PLANNING FOR A
CIVIL OPERATIONAL LAND REMOTE SENSING SATELLITE SYSTEM:
A DISCUSSION OF
ISSUES AND OPTIONS

JUNE 20, 1980

TRANSMITTAL

To assist in the discussion of the establishment of a civil operational land remote sensing satellite program, the Commerce Department has prepared this document entitled "Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options." These issues and options are being given careful consideration by the Administration in its development of the FY 1982 budget and legislative program.

One of the key issues to be resolved by the Federal government is when to initiate an operational system that is fully responsive to the data requirements of users at a cost that users are willing to pay. The timing of the development of such a fully operational system will depend to a large degree on the willingness of users, including Federal agency users, and the private sector to invest in the operational system. Until a decision is reached on the design and funding of the fully operational system, the Federal government will rely on the existing NASA-planned Landsat D system with any extensions or improvements which may be necessary in order to meet the Administration's commitment to continuity of data during the 1980s.

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EXECUTIVE SUMMARY

This document discusses the issues and options relating to a national civil operational land remote sensing satellite system pursuant to the President's decision to assign to the National Oceanic and Atmospheric Administration of the Department of Commerce the management responsibility for civil operational land remote sensing satellite activities.1/ This document, prepared by the Commerce Department (Commerce), in coordination with other interested agencies,2/ discusses the issues involved in implementing an operational land remote sensing system from space, initially based on Landsat technology, with the goal of eventual private sector ownership and operation of the system. Some policy and technical options related to implementing an operational system are contained in this document, but decisions on these options will, for the most part, await the Administration's FY 1982 budget review and subsequent actions.

A land remote sensing satellite system provides information about the condition of the Earth's surface by a process of sensing radiation from objects on the Earth. The system uses sensors located on satellites which transmit the data to ground receiving stations for processing into usable data products. The current system is largely an experimental program called Landsat managed by the National Aeronautics and Space Administration (NASA). Information from the system has proven of value to a variety of public and private sector users in the United States and abroad for helping to make decisions related to such areas as agricultural crop forecasting, rangeland and forest management, mineral and petroleum exploration, mapping, urban and regional land use planning, water quality assessment and disaster assessment.

1/ The White House Press Release of November 20, 1979, announcing this decision is appended to this Summary at Attachment A.

2/ The National Aeronautics and Space Administration, the Departments of Agriculture, the Interior, Energy, State, and Defense, the Agency for International Development, the Environmental Protection Agency, and the Director of Central Intelligence.

Background

The issuance of the President's decision regarding civil operational remote sensing from space culminated a two-year Administration review of the nation's space policy. During this period, the Policy Review Committee (Space) was established and national policy on space programs was clarified. In May 1978, the President announced that the United States will encourage domestic commercial exploitation of space capabilities under appropriate U.S. authorization and supervision. Further, in October 1978, the President made a commitment to continue the availability of data from the Landsat program for all classes of users. In his March 27, 1979, Science and Technology Message, the President reiterated his Administration's commitment to the continuity of land remote sensing satellite data over the coming decade. Subsequently, Dr. Frank Press, the President's Science Advisor, in Administration testimony before the Senate Subcommittee on Science, Technology, and Space on April 9, 1979, stated that "the Administration is committed to an operational remote sensing system, although yet undefined."

From October 1978, through the summer of 1979, Executive Branch agencies examined the potential for integrating U.S. civil remote sensing satellite programs and for private sector involvement in U.S. civil space activities. They recommended that all U.S. civil operational remote sensing programs be managed by a single agency. The agencies also reported that the private sector would be interested in assuming more responsibility for land remote sensing from space if Federal policy and market uncertainties were clarified.

In November 1979, the President provided the framework within which a civil operational land remote sensing satellite system should be implemented, and assigned to the National Oceanic and Atmospheric Administration (NOAA) in Commerce the management responsibility for civil operational land remote sensing activities in addition to its ongoing atmospheric and oceanic responsibilities. NOAA's related ongoing responsibilities include managing the national civil operational meteorological satellite program and the Commerce Department's responsibilities for a joint operational demonstration by the Department of Defense (DoD), NASA and Commerce of a National Oceanic Satellite System (NOSS).

The Executive Branch's review of remote sensing satellite programs and policies was paralleled by a series of Congressional hearings during the 96th Congress on operational land remote sensing from space, including hearings before the House Subcommittee on Space Science and Applications of the Committee on Science and Technology and the Senate Subcommittee on Science, Technology and Space of the Committee on Commerce, Science and Transportation. Two bills before the 96th Congress focused on operational land remote sensing: S. 663, introduced by Senator Adlai E. Stevenson, which proposed the establishment of an Earth Data and Information Service in NASA, and S. 875, introduced by Senator Harrison Schmitt, which proposed the creation of a for-profit Earth Resources Information Corporation.

Assumptions

This document was developed in accordance with the following assumptions, which reflect the policies, established in the President's decision on civil operational remote sensing and previous space policy pronouncements, and the prerequisites to their achievement:

- The Federal government will ensure continuity of data during the 1980s;
- A national civil operational land remote sensing satellite system should ensure continuity of data and the appropriate reliability and timeliness of standard data products;
- User requirements, projected levels of demand and the cost of meeting these requirements should determine the design of the operational system;
- The Administration's goal is eventual private sector ownership and operation of the operational system, which includes the assumption of financial risk, as well as operational control by the private operator;
- Prices for land remote sensing satellite products should be set at levels that ensure maximum recovery of system costs consistent with the public good;
- The practice of the widest practical dissemination of Landsat data on a public nondiscriminatory basis will be continued for the data and standard data products from the Interim and Fully Operational Systems in accordance with prevailing U.S. national policies;

- o Eventual private sector ownership and operation of the U.S. program will be conducted under Federal government regulation, consistent with U.S. policies and international obligations;

- o The civil operational land remote sensing satellite program is a national program responsive to Federal interests and U.S. user requirements. Due regard will be given to foreign user interests and to foreign participation in the U.S. program;

- o NOAA will manage the operational system until a new institutional framework is established.

The Present Landsat System

The existing Landsat system consists of one satellite, Landsat 3, launched in 1978, which covers the Earth once every 18 days and transmits sensed data from an on-board multi-spectral scanner (MSS) and two return beam vidicon (RBV) cameras back to Earth, either directly to U.S. or foreign ground stations or indirectly from an on-board tape recorder which stores data until the satellite is within range of a U.S. ground station. NASA's Goddard Space Flight Center controls the satellite and performs the initial preprocessing of the data transmitted to Goddard from U.S. ground stations via domestic communications satellite (DOMSAT).

At the Department of the Interior's EROS Data Center in Sioux Falls, South Dakota, the Goddard preprocessed high density digital tapes are archived and further processed into standard data products (either computer compatible tapes or photographic images) for dissemination to domestic and foreign users at the cost of processing the order and reproduction. Similar preprocessing, processing, archiving and dissemination functions are performed by the nine foreign ground stations that now receive data direct from Landsat 3.

Two additional satellites, Landsat D and D', currently are under construction, with Landsat D tentatively planned for launch in 1982. The Landsat D series of satellites is designed to carry a new sensor, the Thematic Mapper (TM), which will provide 30m resolution1/ for the first time, as well as the MSS, and to use the Tracking and Data Relay

1/ The term "resolution", as used in this document, refers to the instantaneous field of view (IFOV).

Satellite System (TDRSS) for relay of data direct from Landsat to a single U.S. ground station at White Sands, New Mexico. To provide continuity with data from previous Landsats, the multispectral scanner (MSS), which provides 80m resolution, will continue to be deployed on Landsat D and D'. Direct readout of sensor data to foreign ground stations will be continued.

Because of difficulties in developing the TM and the associated ground data processing system, NASA is considering launching Landsat D without TM in 1982, to be followed by Landsat D' with TM later.1/ Current estimates for the operational preprocessing of Landsat D and D' data at Goddard are 200 MSS scenes per day beginning no earlier than 1983 and up to 50 TM scenes per day when the TM system becomes operational possibly no earlier than 1985.

The Interim and Fully Operational Systems

A fully operational land remote sensing system that meets optimal performance standards can be implemented at the earliest in 1989, given best estimates of the state of the art advances in sensors and the time required for Federal contracting procedures if they are used. Until that time, extension of the Landsat D system can ensure that, after 1983, the commitment to continuity of data during the decade of the 1980s is met.

From a technical standpoint, the following performance standards have been identified as applicable to a high quality operational system:

- o Sensors designed to generate data meeting a broad range of user requirements at a reasonable price;
- o Assured continuity of satellite coverage without break, with one backup satellite in orbit at all times and another on the ground;
- o 95% confidence that, averaged over a two-day period, all data will be processed and made available from the ground station within 48 hours of receipt; and
- o Ability to identify and process certain data out of order to meet urgent user needs.

1/ The Administration is also considering other alternatives such as delaying the launch of Landsat D until 1983 when the TM sensor will be ready.

However, the extent to which these compabilities are pursued will depend upon their full capital and operating costs and the demonstrated existence of an adequate private and Federal market to justify such costs.

While sensors specifically designed to generate data meeting a broad scope of user requirements cannot be provided until the late 1980s, the Landsat D sensors can be used as the basis for an interim system which will help to ensure continuity of data during the 1980s and meet many user needs.

The Administration is currently reviewing the Landsat D system to see where improvements may be required to ensure data continuity during the 1980s. For instance, the current Landsat system includes no satellites after Landsat D'. Anticipated gaps in spacecraft coverage of several years between about 1986 and the initiation of a fully operational system may have to be filled by the construction of one or more satellites or by the refurbishment of Landsat D. In addition, changes in the Landsat D ground segment may be required to minimize the risk of losing some data or having an excessively long delay in processing some data. The Landsat D system, with any follow-on satellites and ground system improvements, has been designated the "Interim Operational System."

The earliest possible date by which all four performance standards for a high quality operational system could be met is 1989, when the R&D necessary for the new solid state, multilinear array sensors should have been completed, and the sensors will have been fabricated, tested, and incorporated into either an existing multi-mission modular spacecraft (MMS) or a new spacecraft. The Landsat D system so modified is designated the "Fully Operational System."

A decision on when to implement the Fully Operational System requires careful examination of the Federal government's priorities, needed financial assistance, private sector willingness to invest in and take over the system, user demands during the interim system and the potential risk of foreign satellite systems obtaining a portion of the domestic and foreign land remote sensing market.

