Chapter 1

Executive Summary

Contents

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A process is now under way that is intended to lead to the early transfer from the Federal Government to the private sector of the Land Remote Sensing Satellite (Landsat) system for remote sensing from space, This technical memorandum was prepared at the request of the House Committee on Science and Technology and the House Committee on Government Operations, which are overseeing this process. The House Committee on Science and Technology is also simultaneously preparing implementing legislation.

This process inevitably raises the separable issues of whether to carry out the transfer at all, or how to carry it out if the Government does go ahead. This memorandum only indirectly addresses the question of whether the transfer is in the net public interest by focusing on one aspect of such a transfer: it discusses the various public benefits provided by the Government's civilian meteorological and land remote-sensing systems and analyzes the effects that transfer of these systems to the private sector might have on the provision of these public benefits.

Principal reasons for transferring remote-sensing services to private hands are that the private sector excels both at innovation and at developing markets. In an earlier study, OTA found a potential exists for greatly expanding the market for land remote-sensing services, and that other nations intend to compete for the market. *

Another reason for transferring these services to the private sector is the hope of reducing Federal expenditures. This technical memorandum bears directly on the question. Most of the public benefits which the United States now derives from remote sensing could be provided just as well by the private sector—for a price. However, OTA has found that a private owner/operator who was obliged by contract to provide all of these public benefits would probably require a large Federal subsidy. Until the market expands substantially, and **more efficient spacecraft are developed and deployed, it could cost the Federal Government as much to subsidize a private owner as to continue operating the system itself.**

The public benefits of land remote sensing *could* justify any of the following policy options:

- continued Government ownership and direction of the system, whether or not actual operation was contracted out; or
- maintenance of Government ownership for a limited period, in order to effect a phased transfer to the private sector, as the market grows large enough to support commercial ownership; or
- mixed, public-private ownership of the system; or
- quick transfer to a private owner/operator, but with a series of conditions and requirements designed to assure the public benefits; *and*
- a substantial subsidy to a private owner, in order to maintain the public benefits and maintain continuity of operation and data.

An understanding of the nature of the benefits is critical to an informed choice of policies. However, **this memorandum does not take the next step of comparing the value of the public benefits to alternative uses of the public resources required, nor does it address directly the relative merits of public and private ownership.**

Since this memorandum was requested, Congress passed appropriations bill H.R. 3222, a provision of which prohibits the sale or transfer of the meteorological satellite (metsat) systems to the private sector. On November 28, 1983, President Reagan signed this bill into law (Public Law 98-166). Because the issues raised by the administration's proposal may be important in considering the disposition of other Government-developed technologies, OTA has retained discussion of metsats in this technical memorandum.

The metsat and Landsat systems not only serve different, if related, functions and constituencies,

1Civilian Space Policy and Applications (Washington, 11. C.: U.S. Congress, Office of Technology Assessment, OTA-STI-177, June **1982), pp. 53-67.**

but also differ sharply in their developmental history and current status. The metsat systems are fully operational and run by the Government as part of its responsibility to provide weather services. Provision of these services has a long domestic and international history and a set of usages and established procedures. The Landsat system, by contrast, has until recently been entirely a research and development (R&D) effort, although in many respects it has been used as if it were operational. Landsat data are also fundamentally different in format, repeatability, and continuity from other remotely sensed images, such as aircraft photography, and therefore have not had an easy market niche. The Landsat program as a whole is clearly ready to shift from the earlier emphasis on R&D toward provision of routine services. Moderate-resolution land remote-sensing technology* is ready for full operational status. The question Congress now faces is whether the United States should treat land remote sensing as a fully appropriate Government operational activity (as it has with metsat), or transfer it to private hands under a variety of conditions, or drop it completely.

This technical memorandum outlines the tangible and intangible public benefits that flow from operational remote sensing managed in the public interest. It provides a basis for deciding which requirements and conditions a private offeror could be asked to meet if the Government proceeds with transfer of the land remote-sensing system. Further, this memorandum provides a summary of what public social, economic, and political losses could accrue if the Government decided to drop civilian land remote sensing altogether, and leave the field to the French, Japanese, Soviets, and others.

● That is, the multispectral scanner or equivalent systems, whose spatial resolution is about **80** meters.

