, and coastal issues. In the 1970s, through U.S. AID and NASA, the United States mounted a major effort to make Landsat imagery available to developing nations. Thosc efforts often resulted in a beneficial transfer of know-how and technology to these countries. However, because they were not continued in the 1980s, the growth in use of Landsat imagery has slowed considerably. Many developing countries still lack supportive institutions and appropriate training to make effective use of land remote sensing data. Others are highly capable but often lack funding to support extensive use of Landsat data.

To the extent the United States has an interest in helping other nations learn more about their resources and processes of change, it may have a strong interest in providing data to some foreign governments at cost-of-service prices. On the other hand, two participants proposed that the U.S. foreign aid program be empowered to subsidize friendly countries' purchase of Landsat data at whatever price is charged. U.S. foreign aid could also be directed to help other nations build or maintain downlink stations on their territory and assist indigenous research using the data and value-added enhancement of imagery.[56] A fundamental problem with such ''aid' to many developing countries, however, is the difficulty of making such resources available through the foreign aid budget, which has many other demands placed on it.

Foreign countries also use earth imagery to find out information about their neighbors and adversaries. Some participants noted that some governments would be willing to pay extremely hi@ prices for scenes of adjoining areas for purposes of national security. Such uses of Landsat data may not qualify as a "public good" by the standards of the U.S. foreign aid program. This leads to the awkward conclusion that in a free market for earth imaging information, some governments-perhaps

56 Off& of **Technology Assessment**, op. **cit., footnote 22, ch.** 7.

ones at war with their neighbors--would be in the same price category as farmers or state governments, Le., "commercial" users paying the market or tier two, prices.[57] Foreign companies would be expected to pay market prices; they could be very large customers for Landsat data m the future, as they already account for about 25 percent of EOSAT sales.

The workshop did not resolve how a two-tier pricing arrangement, if it were instituted would apply to foreign users. Participants contended that the application of mm-tier pricing to foreign users warrented careful study. A related issue, barely discussed was the extent to which the U.S. government should open its "black" systems in remote sensing for public access and international use. The Russian release of data from its synthetic aperture radar system Almaz, could be an important precedent~ since the system offers an important new source of data about the oceans, ice pack and land Surface.[58] Some asked whether-with the Cold War over and the Russians opening up formerly closed systems to public, international use--the United States should make some of its now-classified systems publicly available as well? One participant noted that the U.S. national security community is closely following the fate of EOSAT, the overall commercialization process, and NASA's Landsat 7 and EOS programs, with an eye to what role its own classified systems might play in the public market.[59]

Most legitimate foreign policy uses-such as helping friendly governments or monitoring global change-might deserve a low, cost-of-service price for data. However, the international market for Landsat imagery offers the same problems as the domestic one: the smaller value of unenhanced data versus a potentially large market for value-added information.[60] These problems underscore the vital role of private value-added firms in enhancing data and making it more useful. The workshop did not resolve these issues, except to note that the French, the European, Japanese, Russian, and Indian systems will no doubt be joined by other earth-imaging systems. In short, an international industry will grow, no matter what the United States does with Landsat.

The workshop also explored the U.S. nondiscriminatory data distribution policy, which is codified in the Landsat Act of 1984. When the Landsat Act was under debate in Congress, several private entities, who wished to launch and operate their own satellites, contended that they should have the right to market data on whatever terms would result m a profitable business. In their view, the right to discriminate among services and, for exampie, to offer exclusive rights to data to those who would pay substantially more than the standard price for the privilege, was key to establishing a viable commercial business. Others argued on the contrary, that the nature of Landsat as a government-owned system required that data sales adhere to the "open skies" principle originally enunciated by Resident Eisenhower, and that data should be offered on a nondiscriminatory basis to al potential buyers.[61] These experts reasoned that a **nondiscriminatory policy would allay** fears among the poor nations that the United States or some other rich country would gain important economic information about a poorer country, itself without access to similar data. A nondiscriminatory data policy would also underscore U.S. adherence to the principle of the free flow of public information across national boundaries.

The Administration has proposed changing the law regarding nondiscriminatory data policy in order to encourage private entry.[62] H.R. 3614 as passed by the House of Representatives and S. 2297 also include a provision that would void the nondiscriminatory provision for privately funded satellite systems. However, even if changing this policy enhanced the chances of a private firm launching its own satellite, the firm would still have to compete with Landsat in marketing data. Therefore, the data a private system supplied would have to hold considerable additional or distinct value over Landsat data in order to earn a Profit.[63]

Most workshop participants felt that, on the whole, the nondiscriminatory policy has served this country and users of remotely sensed data well, as it has not only made data readily available (for a price) to all U.S. users, but has helped stimulate the overseas market as well. U.S. policy has set the standard for the world community. It was a major factor in the French decision to establish the same policy for data from SPOT However, with the entry of SPOT and other satellite systems offering remotely sensed data, some workshop participants felt that the supply of data was sufficiently diverse and the market sufficiently competitive that systems financed entirely

57 On the other ha@ the united states government intervenes m export markets for other commodities of strategic value during times of war or vastly heightened tensions. It could do so for remotely sensed data as well.