Management Arrangements for the Interim Operational System

Certain changes in management responsibility will take place as the Interim Operational System is implemented. Although the exact dates for transferring managerial responsibility to NOAA are subject to changes in NASA's schedule for Landsat D, NOAA plans to assume the following responsibilities from NASA and Interior on the following schedule:

- o NOAA will assume responsibility from NASA in FY 1983 for the command and control of the system and will begin providing MSS data on an operational basis after the successful launch and check-out of Landsat D and the MSS ground system and after NASA has demonstrated that the system is operational. NOAA will assume responsibility for TM data when that portion of the system reaches an initial operational level of performance;

- o NOAA will assume responsibility from NASA and the EROS Data Center in FY 1983-84 for the generation and dissemination of data and standard data products. Assuming it is cost-effective, a new facility would be co-located with the Landsat D preprocessing facility at Goddard and would be the sole sales outlet in the United States of data and standard data products from the Interim Operational System; and

- o NOAA will take title to the Landsat archival material at Goddard and the EROS Data Center in FY 1984 and will be responsible for archival and dissemination functions for the Interim Operational System.

During the interim operational phase based on the Landsat D series of satellites, NOAA will manage the system in coordination with an interagency Assistant Secretary level Program Board. In addition, the Secretary of Commerce will establish a Land Remote Sensing Satellite Advisory Committee with representatives of state and local governments, other domestic non-Federal users, and interested domestic private sector groups. Within NOAA, a new major line component, the National Earth Satellite Service, has been proposed to have managerial responsibility for the civil operational land remote sensing satellite program.

User Requirements for the Fully Operational System

User requirements should determine the design of the fully operational land remote sensing satellite system. A survey of governmental and private users indicates a wide range of possible requirements, depending on the type of application being considered, which could justify differing types of satellite systems.

To assist NOAA or an eventual private owner to develop a responsive operational system, a preliminary survey of possible user requirements was made. This survey indicated,

for example, that agencies that are interested primarily in renewable resource applications such as agricultural crop assessment want frequent observations, delivery of data within 48 hours in certain circumstances, spectral bands that discriminate between various types of vegetation and resolution higher than that provided by the current Landsat system. State and local governments, requiring data for land use management and protecting environmental quality, request higher resolution over urban and suburban areas and time-series analyses to detect detailed changes. The U.S. mineral extraction and related industries call for stereoscopic1/ capabilities, global coverage, thirty to forty meter resolution and processing of data within a few weeks. Foreign users interests appear to be similar to those of their U.S. counterparts, although area coverage requests obviously differ.

Further analysis and sorting of these requirements with respect to resolution, spectral bands, stereo coverage, frequency of observation and timeliness of product delivery will be necessary as plans are developed for the operational system.

Performance Options for the Fully Operational System

Hypothetical system performance options have been identified to meet some or most of the preliminary user requirements identified above. These options range from designing a system with capabilities similar to the Landsat 3 with MSS only, at an estimated 10-year cost of $1 billion, to building a new system which meets most of the currently stated user requirements, including two meter resolution, at an estimated 10-year maximum cost of $10 billion.2/ Stereo coverage can be provided at an additional cost of up to $700 million.

A final decision on the system design to be pursued for the Fully Operational System can be reached only after further analysis of user requirements, technical options, cost comparisons, system financing, and the effect of potential foreign competition.

1/ As used in this context, stereoscopic means two or more images, taken from different angles, to permit inference of the relative height of various topographic features.

2/ All costs are in FY 1980 dollars.

Revenues, Pricing Policies and Financial Assistance

Reliable projections of revenues from sales of standard data products, and from the direct reception fees to be paid by foreign ground station operators cannot be made at this time since the characteristics of the Interim and the Fully Operational Systems, the users' level of demand at various prices, the impact of a market expansion program and the impact of foreign competition are not now known. Tentative projections indicate that this system may not and probably will not be self-financing before the end of the century. Therefore, continued Federal financial contributions to support of the system likely will be necessary for the foreseeable future.

System revenues, generated by the sale of standard data products and foreign ground station access fees, now amount to only $6 million1/ a year.2/ Current fees consist of a nominal $200,000 access fee for foreign ground stations and cost of reproduction charges for standard data products -- $200 for a computer compatible tape and between $8 and $50 for various types of Landsat images. The projected costs of the Fully Operational System range from $100 to $400 million a year. To achieve the objectives for the sharing of costs by users, and for the eventual ownership and operation by the private sector, prices must be increased to cover, over time, the capital and operating costs of the system and the data and data products treated in a proprietary manner.

The system's manager could charge three types of fees for data and standard data products:

- o Basic Fee. A fee paid by each user on each standard data product it purchases from the U.S. system operator. These fees would vary in proportion to the costs incurred in producing that product. They would be paid by users of both real-time and retrospective data. Other factors such as timeliness, the placing of special orders and special handling could be reflected in a surcharge schedule.

1/ All revenues are in FY 1980 dollars.

2/ This figure includes $2.7 million from sales, $1.8 million from foreign ground station access fees and $1.3 million attributed to the value of the data distributed without charge to Federal agency users.

- o Royalty Fee. A fee paid by each U.S. and foreign user and foreign ground station operator on the reproduction or resale of Landsat standard data products.

- o Direct Reception Fee. One or more fees paid by foreign ground station operators receiving data directly from U.S. land remote sensing satellites. Examples of such fees are: (1) an annual access fee like the $200,000 fee per station per year currently being paid by Landsat station operators, and (2) a transmission fee paid by foreign ground station operators for data transmitted to and received by the foreign ground stations. This latter fee would be based on the amount of data requested.

Upon the completion of pricing studies, a proposed pricing schedule will be developed based on these types of fees, and possibly others, for consideration by the Program Board and the Land Remote Sensing Satellite Advisory Committee.

Since a substantial shortfall is projected between annual revenues and the estimated annual costs of running an operational system of between $100 and $400 million per year, Federal financial assistance likely will be required. In this event, the Federal government could provide various types of capital and operating assistance to a private or government corporation, whichever institutional option is eventually chosen. Such Federal capital assistance could include grants, equity guarantees, and Federal loan and loan guarantees. Federal operating assistance could include Federal support of research and development, purchase guarantees, appropriations, free services and tax incentives.

Whether for the Interim or Fully Operational System, three possible options for Federal agencies to share in the costs of financing the operational land remote sensing system are under consideration:

- o NOAA could budget for all "core"1/ and special system costs;

- o NOAA could budget for "core" system costs and user agencies would budget for special system capabilities;2/

1/ The "core" system includes the space and ground segment elements necessary to meet the common needs of the majority of users.

2/ Special system capabilities include stereoscopic coverage.

o User agencies could fund individually a predetermined portion of all "core" and special system costs.

A decision on the preferred financing option will weigh, on the one hand, the benefits of having a mechanism that forces agencies to make trade-offs between land remote sensing data and other sources and, on the other hand, the advantages of focusing responsibility for the program and budgeting in one agency.

Institutional Approaches to Eventual Private Sector Ownership and Operation

1. Institutional Alterantives

Several institutional options exist for achieving the goal of eventual ownership and operation by the private sector of our civil land remote sensing satellite activities. The four principal institutional options discussed in the document are:

(1) A private corporation (or consortium) selected competitively to own and operate all or part of the civil operational land remote sensing satellite system and to sell data to Federal agency users under a guaranteed purchase contract;

(2) A for-profit private corporation, authorized by Federal legislation, with private equity and privately and publicly appointed Board members;

(3) A wholly-owned government corporation authorized by Federal legislation, with Government equity, reporting to the Secretary of Commerce, with provision for subsequent transformation to a private stock corporation as system revenues warrant; and

(4) Federal agency ownership with private contractor operation, and provision for subsequent transfer to a private sector owner as system revenues warrant.

Options 1 and 2 offer the earliest possibilities of private sector ownership and assumption of risk. Options 3 and 4 delay implementation of private sector ownership until the next decade.

These options will be examined by the Administration over the next several months to evaluate which alternative best serves the Federal, state and local government and private sector interests in having an operational land remote sensing satellite program.

2. Establishment of Federal Policy to Encourage Private Sector Investment

Several policies impact the likelihood or willingness of the private sector to own the operational system. For example, under present policy, a system ower has no ownership rights in the Landsat data and standard data products. Without a change in this policy, a private owner would be denied the opportunity for profitability; therefore the Federal government would have to authorize the private sector to own and sell civil operational land remote sensing satellite data and standard data products on terms that eventually permit a reasonable return on investment. Other factors that affect private sector investment are competition from ongoing Federally funded R&D land remote sensing satellite systems and the duration of the Federal government's financial commitment to the land remote sensing satellite program. Conversely, a private system owner should be required to abide by the government policy of widest practical dissemination of data and standard data products on a public nondiscriminatory basis at prices that are consistent for domestic and foreign users.

3. Regulation of Private Sector Operation

A private owner of the land remote sensing satellite system could enjoy a monopoly. To protect the national interest, the private owner's activities should be regulated to the extent necessary to conform to national space and other domestic and foreign policy objectives. A private or government entity owning the operational system should be required, for example, to comply with international treaties such as the Outer Space Treaty for the conduct of peaceful activities in outer space; continue the widest practical dissemination of data and standard data products on a public nondiscriminatory basis; meet the needs of U.S. government users; and refrain from misuse of insider knowledge obtained from the land remote sensing satellite data.

Market Expansion

The system manager should undertake a market expansion program to increase revenues, reduce required Federal

financial assistance, and enhance decision-making through the use of land remote sensing satellite data. An important element of this program is assuring continuity of land remote sensing data.

A market expansion progam for the operational system can build on the types of training and technology transfer activities now being conducted by NASA and the Department of the Interior. NOAA could arrange for reimbursable training programs, enter into joint applications demonstration projects with users in all sectors, encourage university land remote sensing instructional programs and work with domestic and international assistance agencies to promote new opportunities for American business in the land remote sensing satellite field. As part of its ongoing R&D responsibility, NASA could continue to develop and demonstrate to users new techniques and technologies for using land remote sensing satellite data.

International Aspects

The United States should continue to encourage international participation in the U.S. civil operational land remote sensing satellite program by further developing an international community of data users and by continuing discussions with prospective foreign land satellite system operators to explore the prospects for encouraging complementarity and compatibility among future operational land satellite systems.

The United States should ensure that data from the Interim and Fully Operational Systems are made available to foreign users through sales of standard data products on a nondiscriminatory basis. NOAA, working closely with the Department of State and other interested agencies, should take the following actions:

- Consider foreign user requirements in planning the Fully Operational System;
- Conclude agreements with those foreign agencies wishing to receive data directly from the Interim and Fully Operational Systems;
- Establish pricing policies for data sales and direct reception fees that are consistent for domestic and foreign users; and

o Continue the Landsat Ground Station Operations Working Group as a forum for the exchange of technical information.