BACKGROUND

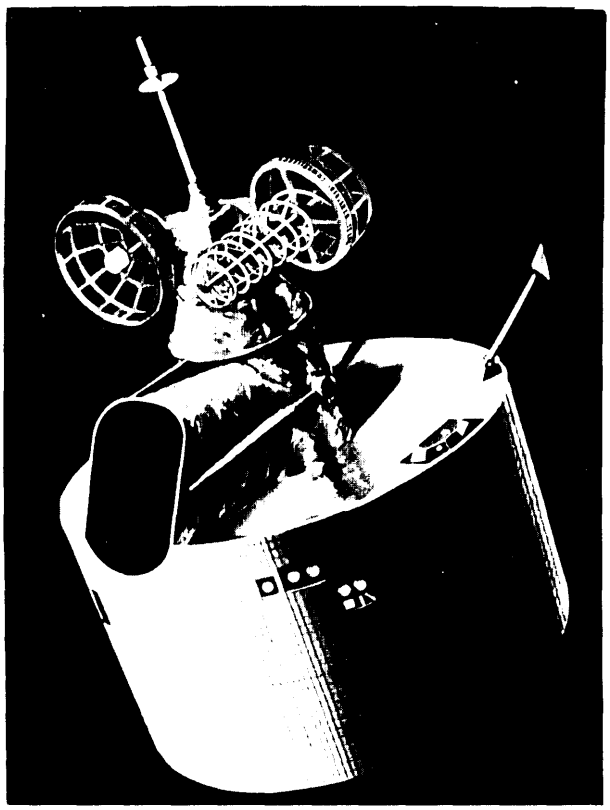
The potential value of viewing Earth's atmosphere, land, and oceans from space for civilian purposes was recognized early in this Nation's development of space technology. The United States launched its first civilian remote-sensing satellite (a polar-orbiting weather satellite called TIROS) in 1960. TIROS provided the first civilian images from space.

The National Oceanic and Atmospheric Administration (NOAA) currently operates two civilian meteorological satellite systems. One is a polar-orbiting system that consists of two satellites (NOAA-N series) orbiting the Earth once every *102* minutes; the other consists of two geosynchronous satellites (GOES) that view the Western Hemisphere continuously and transmit images to Earth every 30 minutes. Both systems carry a variety of relatively low-resolution sensors (1,000 meters (m) or more at the surface of the Earth), which operate at several wavelengths to provide weather imagery and related data.

In 1972, the National Aeronautics and Space Administration (NASA) launched the first of a series of civilian land remote-sensing satellites (Landsat). Among other experimental devices, the first three satellites carried a sensor called the multispectral scanner (MSS), having a terrestrial spatial resolution of 80 m and operating in four spectral bands. Landsat 4, launched in 1982, carries the MSS, as well as a new sensor called the thematic mapper (TM), which has a terrestrial resolution of 30 m and operates in seven spectral bands. * Transmissions from Landsat are received globally by 3 U.S. and 10 foreign-owned ground stations. Landsat 4 is currently failing and could stop working at any moment. Landsat D', which is the backup satellite for Landsat 4, is scheduled for launch in March 1984, Under current administration policy, this will be the last Government-owned land remote-sensing satellite unless new ones are ordered. NOAA now operates the Landsat system.

Although individual systems are typically designed to optimize the observations of the atmos-

'Except for the 10.40 to 12.5 micron band which has a spatial resolution of 120 m.



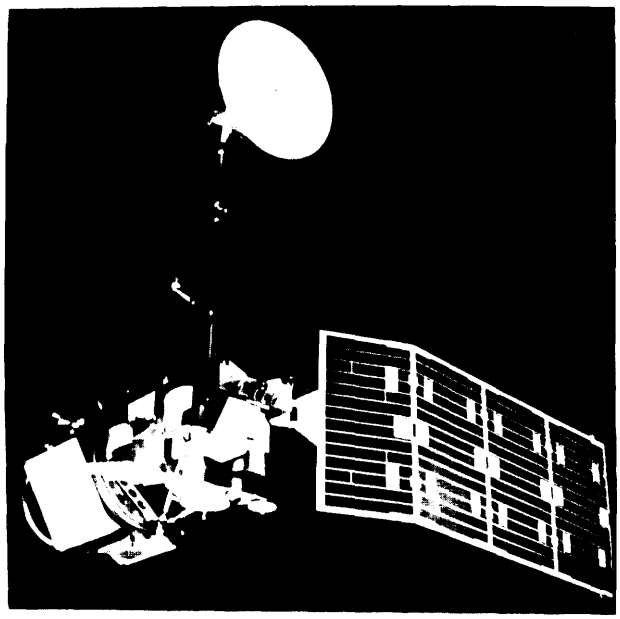


Photo credit National Oceanic and Atmospheric Administration

Geostationary Operational Environmental Satellite (GOES series), artist's conception