58 The European Space Agency's ERS-1 satellite system and Japan's JERS-1 also carry synthetic aperture radar systems.

59 The intelligence community has a - of this question underway, particularly With respect to the use of previously classified data for global change research.

60 While it is true, for example, that photographs made from Landsat data are used directly for some applications, electronically processed digital data potentially carry much greater value.

61 Office of Technology Assessment, op. & footnote 1, for a discussion of the nondiscriminatory policy and its relationship to the open skies policy.

62 *Space Business* News, Apr. 13,1992, p. 5.

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

with private investment capital could soon begin to offer data that discriminated according to price or timing without undercutting the foreign policy benefits of the nondiscriminatory policy for the Landsat system. Most participants agreed that *publicly funded systems* should retain the nondiscriminatory policy consistent with the open skies principle.[64]

5. Academic Research and Instructional Needs

Many participants agreed that the U.S. academic research community can contribute to the development of public and private applications of earth sensing technology. Published research broadens remote sensing technology and applications. Students trained in college and university programs form a cadre of experts needed by government, private industry, nongovernmental organizations, and international institutions.

Several participants suggested strongly that academic researchers should be able to purchase Landsat data on the same terms as government users.[65] Even participants who advocated multiple-tier pricing agreed that university researchers were performing a public service and therefore should be charged cheaper prices or proffered subsidies to support purchases at higher prices. Participants from nonprofit conservation groups stated that the costs of earth imagery for evaluating major environmental problems such as African desertification or depletion of Amazonian rain forests were a major part of their annual budgets. They argued in favor of low data prices

During the 1980s when EOSAT came into operation, federal support for applied research in the earth sciences decreased as did support for new technology exploration and demonstration. The problem the academic community is encountering, according to this argument, is not that EOSAT'S prices are "too" high or unfair, but that support for university research and teaching has declined. Adherents of this view argue that a proper remedy, in this , case, may not be to force data prices lower, but for the Federal Government to offset whatever price is charged--and any price increases-by appropriate grant and contract research support.

Most academic researchers do not require data immediately after it is acquired so that charging of premiums for rapidly filling orders is not an issue for them.[66] A key issue for academics, however, is the need for government to maintain the quality of archived images,[67] so that historical data they need will remain useful in later years.

While university users were considered as legitimate candidates for low prices, some of the workshop participants did not place state and local governments in this category. They said state and local governments form a major market for specialized value-added services, which can be provided most efficiently by private firms. However, participants recognized that cases might arise in which state or local governments need Landsat or EOS data to serve national purposes. In such cases the Federal Government could award grants or offer other preferential treatment to provide these data at a lower price.

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64 H.R. *3614*, while allowing a privately funded system to set its own price, with Administration policy, would retain a nondiscriminatory policy with respect to publicly funded systems.

65 Note that H.R. 3614 would allow such low &~ pricing for global change researchers and those funded by government grant or contract.

66 As global change research grows in importance, many more academic users may require timely access to data in order to evaluate the utility of data for studying environmental changes and for coordinating field campaigns for collecting *in situ* data.

67 Archived photographic and digital Landsat images are maintained at the EROS Data Center in Sioux Falls. which is operated by the U.S. Geological Survey.

Appendix A
Proposed Policy for Handling Remotely Sensed Data

S.2297 Land Remote Sensing Policy Act of 1992, Section 202 Dissemination of Unenhanced Data.

(a) DISSEMINATION POLICY-The Administrator and the Secretary of Defense shall implement a Landsat data dissemination policy, defined in the plan required by section 201(b)(3), that—

(1) ensures that existing Landsat data and future unenhanced data **acquired by the Landsat system are routinely available** to Earth and global change research scientists at costs that do not exceed the marginal cost of filling a specific user request;

(2) considers the reasonable and legitimate requirements of all segments of the satellite land remote sensing user community for access to unenhanced Landsat data; and

(3) ensures that copies of all unenhanced data acquired by the Landsat system are provided to the Secretary of the Interior for permanent preservation.

(b) AUTHORITY NOT AFFECTED—The provisions of this section shall not affect the authority of the Administrator and the Secretary of Defense to contract for the dissemination of data acquired by the Landsat system, so long as-

(1) the Federal Government retains ownership of all unenhanced data acquired by the Landsat system;

(2) no exclusive marketing rights are extended to any contractor.

(3) the Federal Government retains the right to set pricing policy for unenhanced data; and

(4) all other requirements of this section are met.

Section 501. Nondiscriminatory Data Availability.

(a) MAKING DATA AVAILABLE---Any Unenhanced data generated by the Landsat system, or by any system operator under the provisions of this Act, shall be made available to all users on a nondiscriminatory basis in accordance with the requirements of this Act.

(b) INFORMATION-The Administrator and the Secretary of Defense and any other system operator shall make publicly available the prices, policies, procedures, and other terms and conditions (but not necessarily the names of buyers or their purchases) upon which the operator will sell such data.

Section 502. Archiving of Data.