The land remote sensing satellite systems being developed by other countries offer the prospect of both competition and cooperation with the U.S. The competitive challenge to U.S. technological leadership is likely to occur in such areas as the development of multilinear array sensor technology, and sales of ground equipment, services and data products. NOAA, working closely with the Department of State and other interested agencies, should encourage the expansion of world-wide markets for U.S. equipment, services and data products, and pursue prospects for complementarity with foreign satellite operators in order to develop complementary system characteristics (e.g., orbits, coverage patterns and repeat cycles) and compatible system outputs (e.g., standard data product formats).

Legislation for the Operational System

Legal authority in four principal areas may be required in order to implement a civil operational land remote sensing satellite system:

1. Authorization for NOAA to develop, own and manage the civil operational land remote sensing satellite system until the responsibility is transferred to a private or other entity;

2. Establishment of the institutional structure, financial assistance and transition to private sector ownership and operation of the U.S. civil land remote sensing satellite system;

3. Establishment of a regulatory system to ensure that a private sector owner's activities are in compliance with U.S. laws, policies and international obligations; and

4. Establishment of proprietary interests in operational land remote sensing data and standard data products.

Summary of Issues

The following is a summary of the issues that have to be addressed as the Federal government moves toward an operational land remote sensing satellite system:

1. Continuity of Data in the 1980s

a. Operations

- o Whether to fund, construct and launch additional Landsat D series satellites with tape recorders to provide continuity in the acquisition of data from space until a Fully Operational System can be deployed?

- o Whether to improve the existing Landsat D ground segment at the Goddard Space Flight Center to provide continuous processing of the acquired data into timely and reliable standard data products?

- o Whether to transfer responsibility for command and control of the Landsat D space and ground segments from NASA to NOAA?

- o Whether to transfer responsibility for archiving and disseminating land remote sensing satellite standard data products from the Department of the Interior to NOAA, and whether to co-locate these functions with the satellite command and control and preprocessing facilities at the Goddard Space Flight Center?

b. Management

- o When to submit to Congress an Administration bill that authorizes NOAA to own and manage an operational land remote sensing satellite system until that system is transferred to another entity?

2. Initiation of a Fully Operational System

- o How to validate user requirements and their priorities?

- o When to establish a Fully Operational System utilizing new sensors that meet a broad range of user needs?

3. Pricing Policies and Financial Assistance

- o How to establish initial price increases for direct reception and for data and standard data products that are consistent for foreign and domestic users, provide adequate advance notice of price increases, and encourage potential users to invest in support equipment and reduce use of competing methods of data collection?
- o When to implement price increases?
- o How to fund the capital and operating costs of the Interim and Fully Operational Systems that exceed revenues?

4. Institution for Private Sector Involvement

- o What, if any, institutional framework for private sector ownership should be submitted to Congress?
- o What mechanisms for regulating and providing Federal financial assistance to the private sector should be provided in any bill authorizing an institutional framework for private sector involvement?
- o What policies should control the activities of any private sector owner for ownership of data and standard data products, for conditioning their dissemination on the payment of appropriate fees, for making possible the users' sharing of system costs beyond the costs of reproduction, and for requiring consistent pricing and ensuring nondiscriminatory availability of standard data products.

5. Market Expansion

- o What market expansion should be authorized for the Federal system manager?

6. International Aspects

- o How to encourage the growth of worldwide markets for U.S.-produced equipment, services and land remote sensing satellite data and standard data products?

Chapter I

INTRODUCTION

This document discusses the issues and options relating to a national civil operational land remote sensing satellite system pursuant to the President's decision to assign to the National Oceanic and Atmospheric Administration of the Department of Commerce the management responsibility for civil operational land remote sensing satellite activities. The document addresses the issues involved in implementing an operational system, including the physical elements of an operational land remote sensing satellite system, user requirements, system financing including pricing policies for users sharing of costs, Federal management and private sector involvement, market expansion, international aspects, transfers of functions, hardware and personnel and legislative matters.

This chapter discusses land remote sensing from space, reviews the development of applicable civil space policy with respect to land remote sensing from space, and sets forth current Administration direction and the assumptions underlying the document.

A. Land Remote Sensing from Space

The purpose of a land remote sensing satellite system is to provide data and information about the condition of the surface of the Earth's land masses to assist a wide variety of users to make resource-related decisions. Observing instruments are placed aboard a satellite which circles the Earth in an orbit chosen so that the satellite will traverse almost all areas of the Earth on a schedule that facilitates the observations of most interest. The instruments respond to emitted or reflected energy at a number of discrete wavelengths ranging from those of visible light into the infrared region and, potentially, on into the microwave region normally associated with radar.

The character of the data produced and its utility to users are determined by the following key parameters:

- o Resolution, related to the size of the smallest object that can be delimited accurately from the data;

1/ The term "resolution," as used in this document, refers to the instantaneous field of view (IFOV).

- o Spectral bands, related to the portions of the electromagnetic spectrum of energy radiated or reflected by the earth to which the spacecraft sensors are sensitive;

- o Stereo coverage, related to the availability of data from which the variation in the height of the surface being viewed can be determined;

- o Frequency of observation, related to the interval between repeat coverage of the same spot on the Earth; and

- o Timeliness, related to the length of time between the observation itself and the delivery of suitable processed data to users or to the archive.

The signals from the instruments are combined into a data stream which the satellite transmits to one or more receiving stations when it is instructed to do so. The received data stream is recorded and processed to various standard formats. These materials, which are described in greater detail in Chapter II, will be referred to in this document as "standard data products."

Data are either used immediately or stored in an archive for later retrieval and study. Since many processes of long-term interest, such as desertification, land use, or the spread of disease in forested areas, require accurate detection of changes, the ability to retrieve standard data products from the archive for so-called retrospective users significantly enhances the usefulness of the data.

Depending on the information desired by a user, the standard data products may be used directly, or manipulated by computers and interpreted in various ways to produce "value added products". For instance, an image can be constructed using arbitrary colors assigned to ranges of the measured quantities to emphasize differences from one part of the scene to another. The contrast at boundaries within the scene can be enhanced, and the intensities of two wavelength bands at each point of the scene can be compared. This information can be combined with information from other sources, such as topographical surveys or precipitation records. Users often employ professional geologists,

agronomists, urban planners, or others as appropriate to interpret these products, providing information that is valuable to those who wish to make decisions involving knowledge about or changes on the surface of the Earth.

The benefits of this information have become evident in decisionmaking on renewable resources (agricultural production and forecasting, and management of rangeland, forests and water resources), non-renewable resources (geologic survey; mineral and petroleum exploration; cartography, coastal oceanography and resource evaluation; and demography) and environmental management (urban and regional land use planning; environmental protection; disaster assessment; and coastal engineering). These uses are detailed in Chapter III, User Requirements for the Fully Operational System.

The growing recognition of the value of and need for this data has led to a widespread demand that the Federal government take steps to assure continuity of data.

B. Development of The Administration's Decision on Civil Operational Remote Sensing

The President's decision regarding civil operational remote sensing from space culminated a two-year Administration review of the nation's space policy. In 1977, President Carter directed the National Security Council to lead a review of the existing space policy of the United States and to formulate overall principles to guide United States space activities. This review resulted in a Presidential directive in May 1978, which articulated broad national policies to guide the conduct of United States activities in space and established a Policy Review Committee on Space (PRC (Space)) to provide a forum for discussion of proposed changes to national space policy and for rapid referral of issues to the President. The directive also established that the United States will encourage domestic commercial exploitation of space capabilities under United States government authorization and supervision.

Upon the completion of a four-month interagency analysis by the PRC (Space), in October 1978, a more detailed space policy was formulated setting the direction of U.S. efforts in space over the next decade. Three principal directions for the nation's civil space program were specified: (1) activities will be pursued in space when they can be more efficiently accomplished there; (2) our space policy

will reflect a balanced strategy of applications, science and technological development; and, (3) an adequate Federal budget commitment will be made to achieve the objectives of identified space applications.

In October 1978, the decision was also made that the United States would ensure continuity of data from the experimental Landsat program and continue to provide these data to public and private users. In his March 27, 1979, Science and Technology Message, the President reiterated his Administration's commitment to the continuity of land remote sensing satellite data through the 1980s.

In the spring of 1979, Congressional attention also was focused on operational land remote sensing from space. Two major land remote sensing satellite bills were introduced in the 96th Congress: S. 663, introduced by Senator Adlai E. Stevenson, proposed the establishment of an Earth Data and Information Service in NASA, while S. 875, introduced by Senator Harrison Schmitt, proposed the creation of a for-profit Earth Resources Information Corporation. The House Subcommittee on Space Science and Applications of the Committee on Science and Technology, and the Senate Subcommittee on Science, Technology and Space of the Committee on Commerce, Science and Transportation, among others, held hearings. The President's Science Advisor, Dr. Frank Press, stated in Administration testimony that the Administration "is committed to the continuity of remote sensing data for civil application through the 1980s," and further that "the Administration is committed to an operational remote sensing system, although yet undefined." He asked the Congress not to enact a specific bill on operational land remote sensing until the PRC (Space) completed its studies of the system.

The Federal government's policy review of civil operational land remote sensing activities considered in part the satellite system plans of other countries:

- o France is planning a two satellite land remote sensing system called SPOT, which will begin with a launch in 1984.

- o Japan is planning a five satellite land and ocean observations program--including a Marine Observations Satellite (MOS-1) in 1985 and a Land Observations Satellite (LOS-1) in 1987.

- The European Space Agency (ESA) is planning to launch a Coastal Ocean Monitoring Satellite System (COMSS) in 1986 and a Land Applications Satellite System (LASS) in late 1987 or early 1988.

- India launched a rudimentary remote sensing satellite in 1979 and plans one similar to the first in 1982 and a more elaborate mission in the mid-1980s.

- The Soviet Union has flown a high resolution land observations camera system on manned and unmanned missions. The Soviets also are testing coarse resolution multispectral scanners on their meteorological satellites.

Some of these systems will incorporate high resolution solid state multilinear array sensors more advanced in terms of resolution than those on Landsat D.

By the summer of 1979, agency task forces had completed their studies and had submitted their recommendations to the PRC (Space). A principal recommendation was to integrate the management of civil operational remote sensing satellite programs within a single agency.

C. Current Presidential Direction

President Carter announced the United States policy on civil operational remote sensing in space in November 1979, outlining the policy framework for civil operational land, meteorological and ocean remote sensing satellite programs. NOAA was assigned the management responsibility for civil operational land remote sensing satellite activities in addition to its on-going atmospheric and oceanic responsibilities, and was directed to prepare, in coordination with other appropriate agencies, a time-phased transition plan proposing how to move from the largely experimental Landsat program built by NASA to a fully operational system, with the goal of eventual operation by the private sector.