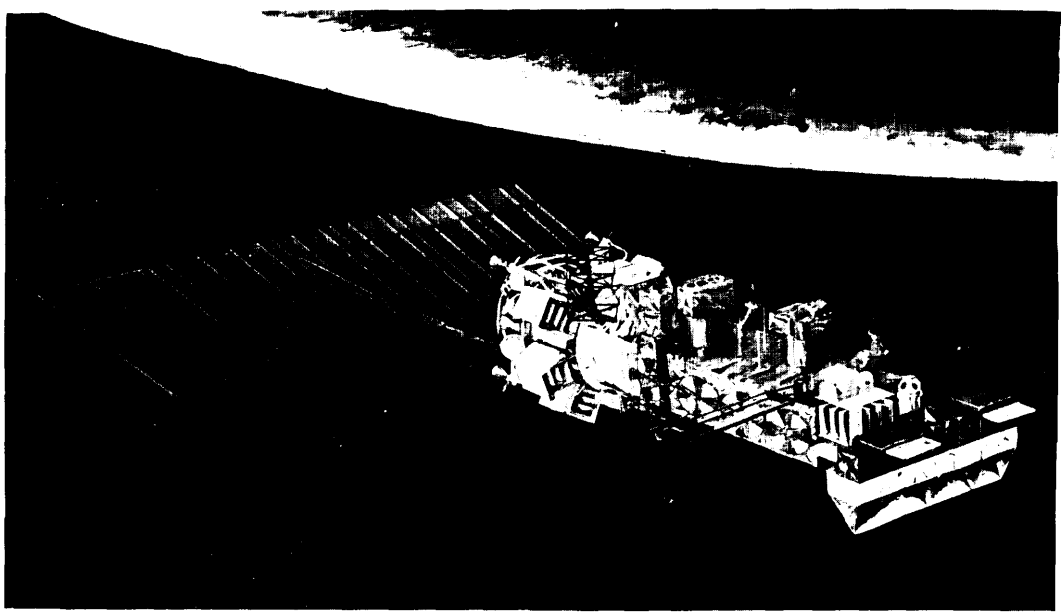


Photo credit National Ocean/c and Atmospheric Administratio

NOAA-N series polar-orbiting environmental satellite, artist's conception

phere, the land, or the oceans, sensors on board each satellite can also collect useful data on other components of the Earth. For example, agricultural managers use images from the meteorological satellites to estimate crop production, coastal-zone managers use Landsat data to study water pollution and pollution sources, and exploratory geologists use Seasat data to locate promising areas for exploration on land.

The Department of Defense (DOD) operates its own polar-orbiting meteorological satellite system. To a certain extent, DOD coordinates its meteorological operations with those of the civilian system. It makes use of data from the Landsat system, in addition to operating a system of surveillance satellites to serve national security needs.

Other countries are developing their own meteorological, land, and ocean remote-sensing systems. The European Space Agency (ESA), India, Japan, and the Soviet Union all currently operate meteorological satellite systems. The Soviet Union operates a land remote-sensing system; ESA and several other countries plan to launch land or ocean remote-sensing satellite systems by the end of the decade. Some of these systems will generate data directly competitive with data from the Landsat or related U.S. systems. By virtue of significantly higher resolution and a planned rapid delivery system, some will exceed Landsat's capacity to return useful data to users of remote-sensing data.