(a) PUBLIC INTEREST-It is in the public interest for the Federal Government—

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

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

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

H.3614 National Landsat Policy Act of 1992. Section 203. Data Policy for Landsat 1 through 6.

(a) CONTRACT NEGOTIATIONS-Within 30 days after the date of enactment of the National Landsat Policy Act of 1992, the Landsat Program Management shall enter into negotiations with the Landsat 6 contractor, with respect to pricing, distribution, acquisition, archiving, and access of Landsat 1 through 6 unenhanced data.

(b) CONSIDERATIONS-In carrying out negotiations under this section, the Landsat Program Management shaU-

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

(2) seek to ensure that 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) seek to ensure that 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) seek to ensure that 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, as long as the unenhanced data will be solely for noncommercial purposes;

(5) explore options, including the provision of vouchers and data grants, for providing unenhanced data to nonprofit, public interest entities engaged in environmental research at the cost of fulfilling user requests, as long as the unenhanced data will be used solely for noncommercial purposes; and

(6) seek to ensure a viable role for the private sector in the promotion and development of the commercial market for unenhanced data from the Landsat system.

(c) FAILURE TO REACH AGREEMENT—If negotiations under subsection (a) have not, within 120 days after the date of the enactment of the National Landsat Policy Act of 1992, resulted in an agreement that the Landsat Program Management determines generally

achieves the goals stated in subsection (b)(1) through (4), 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 for achieving, and recommendations with respect to, 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 marketing rights of Landsat unenhanced data; and

(3) the establishment of an alternative private sector mechanism for the marketing and commercial distribution of such data.

Section 204. Transfer of Landsat 6 Program Responsibilities.

The responsibilities of the Secretary of Commerce with respect to Landsat 6 shall be transferred to the Landsat Program Management, as agreed to between the Secretary of Commerce, the Secretary of Defense, and the Administrator pursuant to section 201.

Section 205. Data Policy for Landsat 7.

(a) LANDSAT 7 DATA POLICY PLANS-The Landsat Program Management, in consultation with the Secretary and appropriate officers of other appropriate United States Government agencies, shall develop a preliminary and a Final Landsat 7 Data Policy Plan in accordance with subsections (b) and (c). The Preliminary and Final Landsat 7 Data Policy Plans shall-

(1) 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 the operations of the Landsat 7 spacecraft;

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

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

(5) ensure that 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, as long as such unenhanced data is used solely for noncommercial purposes;

(6) ensure that the proposed data distribution system contributes to the commercialization goal for land remote-sensing; and

(7) 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) PRELIMINARY PLAN AND REPORT-Not later than December 31, 1993, the Landsat Program Manage**ment shall** develop and submit to the Congress a report that contains a Preliminary Landsat 7 Data Policy Plan and that addresses each of the issues identified in subsection (a).

(C) FINAL PLAN AND REPORT-Not later than July 15, 1996, the Landsat Program Management shall develop and submit to the Congress a report that contains a Final Landsat 7 Data Policy Plain In developing the report and plan, the Landsat Program Management shall assess the operational effectiveness of the data distribution system and policies for Landsat 1 through 6, established pursuant to section 203, in order to assist the Landsat Program Management in determining what, if any, modifications should be made in the preliminary Landsat 7 Data Policy Plan. The report shall address any such modifications.

Appendix B

Office of Management and Budget Circular A-130

The Office of Management and Budget published OMB circular A-130 in 1985 to establish a national policy for the reproduction and distribution of information collected or paid for by the federal government. A-130 can be applied to any federally collectcd data and information, including those as diverse as census data and images collected from space. In particular, distribution of Landsat data and data from future Earth Observation System satellites are governed by A-130.

Information is defined by A-130 as "any communication or reception of knowledge such as facts in various forms and on any medium." Information technology is similarly defined as any hardware or software used in connection with this information.

The circular establishes several ground rules for the collection of information, two of which are important for Landsat data. Firs&in an effort to "minimize the cost and maximize the usefulness" of information collected by the government, the anticipated public and private benefits that can be derived from the information, insofar as they can be calculated should "exceed the public and private ***costs*** of the information." Second, "the open and efficient exchange of information. . . fosters excellence in scientific research and the effective use of Federal research and development funds. "

A-130 also sets policies for information management Foremost for managing information similar to that from Landsat are two **policy** statements **included in the circular. Federal agencies shall:**

> **Disseminate information as required by law, describing agency organization, activities, programs . . . and how the public may gain access to agency information resources.**
>
> **Disseminate . . . products and services**
>
> **a)** in a manner that ensures **that** members of the public . . . have a reasonable ability to acquire the information.
>
> **b)** in a manner most cost effective for the government, including placing maximum feasible reliance on the ***private*** *sector* for the dissemination of the products or services . . . and
>
> **c)** so as to recover costs of disseminating the products or services through user charges, where appropriate . . . .

OMB Circular A-130 also stresses long-term strategic planning by agencies for acquiring data and operating information technology programs. It also encougages timely acquisition of information and information technologies, and also dictates some specific agency requirements. Any data distribution plan must conform with the requirements set forth by A-130, which will be revised in 1992.

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