D. Underlying Assumptions

This document has been developed in accordance with the following assumptions, which reflect the policies, established in the President's decision on civil operational land remote sensing and previous space policy announcements, and the prerequisites to their achievement:

- o The Federal government will ensure continuity of data during the 1980s;
- o A national civil operational land remote sensing satellite system should ensure continuity of data and the appropriate reliability and timeliness of standard data products;
- o User requirements, projected levels of demand and the cost of meeting these requirements should determine the design of the operational system;
- o The Administration's goal is eventual private sector ownership and operation of the operational system, which includes the assumption of financial risk, as well as operational control by the private sector;
- o Prices for land remote sensing satellite products should be set at levels that ensure maximum recovery of system costs consistent with the public good;
- o The practice of the widest practical dissemination of Landsat data on a public, nondiscriminatory basis will be continued for the data and standard data products from the Interim and Fully Operational Systems in accordance with prevailing U.S. national policies;
- o Eventual private sector ownership and operation of the U.S. system will be conducted under Federal government regulation, consistent with U.S. policies and international obligations;

- The civil operational land remote sensing satellite program is a national program responsive to Federal interests and U.S. user requirements. Due regard will also be given to foreign user interests and to foreign participation in the U.S. program; and

- NOAA will manage the operational system until a new institutional framework is established.

CHAPTER II

PROVIDING CONTINUITY IN THE 1980s

Because of the long lead time required for budgeting, design, development, construction, launch and check-out, a fully operational satellite and ground system responsive to user requirements could not become operational until 1989 at the earliest. Accordingly, the United States must rely on the existing Landsat D satellite and ground system designs, with additional satellites and ground system improvements as needed and justified programmatically, to meet the objective of assuring data continuity in a reliable and timely manner through the 1980s. The Landsat D satellite design is largely experimental but its capabilities are generally those desired by most users when the TM sensor is operational. It also carries the proven MSS sensor which is operationally reliable, although the current ground system does not meet fully operational standards.

This chapter reviews the existing Landsat 3 system, the currently planned Landsat D system and identifies some system design changes that could be useful for upgrading the Landsat D "Interim Operational System". The management structure and transfers of hardware and personnel necessary to implement this Interim Operational System are also identified.

The chapter assumes certain dates for launching Landsat D and Landsat D', the currently NASA-planned satellite system, but these dates may be changed when a final launch schedule is developed later this year.

A. The Existing Landsat System

At the present time, United States land remote sensing satellite data comes from a single experimental satellite, Landsat 3, and its associated ground facilities.1/ Its design and operating characteristics are described in the following paragraphs.

1. Data Acquisition

Landsat 3 was launched in 1978 and currently is operating in an orbit that allows it to acquire data from almost any given spot on the Earth every 18 days. Two

1/ After ceasing operation in November 1979, Landsat 2 is currently able to provide data within view of the receiving stations within the U.S. and abroad.

instruments are aboard: (a) a Multi-spectral Scanner (MSS), which provides data in four bands of the visible and near-infra-red portions of the spectrum, and (b) two Return Beam Vidicon (RBV) cameras, which essentially provide black and white TV images. The MSS scans a swath 185 km wide and has an instantaneous field view (IFOV) of 80 meters, which for many scenes is approximately equivalent to a photographic resolution of about 160 meters. Each RBV image from Landsat 3 covers an area 90 km on a side (180 km total swath) and has an equivalent IFOV of 40 meters.

Data can be returned to Earth when the satellite is within view of one of the receiving stations -- the NASA stations in Alaska, California, and Maryland, and nine foreign owned and operated Landsat ground stations which operate under agreements with NASA. Data acquired while beyond the range of a ground station are stored by a wide-band video tape recorder on board the satellite until the satellite is within range of a U.S. station. A control center at the Goddard Space Flight Center (Goddard) monitors and commands the satellite to acquire and transmit data directly to U.S. or foreign ground stations.

The total anticipated life of Landsat 3 is three years, although it may cease to function at an earlier date. No backup satellite for Landsat 3 exists in the current system, so a gap in continuity of MSS coverage may well exist from at least some time in 1981 until Landsat D is launched and begins to function in 1982 at the earliest.

2. Preprocessing

The master recordings (station tapes) at U.S. ground stations of Landsat 3 data are processed at Goddard to segregate data from each of the spectral bands of the MSS and to apply (a) radiometric corrections to account for the difference in response of the detectors in the various spectral bands, and (b) geometric corrections which account for distortions in the satellite viewing process and relate the received data to the exact position on the ground that was observed by the satellite.

The results of this preprocessing are recorded in High Density Digital Tape (HDDT) form, either as fully corrected data, or with the required geometric corrections only noted on the tape. Foreign ground stations perform an equivalent function, although not all of them apply a full set of corrections. The time required for this process currently averages about two weeks at Goddard, although high priority special tasks can be completed within 48 hours.

HDDTs are provided to the Department of the Interior's EROS Data Center in Sioux Falls, South Dakota, and the Department of Agriculture's facility in Houston, Texas.

3. Processing into Standard Data Products

At the EROS Data Center, the data in HDDT form are put through additional computer processes to convert them into standard data products suitable for sale to public or private sector customers, who in turn may use them in that form or further process them for their own use or for resale to additional customers. Two classes of standard data products are available -- film imagery, which is convenient for those accustomed to working with maps and photographs, and computer compatible tapes (CCTs). The tape form is suitable for input to standard computers and lends itself to automated or specialized data handling and analysis. Depending on workload and priority, the time required for the preparation of standard data products averages about 10 days, ranging from a few days to several weeks. The prices charged for these standard data products are set by the cost of producing copies and handling orders. Each of the foreign ground stations is able to generate its own standard products for sale to customers.

4. Special Processing

Some users require extremely rapid processing because of the ephemeral value of the data for such uses as crop forecasting and water quality assessment. Special processing to enhance certain features or to meet R&D needs, such as the development of new interpretation techniques, also is required by users. Some users, such as the mineral extractive industry, arrange for their own special processing to obtain information suited for their particular requirements.

5. Archiving

The bulk of U.S. Landsat data is archived at Goddard and the EROS Data Center. (Master tapes are at Goddard; processed products are at the Center.) In addition to the physical safekeeping of the records in an economical form, the archival function includes maintaining an inventory, a browse system for searching the records, and a retrieval system that permits rapid and efficient response to orders for retrospective data.

The NASA agreements with foreign ground station operators call for such stations to provide the EROS Data Center with a listing, but not copies, of all their accessions from the Landsat program. This approach reduces the cost of operating the archive at the EROS Data Center by avoiding the cost of generating a duplicate archive for the foreign holdings.

In addition to the central products archive at the EROS Data Center, separate partial collections are maintained by major users of Landsat data for their own purposes.

6. Training and Applications Development

Since the application of Landsat observations to resource management is a relatively new field, training is an important part of the current program. Training breaks into two categories: (a) maintenance and operation of station and processing equipment, and (b) training in the interpretation and use of Landsat data.

Training in maintenance and operation is done by the equipment manufacturers or on the job. Training in interpretation and use of the data is available through a number of universities and private organizations, but the major organized effort is run by the EROS Data Center, which has developed curriculum material and acquired the necessary facilities. The EROS Data Center is not able to accommodate all of the requests for training it receives. About 90% of its current training is in support of Department of the Interior (DOI) needs, and the balance is devoted to students sponsored by other U.S. government agencies or foreign governments. Foreign students often are sponsored by the Agency for International Development (AID), either at the EROS Data Center or in training programs abroad, which have been conducted to foster the beneficial use of Landsat data.

The development of new applications of Landsat data and new techniques of interpretation goes hand-in-hand with training professionals in the new methods. NASA, through its technique development and transfer programs, works directly with potential new users partly to develop

and test new application techniques and partly to learn at first hand the users' practical needs. Similarly, DOI has set up arrangements for joint application programs with users. Some private sector firms work directly with customers.

B. The Currently Planned Landsat D System

The Landsat D system was designed by NASA in large part as an experimental system. The major objectives of the Landsat D program are to continue the availability of MSS data after the demise of Landsat 3, to assess the capabilities of a new sensor, the Thematic Mapper (TM), and to provide a transition from MSS to TM data. The Landsat D system as currently designed has the following characteristics:

1. Data Acquisition

The Landsat D series of satellites is designed to carry a TM in addition to an MSS. The TM will have seven spectral bands, including three in the infrared region, and an instantaneous field of view (IFOV) of 30 meters for all but the thermal infrared band. Each satellite's sun-synchronous orbit will have a repeat cycle of 16 days. Data will be returned to ground stations in two ways: (a) directly to foreign ground stations, at S-band for those who wish to continue to receive only MSS data without modification to their equipment, and at X-band for those who wish to receive a combination signal of MSS and TM data; and (b) indirectly through the Tracking and Data Relay Satellite system (TDRSS) to the single U.S. TDRSS ground station at White Sands, New Mexico.

Two satellites, Landsat D and D', are currently under construction. Each satellite is estimated to have a life expectancy of about three years.

2. Preprocessing

Preprocessing will take place at the Landsat D ground system facility at Goddard. The production objective is a daily output in HDDT form of 200 MSS scenes per day beginning no earlier than 1983, and up to 50 TM scenes per day no earlier than 1985. Because of the additional spectral bands and the higher resolution of the TM, and the resultant substantially higher complexity and volume of data, TM preprocessing, although similar in nature, is substantially more complex than MSS preprocessing. Current system design provides for serial processing with 85%

confidence that, averaged over a ten day period, all data will be processed and made available from the ground station within 48 hours of receipt. A Landsat Assessment system, an R&D facility for investigation and development of new earth resources management techniques using data from the TM sensor, is planned by NASA in conjunction with the Landsat D ground facility.

3. Processing and Dissemination of Standard Products

Standard data products will include film imagery, digital data for direct transmission where required for immediate use, and digital data on magnetic tape. The data will be radiometrically corrected and will include geometric referencing information (i.e., HDT-A form). In addition, a limited variety of standard mapping projections will be available in both digital and film form.

The EROS Data Center will archive and disseminate Landsat standard data products to domestic and foreign users from its facility in Sioux Falls, South Dakota.

C. The Interim Operational System

1. System Design

From the point of view of the users, "data continuity" means that data will be collected continuously and made available in a timely manner with a reasonable degree of reliability. From a technical standpoint, the following performance objectives have been identified as applicable to a high quality operational land remote sensing satellite system:

- Sensors designed to generate data meeting a broad range of user requirements at a reasonable price;
- Assured continuity of satellite coverage without break, with one backup satellite in orbit at all times and another on the ground;
- 95% confidence that, averaged over a two-day period, all data will be processed and made available from the ground station within 48 hours of receipt; and
- Ability to identify and process certain data out of order to meet urgent user needs.