NASA's and NOM's efforts with remote-sensing systems have demonstrated to domestic and foreign users, both inside and outside Government, that data from these systems can be highly effective in meeting their weather and resource information needs. In light of the potential commercial economic value that **Earth resources remote-sensing data could have, the Carter administration, through Presidential Directive PD/54, directed that "Commerce will budget . . . to seek ways to enhance private sector opportunities"** in land remote sensing. Although this directive left open the timetable and the means of a possible transfer of the Landsat system to the private sector, at the same time it committed the U.S. Government to provide a continuous flow of data from a land remote-sensing system through the 1980's. The Reagan administration decided early in its tenure to hasten the process of transfer; it further widened the scope of this policy by proposing that both the meteorological and land remote-sensing satellite systems be transferred to private ownership as soon as possible,

The Commerce Department set up a Source Evaluation Board (SEB) to draft the Request for Proposal (RFP) for transfer of the systems to the private sector. The RFP is intended to specify the Government's qualitative requirements for data for a period of time after transfer takes place, and to lay out the operational constraints that would be placed on the private offeror. The SEB issued a draft proposal for public comment on October 24, 1983. Prior to that time, it had solicited and received a number of comments from other Government agencies and from Congress. Commerce issued a revised RFP in January 1984 for industry's response. In keeping with the legislative prohibition on sale of the metsat systems, it no longer contains provisions for their transfer.

The RFP is long, technically thorough, and contains input from a wide variety of interested parties. In some respects, it is a very unusual RFP. For one thing, it leaves several important areas of Federal policy to be defined by the private sector. Further, in the absence of clear policy direction from either Congress or the administration, the private offeror runs an awkward and expensive risk of offering to invest and become involved in ways that could later be changed by policymaking legislation.

Congress held several hearings on the subject in 1983. The House and Senate are now considering legislation designed to encourage transfer of the Landsat system to private ownership reinforcing and specifically preventing similar transfer of metsats. Some members of both Houses favor transfer of the Landsat system; others feel it should remain a Government-owned and operated system.

INTERNATIONAL RELATIONS AND FOREIGN POLICY

Transfer of either system to the private sector would certainly affect our relationships with other nations. International issues related to transfer are among the most important and difficult to resolve satisfactorily. Consequently, the transfer proposal cannot possibly be approached as merely a domestic decision. Realistic planning for the disposition of the remote-sensing systems must address global concerns in the following areas:

International Relations and Foreign Policy Aims

Landsat and metsat data have served as useful and constructive instruments of U.S. foreign relations. These data have aided other countries to prepare in advance for severe weather conditions, and to map, manage, and exploit their own resources; they have also served to raise the general level of awareness about growing environmental problems throughout the world. **The data from both systems, and the equipment with which to process them, have provided the United States with access to, and influence in, many other countries.**

Although the private sector is technically capable (given adequate financial incentives) of providing the data promptly to meet the requirements of the Federal Government and other potential customers, commercial objectives may conflict with U.S. foreign policy objectives. Constraints on a private firm that **are** sufficient to protect **U.S. foreign policy objectives could well make such an enterprise unprofitable or require a large and continuing Government subsidy to make the enterprise viable.**

Data Sales

The United States has followed the policy, consistent with the practice of other countries, of providing meteorological data freely and without charge. After exploring the feasibility of charging for meteorological data, which raised ire and concern in other countries (especially those that participate in the data gathering), the administration decided to continue the earlier policy. If the metsats were to be transferred to the private sector, the Government would presumably purchase the data from the operating firm and then distribute them free of charge to other countries. **Since the United States receives free of cost more vital meteorological data from other countries than it gives away, and since providing global weather data is a public good, maintenance of this data policy would continue to benefit the United States.**

Landsat data have always been sold to non-U.S, Government users, and they have been made available to all purchasers on a nondiscriminatory basis. Indeed, the data policy of the Landsat program can be considered to be a cornerstone of the U.S. "open skies" policy and of the use of space for peaceful purposes. By following this policy, the United States has been able effectively to blunt criticism of other activities, such as the operation of classified surveillance satellites. It has also been able to demonstrate to the entire world its adherence to the principle of the free flow of information. **It is a powerful message to send to all governments, especially those opposed to the open interchange of ideas and information, that LandSat data** are **available even to our political and economic adversaries at the same price and under the same terms as to our friends.**

Yet, if the transfer to the private sector were made, potential owners would exert strong pressure to be allowed to set their own data sales policies in order to maximize profitability. Such a posture would frustrate the very policy the United States has fought so hard and so long to maintain in the United Nations and in its foreign relations. In **view of the continued importance of the "open skies" principle to the United States, altering the principle of nondiscriminatory sale of land remote-sensing data would be harmful to many U.S. foreign policy interests, not just those involving outer space.** Whether or not the Government decides to continue the nondiscriminatory policy, **any charter for a private firm should be unambiguous with respect to the data distribution policies the firm could pursue.**