While sensors designed to generate data meeting a broad range of user requirements cannot be provided until the late 1980s, the Landsat D sensors will be able to accommodate many user needs. Some system design changes could be made in the currently planned Landsat D system that would move towards meeting these performance objectives during the Interim Operational System. Such system design changes have to be justified on how essential they are to the users and how they will be financed.

a. Data Acquisition

In response to the commitment to continuity of land remote sensing satellite data through the 1980s, NASA and NOAA are reviewing the Landsat D series launch schedule in light of two interrelated concerns:

- o No backup to Landsat 3 exists other than Landsat D which could lead to a gap in coverage between the demise of Landsat 3 and the launch of Landsat D; and
- o One or more additional satellites may have to be scheduled to follow Landsat D and D', to ensure coverage following the end of the useful life of Landsat D' and before the Fully Operational System is established.

There is a strong likelihood that there will be some data coverage gap between Landsat 3 and D. NASA, however, is currently reviewing possible alternatives for launching Landsat D. One alternative is the launch of Landsat D without the TMM in 1982. In that case, Landsat D' with the TM, which will be available for launch in 1983, would be launched in late 1983 or early 1984.1/ To maintain continuity between Landsat D' and the eventual Fully Operational System may necessitate procurement of follow-on spacecraft.

Another change which could be made to the Interim Operational System is the placement of tape recorders on Landsat D' and subsequent satellites to ensure full collection of MSS data when the TDRSS system is unavailable due to schedule conflicts and to provide MSS data from the so-called "zone of exclusion," the area over the Indian

1/ The Administration is also considering other alternatives such as delaying the launch of Landsat D until 1983 when the TM sensor will be ready.

sub-continent and south-central USSR where direct satellite transmission via the TDRSS is physically impossible. However, some of the data might be obtained through ground stations on an as needed basis.

b. Preprocessing

Improvements to the Landsat D ground system facility at Goddard could also be made at some time in the interim phase if necessary to minimize the risk of losing some data or having an excessively long delay in processing some data. Some possible ground system changes are discussed below. To increase reliability, points in the current system where failure of a single component could completely halt the processing of data could be eliminated. Equipment also could be added to provide out-of-order processing for data on significant events such as flooding and crop freezes. Initiation of these improvements could move the system towards the high quality operational performance standards.

MSS data and standard data products will be available on an initial operational basis no earlier than 1983. Following the launch of Landsat D', no later than early 1984, and assuming techniques for producing standard data products from TM are developed, TM data can be produced on an initial operational basis by 1985.

c. The "Core" System

The Landsat D system, with any improvements suggested above, will be considered the "core" Interim Operational System for purposes of the document. Additional capabilities, such as stereoscopic capability and continuous dedicated dual coverage, will not be added to the Interim Operational System unless users are found who are willing to pay the initial capital and subsequent operating costs.

2. Management Arrangements

a. NOAA's Management Functions

The following transfers of operational responsibility will allow NOAA to operate the Landsat D System as an Interim Operational System:

- o NOAA will assume responsibility from NASA in FY 1983 for the command and control of the system and will begin providing MSS data on an operational basis after the

successful launch and check-out of Landsat D and the MSS ground system, and after NASA has demonstrated that the System is operational. NOAA will assume responsibility for TM data when that portion of the System reaches an initial operational level of performance;

- o NOAA will assume responsibility from NASA and the EROS Data Center in FY 1983-84 for the generation and dissemination of data and standard data products. Assuming this is cost-effective, a new facility would be co-located with the Landsat D preprocessing facility at Goddard and would be the sole sales outlet in the United States of data and standard data products from the Interim Operational System; and

- o NOAA will take title to Landsat archival material at Goddard and the EROS Data Center in FY 1984 and will be responsible for archival functions for the Interim Operational System.

Plans for the transfer of functions, hardware and personnel are described in Section D of this chapter.

In addition to managing the technical system during the interim operational phase, NOAA should carry out the following functions in order to assure full implementation of an operational system:

- o Manage all Federal funds required for the operational system. Except as necessary for its market expansion programs and NOAA's other mission needs, NOAA will not fund the purchase of data and standard data products by users, the provision of special services uniquely required by user agencies, the preparation of value-added products, or the R&D and any prototype procurements required for the operational systems (the latter being funded by NASA);

- o Evaluate the data requirements of users and ensure that the operational system meets their needs to the maximum extent possible, given user willingness to reimburse for services and budgetary constraints;

- o Establish and operate a satellite and ground processing tasking system that responds to programmatically justified user priorities;

- o Implement the President's goal with respect to the eventual ownership by the private sector of the land remote sensing satellite system by pursuing appropriate pricing and market expansion efforts, and the establishment of a satisfactory institutional framework based on the private sector's willingness to invest and share in the risk;

- o Establish policies for the sale of Landsat data and standard data products to users;

- o Arrange for direct reception at appropriate cost of Landsat data by foreign ground stations, pursue complementarity and compatibility among national operational land remote sensing satellite systems, and represent U.S. operational land remote sensing satellite interests with other countries and international organizations;

- o Seek such legislation, Executive Orders, and Presidential directives as are necessary for the operation of the U.S. operational land remote sensing satellite system and for the adoption and enforcement of appropriate regulations.

NOAA proposes to assign the responsibility for managing the operational land remote sensing program to a new National Earth Satellite Service (NESS). When approved, NESS would be a major line component within NOAA, headed by an Assistant Administrator for Satellites who reports

directly to NOAA's Administrator. NESS will consist of NOAA's programs under the former National Environmental Satellite Service, augmented to handle NOAA's new management and policy responsibilities and the additional technical activities. NESS will be organized to ensure adequate attention to policy formulation, regulation, relations with users and private industry, and international activities related to land remote sensing. NESS will continue to manage the Nation's civil operational meteorological satellite system and NOAA's responsibilities related to the proposed National Oceanic Satellite System (NOSS). NOAA'S Environmental Data and Information Service will manage the Landsat archiving function and will disseminate Landsat standard data products to users of retrospective data.

b. Interagency Coordination

Pursuant to the President's decision, the Commerce Department will, in FY 1981, establish and chair an Assistant Secretary level Program Board for continuing federal coordination and to consider issues related to regulation of private sector involvement. The Board will be composed of representatives from the Departments of Defense, the Interior, Agriculture, Energy, State and Commerce, the National Aeronautics and Space Administration, the Environmental Protection Agency, the Agency for International Development, the U.S. Army Corps of Engineers-Civil Works, the Director of Central Intelligence and the Executive Office of the President.

The Program Board will serve as a mechanism for continuing Federal coordination and regulation on such matters as:

- Policy issues related to the civil land remote sensing statellite program;
- NOAA's management of the civil land remote sensing satellite program;
- International negotiations;
- Priorities among the data requirements of the Federal and other users;
- A satellite and ground processing tasking system;

- Data and pricing policies;
- Proposals for private sector involvement;
- Private sector regulation;
- Federal budget requests;
- Relationships with other Federal data sources; and
- Necessary research and development.

If NOAA's management decisions are at variance with the Program Board's policy recommendations, the Program Board or any one of its members may refer such issues to the PRC (Space) for consideration and action.

The role of the Program Board will be re-evaluated by the PRC (Space) if an entity other than NOAA assumes responsisibility for the ownership and operation of the U.S. civil land remote sensing satellite program.

c. Non-Federal Participation

The Commerce Department plans, in FY 1981, to establish a Land Remote Sensing Satellite Advisory Committee consisting of fifteen representatives from the interested domestic non-Federal communities, including State and local governments, end users, organizations that use Landsat data to supply information products, service organizations, and potential commercial system developers and operators. These representatives will be selected by the Secretary of Commerce and will serve three year staggered terms. The Chairman and Vice-Chairman will be designated by the Secretary of Commerce. The Chairman will be asked to attend Program Board meetings as necessary. NOAA/NESS will provide staff support to the Advisory Committee.

The Land Remote Sensing Satellite Advisory Committee will advise NOAA with respect to the interests of the domestic non-Federal user communities in the following areas:

- Management of the civil land remote sensing satellite program;

- o Priorities among the data requirements of non-Federal users;
- o Policy issues related to the civil land remote sensing satellite program; and
- o Proposals for private sector involvement.

The role of the Advisory Committee will be re-evaluated if an entity other than NOAA assumes responsibility for the ownership and operation of the U.S. civil land remote sensing satellite program.

In addition to creating the Advisory Committee, NOAA will continue to work closely with all users on their data requirements and on approaches to private sector involvement in the operation of the system. NESS will establish an office to serve as a focal point for liaison with the Landsat user community, technical societies and special interest groups, and with those companies concerned with private sector involvement.

D. Transfers of Functions, Hardware and Personnel

Implementation of the Interim Operational System will require transfers of the function of archiving and dissemination of standard data products from the EROS Data Center (EDC) in the Department of the Interior and of hardware and personnel from the National Aeronautics and Space Administration (NASA). The necessary transfers are set forth below. Interior and NASA have indicated their concurrence in these transfers.

1. The EROS Data Center

The only functions at the EROS Data Center within NOAA's new management responsibility for the U.S. civil operational land remote sensing satellite program are the national archiving of Landsat data, and the servicing of users who draw upon this archive. The many other functions performed at EDC, such as the archiving of Interior's aircraft data, serving users who draw upon this archive, as well as research related to Landsat applications and the conduct of training programs in the use of Landsat data, primarily service Interior in the performance of its missions.

Interior and Commerce have agreed that it is probably in the best interests of the programs of both agencies that the national Landsat archiving and retrospective user service functions be co-located with the preprocessing facility for the Landsat program at the Goddard Space Flight Center. Such a co-location should ensure more efficient and reliable operation under one contractor, enable cost savings to be realized in the modification of the MSS ground system to handle TM data, and facilitate any future integration of Landsat data processing with the processing of data from the meterorological and ocean remote sensing satellite systems.

The transfer of these functions to NOAA will occur by FY 1984 when operational use of Landsat D MSS data has begun and management responsibility has been transferred to NOAA. These transfers will result in the loss of revenues to Interior from the sale of Landsat standard data products -- currently $2.7 million. Future revenues will be collected by NOAA.

2. NASA Transfers

NASA and Commerce have agreed on a phased transition of operational responsibility from NASA to NOAA with respect to the Landsat D program beginning in 1983.1/ Ownership of the operational Landsat D hardware will transfer to NOAA along with the transfer of operational responsibility. Major steps in this transition are set forth below:

FY 1983	Data processing responsibility for MSS data transferred after NASA has demonstrated that the system is operational;
FY 1983	Command and control responsibility for Landsat D transferred at the time data processing responsibility for MSS data is transferred;
FY 1984	NOAA will work with NASA to archive and disseminate TM data during the initial production phase from early 1984 until operational status is achieved.

1/ These dates are subject to refinement when the final launch schedule for Landsat D and D' is determined.

Specifically, NASA will provide NOAA with space in Building 28 and elsewhere at the Goddard Space Flight Center to house the command and control, preprocessing, processing, archiving and dissemination functions for the Landsat D program. NOAA will reimburse the Goddard Space Flight Center for operational support costs and maintenance. No building transfers will be required.

NASA uses contract personnel for most day-to-day Landsat operations and control. Since NOAA plans to contract out the operation and maintenance of the Landsat D facilities, existing NASA contract tasks will be phased over to NOAA during the transition period and appropriate budget adjustments between the two agencies will be made.

When Landsat D MSS operations are transferred to NOAA, NASA will transfer to NOAA available positions from the Goddard Space Flight Center and from its Office of Space and Terrestrial Applications, which provide current civil service support, for the management of operational aspects of the Landsat program, the tasking of Landsat satellites and the interface between operational users and the Landsat program.

Staff support of these functions is also provided by NASA Headquarters staff offices, including the Office of the Comptroller, the Office of General Counsel, and the International Affairs Division. As needed, civil service positions will be transferred from the International Affairs Division in connection with functions related to the Landsat Ground Station Operations Working Group and the negotiation of Memoranda of Understanding with foreign station operators, which will be assumed by NOAA in FY 1983.

Chapter III

USER REQUIREMENTS FOR THE FULLY OPERATIONAL SYSTEM

The earliest opportunity to achieve significant improvements in performance characteristics beyond the Landsat D system would be 1989, since the sensor research and development activities necessary to support an improved system cannot be completed before that time at the earliest. To determine the optimum design of such an improved system, an evaluation of anticipated user requirements for data and standard data products from the Fully Operational System is required.

This chapter reviews briefly the methodology used in projecting user requirements, the current uses of land remote sensing satellite data, and the preliminary estimates of technical performance characteristics to meet user needs at varying levels of satisfaction.

A. Methodology Used in Projecting User Requirements

Projecting the types and quantities of data that users will desire a decade from now from a largely unknown, highly sophisticated, multiple use system is an extremely risky effort. Among the factors inhibiting meaningful projections are:

- For those users requiring reliable and timely standard data products, the current absence of such products with which users can experiment to determine the products' usefulness;
- The rapid changes in computer technology -- both increased capacity and reduced cost -- that may make currently impracticable types of data analysis routine by the end of this century;
- The importance of interactive use of these products with other sources and types of information, such as weather, seismic, geomagnetic, and demographic data, which makes the value of these products dependent on changes in the availability and cost of other products;

- o The continuing identification of new techniques for using the products, as research on the interpretation of new types of land remote sensing satellite data progresses;

- o The tendency of users to express a preference for currently available types of data or to make self-limiting assumptions about available technology when defining their needs;

- o The converse tendency of sophisticated users to want the very best product, especially when price differentials and their own levels of use cannot readily be predicted, because the very best product will then be available if needed; and

- o The tendency of users to define product requirements in terms of their current missions and objectives, which may undergo significant alteration by the end of the century.

Several of these factors will be affected significantly during the 1980s by the experience derived from the Interim Operational System described in Chapter II, and by the scope and character of a domestic and foreign market expansion program further described in Chapter VII.

In analyzing user needs, the Commerce Department drew upon the existing body of literature -- prior space policy studies; internal studies within the major federal user agencies; studies by associations of state and local government users; statements by an association of users in the minerals extraction industry; NASA studies related to the Landsat program; and the limited number of assessments by private companies of the future requirements of U.S. industry, foreign industry and foreign governments.

In addition, NOAA requested the major user groups to evaluate the initial assessment of user requirements that was developed from the existing literature. Domestic non-federal users were asked to contribute by reviewing the initial assessment at five regional user workshops, commenting particularly on those system performance characteristics which were of importance to their applications.

The material in this chapter includes changes suggested by the major user groups. It represents the most comprehensive survey of user requirements conducted to date.

The process of collecting and assessing user requirements is by no means complete, however. The initial assessment was not tied to any information about prospective costs of standard data products, which will be a key determinant of actual user demand. In addition, no assessment has been made of the number of images or computer compatible tapes or other standard data products that could be sold as a function of price. Such a market survey would not yield limited meaningful results until the options for a Fully Operational System are clearly defined and a range of probable prices for particular types of data can be offered for evaluation by users.

Assessment of user requirements must, therefore, be a continuing, interactive process involving the evaluation of needs and relative benefits as a function of system performance and cost. Mechanisms for achieving this ongoing evaluation will be available to federal users through the Program Board described in Chapter II, and to the relevant professional societies, industry associations, associations of state and local governments and representative commercial users through the Land Remote Sensing Satellite Advisory Committee, also described in Chapter II.

B. Current and Projected Uses of Landsat Data

This section reviews the currently expressed requirements of users in terms of the types of uses to which Landsat data are now being applied. As the section will indicate, users have widely varying needs. These needs have been analyzed to identify probable performance characteristics that the Fully Operational System could possess to serve the stated users' purposes. Table III-1 summarizes these needs for the various types of domestic users. No prioritization of these needs was attempted. Decisions of this type must await the budget review process and subsequent actions. Likewise, no assessment has been made as to how essential these characteristics are in terms of users' stated purposes and their willingness to pay higher costs.

SUMMARY OF POSSIBLE REQUIREMENTS FOR LAND REMOTE SENSING (All Domestic Users) (Based on Available Data as of April 1, 1980)

Performance Parameter	PROGRAMMATIC CATEGORY GROUPS: Renewable Resources	Non-Renewable Resources	Planning/Environmental Management
Spatial Resolution (Meters)	Range 2-80 m; 10-30 m Most Useful 2-30 m meets 90% of Requirements[1/] 10-30 m meets 81% of Requirements 15-30 m meets 80% of Requirements[1/] 30-80 m meets 10% of Requirements	Range 3-100 m; 30-80 m Most Useful 3-30 m meets 30% of Requirements 10-30 m meets 28% of Requirements 15-30 m meets 20% of Requirements[1/] 30-80 m meets 70% of Requirements	10-80 m; 10-30 m Most Useful 10-30 m meets 60% of Requirements 15-30 m meets 50% of Requirements[1/] 30-80 m meets 40% of Requirements
Spectral Bands	MSS/TM Type Plus Microwave	MSS/TM Type Plus Microwave	MSS/TM Type
Timeliness (Observation to User, Days)	2 Days – 15%[2/3/] 2-7 Days – 50% 7-30 Days – 35%	30 Days 100%	2-7 Days – 40%[2/3/] 7-30 Days – 60%
Repeat Coverage Cycle (Days)	5-7 Days – During Growing Season Seasonal at Other Times[3/]	Seasonal	Seasonal
Area Coverage	Global Capability	Global Capability	Domestic Capability
Stereo Coverage	Needed for 20% of the Requirements	Needed for 35% of the Requirements	Needed for 15% of the Requirements
Estimated Annual Data Volume (185 KM Square Scenes)	22,000 to 29,000	15,000 to 19,000	4,000 to 6,600

1/ Percentage determined largely from expressed agricultural requirements. Other applications, as they become known, would cause some limited increase.

2/ Very rapid data delivery is required for observations over areas affected by major hurricanes, floods, earthquakes, pollutant events, and similar episodes.

3/ Most critical requirements are for data which is used by the government or industry in regional or global crop condition assessment and production forecasting.

4/ Estimated by NOAA based on incomplete information in user requirements data base. Cost and complexity for adding a single channel at 10 m instead of 15 m is under evaluation.

1. Renewable Resource Applications

The feasibility of using remotely sensed data as a component of a global agriculture monitoring system was indicated in the Large Area Crop Inventory Experiment (LACIE) from 1974 to 1977. This program drew upon Landsat data and upon weather information to provide timely, objective estimates of wheat production in several areas of the world. It substantially transformed the state of the art in machine-processing of Landsat data.

The LACIE results led to the initiation of the Agricultural and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS), a six-year research and demonstration program involving NOAA, USDA, NASA, DOI and AID. Its goals are to develop and evaluate procedures and methods to provide routine early warnings of changes in crop conditions; more objective and reliable production forecasts of wheat, barley, corn, soybeans and rice; and better inventories of U.S. land cover, water, forests, rangeland, and other renewable resources.

Landsat data also appear useful in inventorying and managing rangelands and in forest management, helping reduce forest management costs through improved sampling procedures for estimating volumes of timber, monitoring the progress of "clear-cutting" operations, and mapping forest fire burn areas to guide replanting efforts.

Cooperative demonstration programs with a major wood products company with large holdings of forest areas, with an industry association concerned with global trading in cotton, and other commercial organizations have encouraged these industrial participants to plan for or implement operational programs using Landsat data. Value added service companies have created a small but growing service to supply information to commercial users concerned with commodity trading.

2. Nonrenewable Resource Applications

Landsat data, combined with other data sources such as aircraft magnetic and gravity surveys, are widely used by the minerals industry in its search for and exploitation of new sources of oil, gas, and other minerals.

Landsat data are being used to create geological maps for the siting of major construction projects, including railroads, highways, dams, and power plants. Landsat images have shown many fault lines not detected using conventional aircraft or ground data, which are important in assessing nuclear power plant sites and for earthquake prediction research.

Landsat data are particularly useful in detecting features that change over a short period of time, such as a stream course following a major flood, or a coastline after a major storm. Landsat images were used, for example, by scientists in Bangladesh to measure the accretion of new lands to islands in the Bay of Bengal, opening the way for a tree-planting program to stabilize the land and expand agricultural capacity.

3. Planning and Environmental Management Applications

Landsat imagery has proven useful for a variety of applications related to regional planning, such as monitoring the conversion of agricultural land to housing or the pace at which forest land is being depleted. Because of its limited resolution, MSS data have served only to pinpoint areas of rapid change on which planners can focus more intensive study. Higher resolution space-derived data would reduce the need for more expensive follow-up data collection programs.

The ability to recognize discontinuities in the color of inland or coastal waters using Landsat data has proven of value in identifying erosion, river sediment loads, oil slicks and oil seepage in coastal areas, effluents carrying industrial or municipal wastes, siltation and wetlands conditions. Navigation channels and inlets can be watched to detect changes in depth which may endanger shipping and boating.