Value-added Services

To date, most of the revenue from the use of remote-sensing data has been earned by those corporations that process, analyze, add other information, and/or interpret the data for themselves or for others (the so-called value-added industry). The value-added companies constitute a small, but growing, specialized industry. Most bidders for a remote-sensing system would want to participate in the value-added business, The primary economic value **of the data from the meteorological satellites is in warning of impending severe or unusual weather. Since receiving terminals are relatively inexpensive, most countries and many organizations can afford to own and operate them. For meteorological data, allowing a data supplier to sell value-added services as well as data appears to raise no special concerns in developing countries as long as the raw data remain freely available to everyone with the capacity to receive them.**

High-resolution land remote-sensing data and the ability to analyze them are potentially powerful tools for resource development. Many developing countries have expressed the fear that if the company owning the data collection and distribution system were also allowed to offer value--added services, it might take special advantage of having control over the acquisition and distribution process to make its own value-added services more timely or more complete than the services of its competitors. Under such conditions, the company, and its most favored customers, could obtain economic leverage over countries that lacked the facilities and personnel capable of interpreting the data. **Therefore, from the standpoint of maintaining good relations with developing countries, it may be appropriate for the United States to restrict the private data distributor from entering into the value-added business, or to regulate it closely to prevent such a company from exerting unfair economic leverage over others.** As competition from foreign or even other domestic systems grew, it should be possible to relax such restrictions. Alternatively, the Government could require data analyses to be sold openly as well.

U.S. Technological Leadership

The existence of metsat ground stations, owned and operated by over 125 countries, and the much more expensive Landsat ground stations in 10 countries, constitute an eloquent statement of U.S. leadership in successfully applying high technology for the benefit of all mankind. The United States has also participated with both industrialized and developing countries in pursuing applied research in the uses of the data. **It is critical to the continuing R&D of remote-sensing technology and the growth of the data market for the United States to maintain its cooperative basic and applied research programs with other countries, both to advance U.S. research objectives and to retain U.S. leadership in the technology of outer space.**

Cooperation With Developing Countries

Through its international cooperative projects with developing countries, the United States has advanced the state of the art in remote sensing, and provided access to information and processes that those countries would not have been able to afford to develop unilaterally. This cooperative approach has materially helped such countries to cope with the enormous human and physical problems of resource management, especially in isolated, rural areas.

In an era of rising costs and decreasing budgets, it may be increasingly difficult for the Agency for International Development (AID) and other U.S. organizations to provide data and other research support in remote sensing, yet U.S. Government agency technical programs are largely responsible for the development of the international community of users of metsat and Landsat data, and the concomitant market for Landsat data products. **If the transfer to the private sector is made, it will therefore be important to assure that appropriate Government funding is continued for these projects, and that access to data will also continue.** It will also be important to involve private value-added companies in these projects.

International Legal Issues

The United States helped to formulate and is now party to four major international treaties and agreements that may affect the operations of privately owned Earth remote-sensing systems. Of greatest importance to potential private owners of remote-sensing satellite systems is the 1967 Outer **Space** Treaty, article VI of which requires "continuing supervision by the appropriate State party to the Treaty. " At the least, this provision suggests some form of licensing and Government-imposed regulations for private space system operators.

In regulating a private land remote-sensing system, the Department of State, Department of Commerce, or other concerned Federal agencies have the opportunity to develop imaginative strategies and institutions for working with the private sector in this technology. The form of these strategies and institutions is particularly important because land remote-sensing data, by the nature of their information content, raise the sensitivities of other countries. **The Department of State's Bureau of Oceans and International Environmental and Scientific Affairs (OES), which would likely be charged with regulatory responsibility over international questions, would have to strengthen its technical expertise in space and its commitment to using space technology as part of the foreign policy of the United States. Such regulations could bring U.S. foreign policy objectives into direct conflict with the profit motives of private enterprise.**

Some countries maintain that they should have priority access to data derived from the sensing of their territory; others have argued that their consent should be obtained before these data are transferred to third parties. The United States maintains that a policy of free collection and dissemination of primary data is both supported legally and encouraged by the 1967 **Outer Space Treaty** and article 19 of the U.N. **Universal Declaration of Human Rights.**

Our historical policies of nondiscriminatory data sales and the free flow of information have served us well in deflecting attempts to restrict the right to sense other countries or to make those data available to third parties. Should transfer to private ownership result in discriminatory access to data—and a reduction in technical assistance and concessionary sales policies aimed at making these data less accessible to less developed countries—the U.S. position about "open skies" would have to be modified, with attendant losses to U.S. foreign policy objectives.

Future International Coordination

The United States currently participates in the deliberations of several international groups that set or coordinate standards for remote-sensing systems. If transfer of the Landsat system takes place, the Government should spell out clearly how private firms would interact with the Department of State and other U.S. agencies having cognizance over these matters.

Landsat Foreign Ground Stations

If the transfer takes place, the Memoranda of Understanding between NOAA and the foreign ground stations would become null and void. Yet the foreign ground stations provide data of significant importance to the U.S. Government. **In order for the private firm to supply the required data to the Government, in the absence of a system like the Tracking and Data Relay Satellite System, it may be essential for the firm to be able to enter into agreements with the foreign governments who own the receiving stations. Some countries may be unwilling to do so without major concessions regarding data distribution policy on the part of the private owner. In other words, foreign owners may insist on placing restrictions on sales of data to their adversaries.**

DOMESTIC PUBLIC GOODS

U.S. remote-sensing programs have contributed significantly to the domestic public welfare. The daily contributions of the meteorological satellites are visibly reflected in the daily media forecasts. Landsat's contribution is less often publicized, but the data it provides make possible new cost-effective ways to assess, manage, and exploit Earth's resources and environment. Landsat data are used for agriculture (to indicate crop stress and to forecast crop yield), forestry (to reveal the state and extent of forest resources and determine appropriate replanting strategies), resource exploration (nonrenewable resources), environmental monitoring and coastal zone management, cartography, and resource management.

State and Local Government

A fully integrated communications network for receiving and disseminating satellite meteorological data already exists in the U.S. National Weather Service, which adds these data to terrestrial observations and distributes them to the States and local communities in the form of long- and short-range weather forecasts. States and local news media use these data to warn citizens of impending weather conditions, including severe weather.

Several States have also begun to integrate Landsat data into their long-term planning, and to add them to computerized information retrieval systems. **However, the high cost of large computers and software and the expense of training and maintaining personnel, combined with uncertainties about Federal policy, are inhibiting the States from relying more heavily on Landsat data.** Further, some States that now use Landsat data to support their planning efforts are worried that transfer of the system to private hands would cause sharp rises in the prices of data over a short time. In order to cut costs, many States share Landsat data purchased from the Government with other States, particularly in border areas where Landsat scenes cover land in two or more States. * **States express concern that private owners would copyright the data in order to inhibit copying and trading them, which would also raise the costs of using Landsat data.**

Continuing Research

Important for satellite remote sensing is research on how to apply the data to environmental and resource problems as well as on improving sensors and related hardware. Although meteorological satellites have been operational for years, experimenters continue to discover ways to use their low-resolution data to solve some resource problems. For example, these data now serve as important adjuncts to the use of Landsat data for agricultural predictions. **It will be important to continue university, private sector, and Government research on applying meteorological data to resource problems. In addition, there is a need for continuing improvements to the meteorological sensors. The present research program within NOAA is inadequate.**

Although the system to produce data from the MSS sensor aboard Landsat 4 is appropriately termed "operational," many of the techniques to use the data effectively are by no means well understood. **Thematic mapper (TM) data will require considerable experimentation in order to learn how to make the best possible use of them. The universities could play a strong role in such research. Without a continuing source of data and continued experimentation in the public and private sectors with applying both MSS and TM data, the market for data and data products will not develop** and potential benefits will remain unexploited by the United States.

NASA plans to fly a variety of advanced experimental remote sensors on the space shuttle. However, there is also a great need to develop

* Sharing **data by** copying data **tapes or photographic products is now a common practice in Federal agencies, private industry, and the universities, as well as in State and local government.**

long-life operational sensors and associated processing hardware that can be used for commercial purposes. Smooth incorporation of new hardware into operational systems generally mandates evolutionary, not revolutionary, changes in design and system capacity.