Landsat data already have proven to be a useful tool for acquiring valuable hydrologic information for water resource management, such as identifying water bodies larger than 10 acres, locating likely ground water supplies, estimating snow cover and monitoring stream networks, all of which contribute to water supply management and flood avoidance studies.

Landsat data have been used for cartography, greatly exceeding original expectations for the many areas of the world where adequate topographic maps do not

exist, as well as for small-scale mapping in the United States. The satellite information can be turned into a finished map product very promptly at a much lower processing cost than aircraft data.

C. Data Specifications of Major Users

A better sense of the nature and scope of the projected user demand for land remote sensing satellite data emerges from considering user specifications in terms of institutional categories as well as by types of use. This section presents user needs in that framework.

1. Federal Agencies

The largest U.S. user group consists of the Federal agencies. In 1979, the U.S. Department of Agriculture, the Department of the Interior, the Civil Works Program of the U.S. Army Corps of Engineers, NASA (which provided data to industry, state and local governments, and the academic community for cooperative research and demonstration programs), and other Federal agencies used approximately 50 percent of the data provided by U.S. data distribution centers. While use by all groups is expected to expand during the coming decades, the Federal government probably will continue to dominate the market.

Performance characteristics related to the analysis of renewable resources dominate the current projected needs of Federal agencies, including

- Frequent repeat observations -- especially during critical times in the growing season;
- Delivery of data within 48 hours to monitor global crop conditions in certain circumstances;
- Spectral bands that are most useful in discriminating between various types of vegetation, such as wheat and other small grains;
- Higher resolution to facilitate analysis of timber, rangeland, and small fields; and
- Capacity to collect and process large volumes of data to deal with global conditions.

Federal programs related to geology, lithology, land forms and related activities of the Department of the Interior, the Corps of Engineers, and other agencies need data from the visible, the near, shortwave and thermal infrared, and the radar portions of the spectrum. These system performance characteristics are similar to those for private industry discussed below, but most Federal users need non-renewable resources data only from the United States. Monthly to seasonal frequency and data delivery within a month are adequate in most cases.

Some Federal data requirements related to planning and environmental management support major program objectives, such as water quality assessment, wildlife habitat monitoring, coastal zone activities, beach erosion assessment and flood control. The system performance characteristics of the Landsat MSS, combined with data from the blue-green band of the TM at resolutions higher than the TM's 30 meters, would meet the needs of these users. The volume of data taken uniquely for these purposes would be relatively low, and all of it would be taken over the United States and its territories. A data set taken monthly to seasonally and delivered within one or two weeks would meet most requirements.

The Federal government also has a substantial interest in the availability of land remote sensing satellite data to support its economic development activities and aid programs abroad through the Agency for International Development and other Federal and international agencies. These activities are described in greater detail in Chapter VIII. The data needs are described below.

Preliminary Federal agency needs are summarized in Table III-2. These projections of data needs are tentative until further analyses are completed of their programmatic value.

2. State and Local Governments

Organizations in thirty-five states have used Landsat data -- some as part of demonstration programs, some as parts of established programs.

According to the National Governors Association, use by state and local governments is expected to expand as the technology to extract information is further transferred to local government organizations and to the value added service industry, which can provide derived products to meet governmental needs.

TABLE III-2
SUMMARY OF POSSIBLE FEDERAL REQUIREMENTS FOR LAND REMOTE SENSING

Performance Parameters	Percent of Requirements Satisfied by Specified System Parameter	
	Optimum Value	Minimum Acceptable Value
Spatial Resolution (Meters)	2-3 m – 37% 10 m – 33% 30 m – 28% 80 m – 2%	10 m – 25% 30 m – 20% 80 m – 55%
Spectral Bands	TM Type – 100%[1/]	MSS-Type – 100%
Timeliness (Observation to Users; Days)	1 Day or Less – 14%[2/] 2 Days – 28%[2/] 3 to 14 Days – 45% More Than 14 Days – 13%	1 Day or Less – 2%[2/] 2 Days – 16%[2/] 3 – 14 Days – 42% More Than 14 Days – 40%
Repeat Coverage Cycle (Days)	Complete Seasonal Coverage for Non-Renewable Resources, 4 to 8 Days for Other Users	Same as Optimum Requirements
Area Coverage	Global Capability	Global Capability
Stereo Coverage	Needed for 20% of Requirements	Needed for 20% or Requirements
Estimated Data Volume (185 KM Square Scenes)	Up to 50,000	Up to 30,000

1/ MSS Band 7 (0.8–1.1 μm) is used in analyses and has been found valuable in assessing crop vigor. The TM does not observe in the interval 0.9–1.1 μm. If the number and criticality of such uses is high, spectral bands will be adjusted.

2/ Very rapid data delivery is required for observations over areas affected by major hurricanes, floods, earthquakes, pollution events, and similar episodes.

3/ Most critical requirements are for data which is used by the government or industry in regional or global crop condition assessment and production forecasting.

Renewable resource applications establish data specifications for resolution, spectral bands and data delivery that are similar to those of the Federal government. Only domestic data are required. For non-renewable resource applications, system performance characteristics that meet the requirements of Federal agencies and domestic industries also would satisfy those of state and local governments.

Some state and local government requirements for data needed for land use management and environmental quality protection are more stringent. They call for higher resolution over urban and suburban areas than over rural areas; as well as time-series analyses to detect detailed changes. The relative costs of acquiring these data by satellite or aircraft need to be considered. Other planning and environmental management requirements are similar to those of the Federal agencies.

Table III-3 summarizes the possible requirements of state and local governments.

3. U.S. Commercial Organizations

Those companies involved in the search for and extraction of oil and hard minerals are currently the largest commercial users of Landsat data. Commercial use of the data for crop monitoring and forest management is in the early stages, and projections are that this demand will grow substantially as the interpretation is transferred to the commercial sector and data continuity is assured. Another new market that has begun to develop is the consulting and design engineering community. This value added service industry is composed of those firms that have established the capability to extract information from Landsat data to meet the requirements of their customers. It is expected to grow rapidly in the future.

Spectral specifications for both industry and government use are the same as those specified for the TM, with data from the infrared and thermal portions of the spectrum being more important than for other applications. Industrial users who need global data place a relatively higher priority on the acquisition of stereoscopic data over those portions of the globe that have inadequate topographic information. Good quality data taken seasonally and made available within a few weeks would meet most needs, although delivery within a day or two of acquisition is important to those firms that are sending out field parties. Required data volumes are much higher because industry is involved in the global search for new mineral sources.

TABLE III-3
SUMMARY OF POSSIBLE STATE/LOCAL GOVERNMENT REQUIREMENTS FOR LAND REMOTE SENSING
(Based on Available Data as of April 1, 1980)

Performance Parameters	Percent of Requirements Specifying Value: Optimum Value	Minimum Acceptable Value
Spatial Resolution (Meters)	10-30 m – 42% 30-50 m – 50% 80 m – 8%	30 m – 6% 80 m – 94%
Spectral Bands	TM TYPE – 100%[1]	MSS Type – 100%
Timeliness (Observation to Users; Days)	4 Days – 46%[2] 14 Days – 54%	4 Days – 33%[2] 21 Days – 42% 60 Days – 25%
Repeat Coverage Cycle (Days)	7 – 9 Days[3]	Seasonal
Area Coverage	Domestic U.S.	Domestic U.S.
Stereo Coverage	Needed By 13%	None Specified
Estimated Annual Data Volume (185 KM Square Scenes)	2000 – 4000	

[1] MSS Band 7 (0.8 – 1.1 μm) is used in analyses and is considered valuable in assessing crop vigor. The TM does not observe in the interval 0.8 – 1.1 μm. If the number and criticality of such uses is high, spectral bands will be adjusted.

[2] Very rapid data delivery is required for observations over areas affected by major hurricanes, floods, earthquakes, pollution events, and similar episodes.

[3] Most critical requirements are for data which is used by the government or industry in regional or global crop condition assessment and production forecasting.

Renewable resource applications by industry demand no operational system performance characteriscs beyond those that would be required by Federal users. No unique commercial requirements for data related to planning and environmental management have been identified. A system that met the stated needs of Federal, state and local government users would be adequate for commercial purposes.

Possible requirements of U.S. private industry are summarized in Table III-4.

4. Foreign Users

Thirty-six percent of the revenue from sales of standard data products at the EROS Data Center came from users with foreign addresses. Sales to additional users abroad have been made by countries that have established ground receiving stations. Such purchases may increase as analytical capabilities become more widely developed. NOAA will assist in organizing and will participate in regional meetings with foreign users in order to be better apprised of the interests and data needs of users in other countries.

Commercial and governmental users in other countries have identified requirements for resolution, spectral bands, repeat observations and data delivery that are substantially similar to those of their counterpart organizations in the United States. At lower resolutions, such as 80 meters, approximately the same volumes of data would be acquired and processed to meet the needs of domestic and foreign users because of domestic requirements for foreign data. As resolution increases to 30 meters or higher, the demand by foreign users is expected to grow more rapidly.

TABLE III-4
SUMMARY OF POSSIBLE U.S. PRIVATE REQUIREMENTS
(Based on Available Data as of April 1, 1980)

Performance Parameter	Domestic U.S. Coverage		Foreign Coverage	
	Optimum Values	Minimum Acceptable	Optimum Values	Minimum Acceptable
Spatial Resolution (Meters)	10 m – 64% 30 m – 36%	30 m – 71% 80 m – 29%	10 m – 71% 30 m – 29%	30 m – 80% 80 m – 14%
Spectral Bands	TM TYPE – 86%[1] Radar – 14%	MSS-Type – 100%	TM Type – 100%[1]	MSS-Type – 100%
Timeliness, Days (Observation to User)	2 Days – 14%[2][3] 14 Days – 86%	14 Days – 72% 90 Days – 18%	2 Days – 17%[2][3] 14 Days – 86%	14 Days – 14% 90 Days – 80%
Repeat Coverage Cycle (Days)	Complete Seasonal Coverage for Non-Renewable Resources; 7-9 Days for Other Applications[3]		Same as for Domestic Coverage	
Area Coverage	Entire United States		Global Land Area Capability	
Stereo Coverage	Needed for 50% of Requirements		Needed for 50% of Requirements	
Estimated Annual Data Volume (185 KM Square Scenes)	2000 – 5000		8000 – 12000	

1/ MSS band 7 (0.8–1.1 μm) is used in analyses and has been found valuable for assessing crop vigor. The TM does not observe in the interval 0.9–1.1 μm. If the number and criticality of such uses is high, spectral bands will be adjusted.