Maintenance of Archives

Data gathered from meteorological satellite observations contribute to our knowledge of long-term weather patterns. In particular, the National Climate Program within NOAA assembles these data and combines them with other satellite and terrestrial data to produce world climate models. **In order to continue the research on weather and climate, it will be important to continue to archive meteorological satellite data and to maintain continuity of the data format,**

The EROS Data Center (EDC) currently maintains an archive containing most of the data it receives. However, most foreign data are not included in the archive, nor is it possible to purchase most foreign data directly from EDC. Customers must generally purchase their images of foreign land areas from the appropriate foreign ground stations. The expense of maintaining a complete archive of all the data ever received from the Landsat system is too great. However, it should be possible to construct a complete set of cloud-free images of MSS data for the entire world. To date, because of lack of funds, this has not been done, although NOAA and NASA recognize the value of such an archive, especially for mapping, land-use planning, and for mineral exploration. **The Government would have to decide whether the limited archive maintained at EDC would be transferred to the private sector and, if so, under what conditions. If the archive is transferred, safeguards to protect it from later deterioration or destruction should be instituted so that all interested parties will continue to have access to these data without copyright restrictions.**

University Programs

In addition to their role of developing and instructing in the use of new technologies, universities and other not-for-profit organizations have carried out research in using Landsat data for themselves, State and local governments, private industry, and the Federal Government. At present they face two major concerns: 1) the steeply rising prices of Landsat data and the concomitant decrease of Federal research support have caused some universities to reduce severely their research and teaching programs; and 2) the universities express worries that both the operational and research aspects of the U.S. Landsat program lack direction. **From the point of view of university researchers and teachers, these uncertainties make the prospects for the future grim, presaging further reductions in their teaching and research programs related to land remote sensing. Yet these institutions play a major role in technology transfer, both** in the United States and abroad.

CIVILIAN FEDERAL GOVERNMENT REQUIREMENTS

Data from the meteorological satellites have been used directly by the various Federal mission agencies either as they are transmitted to Earth, or after being processed and integrated with other weather data by the National Weather Service. If the process of transfer of the metsats to private ownership had continued, the Government would have offered to control, and pay for, the provision of required domestic and international meteorological data. It would have left to the private sector the design and operation of future satellites, sensors, and related equipment to ensure that the Government's needs for data were met.

For several years, data products derived from the Landsat MSS sensor have been applied by the mission agencies to specific resource management and evaluation tasks. In most cases, these data products have become the standard for the remote-sensing users, both within and without the Government. Although TM data will continue to be used for research purposes, **because of the difficulties and expense of processing the enormous volume of data represented in a TM scene, they will see relatively limited use. MSS-type data will continue to be of general interest to large parts of the user community for some time to come.**

In part this interest exists because the user community is accustomed to using the data, but for many users, the data's four-band multispectral characteristics and synoptic view are often of greater importance than their. spatial resolution, Although it will be important to continue to study the applicability of advanced data such as TM, which incorporates seven spectral bands, for Federal mission agencies, data equivalent **to MSS in format, spectral and spatial characteristics will satisfy most civilian Federal needs for the rest of the** 1980's.

Even if the private sector assumes responsibility y for providing remote-sensing data for the U.S. Government, it will be necessary for the Government to maintain oversight authority over such corporations to assure that they continue to provide Federal data needs. **It seems appropriate to designate a single lead agency to supervise and regulate all U.S. civilian remote-sensing activities. However, to protect both Government and private interests, it will be necessary that the agency act in such a way as not to stifle realistic opportunities for a private owner to exercise initiative and flexibility in providing data responsive to a worldwide market, including the private U.S. market.**

Government Data Requirements

If transfer of the Landsat system to private ownership were made soon, (i. e., while Landsat 5 is still functional'), it would be appropriate for the new owner to maintain data products and service equivalent to, or better than, the Government now provides using the MSS sensor. However, one of the reasons for transferring the system to private hands would be to achieve better data products, delivery, and services than now exist. **Thus, as the privately owned system evolved, the Government would be likely to demand improved service and products.**

As U.S. private satellites begin to incorporate improved sensors capable of higher resolution and pointing, as the French SPOT satellite has been designed to do, it will be tempting for the Government as well as other customers to ask the corporation to respond to special data needs, in addition to supplying routine data. However, such special tasking can only be accomplished at an extra cost, because it takes the satellite away from routine tasks. Because this differential pricing (for differing levels of service) also has the potential for being discriminatory, it should receive careful consideration and rules for handling it should be developed.

Alternative Systems

The Landsat system provides a unique capacity. No other technique in the world provides the ability to obtain reasonably detailed data (i. e., each minimum unit of Landsat MSS data represents 1.1 acres on the ground), over the **entire Earth,** and at a repetitive frequency that allows most temporal changes to be monitored effectively. However, in order to derive the maximum user benefits of this technology, it will be necessary to find ways to reduce sharply the system costs while improving delivery, **System studies by several private companies have shown it may be possible to achieve cost reductions of up to** 50 percent for **an operational system. If the Government decides to maintain its own civilian land remote-sensing system, it will be essential to find additional ways to reduce system costs. Because R&D is so expensive, major cost cutting for operational services implies that substantial R&D can no longer be done while providing a high level of routine services.**

*Landsat 5 will be called Landsat D ' until it is launched and operating in March 1984. Its nominal lifetime in orbit is 3 years for the spacecraft, 3 years for the MSS, and 1 year for the TM.

NATIONAL SECURITY REQUIREMENTS

The ability of the United States to collect extraterritorial information of military and intelligence value was suddenly and dramatically improved in the early 1960's with the development and operation of classified meteorological and reconnaissance satellite systems by DOD. Satellite programs provide, among other things, essential data about areas of the world where other types of U.S.

access is restricted. So long as both the civilian unclassified programs and the military classified programs are under the direct control of the Federal Government, the activities of both can be coordinated and controlled in the national interest. **However, placing remote-sensing programs in the private sector may make it very difficult to continue appropriate coordination between systems and control over data delivery.**

It is little appreciated that the intelligence and defense communities, taken together, currently are the largest users of Landsat data within the Federal Government. If there were no appropriate civilian Government system or sufficient safeguards on a privately owned system, these communities might find it necessary to build and operate their own system, thereby diminishing any expected budget savings.

DOD Oversight of Technical Specifications

NASA, in collaboration with other Federal agencies, academic institutions, and industry, has carried out a substantial program of experimentation and demonstration of sensors and data-processing techniques for land remote sensing. NASA has pursued its research in cooperation with DOD as provided for in the 1958 National Aeronautics and Space (NAS) Act. Until recently, the ground resolution of the civilian systems has not been sufficient to detect objects of significant military interest. However, the development of advanced high spectral and spatial resolution civilian sensors in the United States and abroad, and the prospect of private sector entry into the realm of land remote sensing, necessitate a re-**examination of U.S. and other national policies regarding technology development and technology transfer. Areas that should be examined carefully include the limits that should be placed on the ground resolution of space-borne sensors, their spectral characteristics, and on sophisticated data-processing techniques. However, in the face of the development of advanced foreign systems, it will be difficult for DOD to exert much control over advances in U.S. civilian hardware and processing techniques without making it impossible for the United States or its firms to compete in the world market.**

Preemption by the Military in Time of Emergency

The increased spectral and spatial resolution of TM or other 1and remote-sensing systems make the data they provide of increasing interest to DOD and the intelligence community. These data could serve as a supplement to other data collection means at any time. It **will be essential to spell out clearly the particular requirements of DOD and the intelligence community for hardening of the system's electronics, and the system specifications, as well as the conditions under which the private system could be preempted. Meeting these special requirements will add cost. If the private owner were to be required to meet them without specific compensation, data prices would be extremely high for all users, which would inhibit the development of a commercial market for data. If the Government were to pay for these additional capabilities, such support would constitute an additional subsidy of the system, beyond the basic ones of no competition and fixed data purchases.**

FOREIGN COMPETITION

It is clear that other countries, building on the experience gained from U.S. applications technology as well as on their own capabilities, see the development of meteorological, land, or ocean remote-sensing satellites as an integral component of their entry into space. In addition to constructing systems competitive with the U.S. Landsat system, they are also moving to develop systems that will sense the physical parameters of the oceans and the coastal waters. The United States, though it has a program within NASA to develop new sensors to fly intermittently on the shuttle, has no plans to develop civilian operational systems for land or ocean remote sensing that would provide continuous data over the long term with repeat coverage.

In order to maintain U.S. leadership in applications of space technology, it will be important for the United States to maintain continuity of data delivery. This is likely to require Government subsidy. It will also be important for the Government and the private sector to sustain a vigorous program of research in both space systems and the applications of the data such systems supply to the solution of a wide range of terrestrial problems. If the United States wishes to maintain leadership in this technology, it will be essential that the technology and the data it produces, whether publicly or privately owned, remain an integral component of U.S. domestic and foreign policy.