2/ Very rapid data delivery is required for observations over areas affected by major hurricanes, floods, earthquakes, pollution events, and similar episodes.

3/ Most critical requirements are for data which is used by the government or industry in regional or global crop condition assessment and production forecasting.

CHAPTER IV

PERFORMANCE OPTIONS FOR THE FULLY OPERATIONAL SYSTEM

Two crucial decisions relevant to the Administration's objective of having a Fully Operational System are when to begin development of a system more specifically designed to meet projected user needs on an operational basis and what additional data specifications are to be met. As set forth below, the earliest that a new system can be brought into operation is 1989. A decision on when to initiate and implement the Fully Operational System requires careful examination of the Federal government's priorities, needed financial assistance, private sector interest in taking over the system, user demands during the Interim Operational System and the potential risk of foreign satellite systems obtaining a portion of the domestic and foreign land remote sensing market.

This chapter explores some of the potential technical options for the Fully Operational System, including extending and improving the Landsat D-based Interim Operational System. Preliminary system studies, further discussions with users, and market and pricing assessments will have to take place before a decision can be reached on the preferred option.

While prompt resolution of the question of private sector ownership would facilitate participation by the private system operator in the design of the system, some minimal initial funding and development of key elements of the new system may have to take place simultaneously with a decision about the institutional arrangement for private sector ownership or operation in order to better meet the requirements of users.

A. System Performance Options

This section presents four hypothetical systems that could serve as the basis of a Fully Operational System:

(1) An extension of the Landsat D series;

(2) A "Minimum System";

(3) A "Middle System"; and

(4) A "Maximum System".

1. Common Elements

The four systems presented below differ primarily in levels of resolution, spectral bands and frequency of coverage, with all of them using more reliable, longer life solid state multilinear array sensors, rather than the mechanical scanners currently being used on the Landsat D series of satellites. User requirements for data from longwave thermal infrared, now on the Landsat D series of satellites, and microwave sensors may be most efficiently met through the modification or addition of appropriate sensors aboard NOAA's polar-orbiting environmental satellites or the National Oceanic Satellite System and will be considered by NOAA in the future design of these satellites. Operational systems for environmental and geophysical data collection from in-situ observing platforms already exist on NOAA's satellites and will be continued. Land data acquired via these and other satellites could be transmitted to the operator of the Fully Operational System for distribution to users.

The initial formats for standard data products produced by the Fully Operational System using any of these tentative designs would be similar to those produced by the Interim Operational System, although the system operator could alter the format in response to users' needs. Standard data products would be available routinely. A "quick-look" capability to assess the quality of images acquired within 12 hours of observation, and coverage of disaster events on a limited basis within 6 hours, would be desirable.

2. Options

At this stage in the planning process, only a limited number of systems options could be examined in a preliminary conceptual fashion. The number of possible technical configurations is large. For example, existing instruments could be redesigned for improved performance, or new instruments such as imaging radars, high-resolution cameras, or thermal infrared heat detectors, could be flown. To focus this initial examination, NOAA developed data specifications having three different levels of quality and utility, drawing upon the still imprecise information on user requirements summarized in Chapter III. NOAA's synthesis of the possible data specifications for the three general classes of uses at the minimum, intermediate and maximum levels is presented in Table IV-1.

POSSIBLE DATA SPECIFICATIONS BY CLASS OF USES

MINIMUM ACCEPTABLE LEVEL	RENEWABLE RESOURCES	NON-RENEWABLE RESOURCES	PLANNING AND ENVIRONMENTAL MANAGEMENT
Resolution (1)	80 m, TM bands 1, 2, 3, 4, plus	80 m, TM bands 1, 2, 3, 4, plus	80 m TM bands 1, 2, 3, 4, plus
Spectral Bands (2)	TM 5 or MSS band 7.	TM 5 or MSS band 7.	TM 5 or MSS band 7.
		30-40 m, TM band 3 or 4	30-40 m, TM band 3 or 4
Repeat coverage	8-9 days	about one month	about one month
Data delay	two days	four weeks	one week
Quick look	yes	yes	yes
Tasking system	yes	yes	yes
Cover special events (3)	yes	yes	yes

INTERMEDIATE LEVEL – Includes minimum level specified above plus the following:

Resolution (1)	Both 80 and 30-40 m	Both 80 and 30-40 m	Both 80 and 30-40 m
Add'l Spect. band	TM 7 (short wave IR)	TM 7	TM 7
Pick up missed scenes on adjacent tracks	yes	no	yes
Stereo heighting	30 m	30 m	30 m

MAXIMUM LEVEL – Includes the minimum and intermediate levels plus the following:

Resolution (1)	derived 80 m and 10 m	derived 80 m and 10 m	derived 80 m and 10 m
Add'l Spect. band	TM 6 thermal IR 4/	TM 6 thermal IR 4/	TM 6 thermal IR 4/
Repeat coverage	increase to 5 to 7 days		
Stereo heighting	increase to 15 m.	increase to 15 m	increase to 15 m.

(1) Coverage of all of the earth's land masses desired at 80 m resolution; more limited, selected coverage on demand at the higher resolution specified. Resolutions given as instantaneous field of view (IFOV). USDA requires 2 m resolution of selected scenes on demand.
(2) See listing below which defines the spectral intervals of the Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) bands.
(3) One day maximum delay for delivery of critical data on such events as floods and earthquakes.
(4) Preferably on another satellite with an orbit that provides coverage at a different time of day.

Multispectral Scanner (MSS)		Thematic Mapper (TM)		
Channel No.	Spectral Interval	Spectral Interval	Channel No.	Band description
		0.45-0.52 μm*	1	blue green
4	0.5-0.6 μm*	0.52-0.60	2	green
5	0.6-0.7	0.63-0.69	3	red
6	0.7-0.8	0.76-0.90	4	near infrared (IR)
7	0.8-1.1			near infrared
		1.55-1.75	5	"Short wave" IR
*Wavelength in micrometers		2.08-2.35	7	"Short wave" IR
		10.40-12.60	6	"long wave" thermal IR

The four hypothetical systems have the following characteristics, which are set out in Table IV-2:

a. The Landsat D system

This system, which could be continued for the remainder of the century by purchasing additional spacecraft and one renewal of the ground system, has 80 meter resolution MSS bands and 30 meter resolution TM bands. The system could provide 16-day revisit time with occasional 8-day coverage when required. This is essentially the same option as the "Middle System," except for the 15 to 20 meter resolution channel, which might be added to the Landsat spacecraft. Evolutionary improvements in the Landsat D system would focus on the introduction of solid state multilinear array sensors as soon as possible and increasing satellite life to improve reliability and reduce costs.

b. The Minimum System

This system would provide coverage in four or five bands at a resolution of 80 meters. The spectral intervals would be similar to those used in TM visible bands 1, 2, 3 and 4, plus either TM shortwave infrared band 5 or 7 -- when technologically feasible. A band from 0.9 to 1.1 micrometers (near infrared) could be substituted for any one of these bands. Observations from TM band 3 at 40 meter resolution, as well as 80 meter resolution, would be a highly desirable addition.

This system would provide 16 or 18 day revisit time with occasional 8 or 9 day coverage when required. Each year, the system would produce a data output equivalent to about 40,000 scenes1/ equivalent to MSS scenes of an area 185 km square at 80 meter resolution, plus 10,000 selected scenes at 40 meter resolution.

1/ As used here, "scenes" means usable scenes. Approximately twice as many scenes must be carried through the early pre-processing stage to eliminate those with cloud cover or other defects. This estimate reflects current experience with Landsats 1, 2 and 3.

PERFORMANCE CHARACTERISTICS OF THE HYPOTHETICAL LANDSAT-D, MINIMUM, MIDDLE, AND MAXIMUM OPTIONS

	LANDSAT D SERIES	MINIMUM SYSTEM	MIDDLE SYSTEM	MAXIMUM SYSTEM	HIGH RESOL. SYSTEM
"TM-bands"					
1 0.45 - 0.52 μm	30 m	80 m	30 m	10 m	(Panchro-matic) 2 m
2 0.52 - 0.6 μm	30 m	80 m	30 m	10 m	
3 0.63 - 0.69 μm	30 m	80 and 40 m	30 and 15 m	10 m	
4 0.76 - 0.9 μm	30 m	80 m[2/]	30 m[2/]	10 m[2/]	
5 1.55 - 1.75 μm	30 m	one band	30 m	20 m	
7 2.08 - 2.35 μm	30 m	80 m	30 m	20 m	
6 10.4 - 12.5 μm	120 m	[3/]	[3/]	[3/]	
"MSS-bands"					
4 0.5 - 0.6 μm	80 m				
5 0.6 - 0.7 μm	80 m				
6 0.7 - 0.8 μm	80 m				
7 0.8 - 1.1 μm	80 m[2/]				

1/ Figures in table are instantaneous-field-of-view (IFOV) in meters.

2/ MSS Band 7 (0.8 - 1.1 μm) is valuable in crop vigor analyses. The TM does not observe in the interval 0.9 - 1.1 μm. If the number and criticality of such uses is high, spectral bands will be adjusted.

3/ Thermal IR coverage may be provided, if required, by a sensor from another civil satellite.

4/ On-board processing to provide data at integral multiples of stated resolution could be considered to reduce data rates where desired.

5/ Stereo coverage, either by pointing of the primary sensor or by periodic inclusion of a framing instrument could be considered for both the middle and maximum systems.

This system would provide a level of service less than the Landsat D system.

c. The Middle System

This system would provide coverage in the same bands as the Minimum System at two different resolutions: 30 or 40 meters and 60 or 80 meters. The lower resolution will be half that of the higher resolution in order to facilitate use of a single sensor and simplify on-board data processing. As soon as technology allows, TM shortwave infrared bands 5 and 7 would be added at both resolutions. Observations from TM band 3 at 15 or 20 meter resolution would be a highly desirable addition.

This system would provide an 8 or 9 day revisit frequency most of the time, In addition, imaging sensors could be steerable to avoid cloudy areas or to pick up areas which were covered with clouds at the regular viewing time. The number of scenes processed each year would be 40,000 equivalent scenes at 60 or 80 meters resolution and 20,000 equivalent scenes at 30 or 40 meters resolution; 10,000 equivalent scenes at 15 or 20 meters resolution would be gathered from limited areas.

This system, without 15 or 20 meter resolution, would provide a level of service essentially equivalent to the Landsat D system.

d. The Maximum System

This system would provide coverage in the four TM visible bands 1 through 4, at a resolution of 10 meters, plus TM shortwave infrared bands 5 and 7 at 20 meters resolution. On board data processing also would provide data at 40 and 80 meters. The latter would provide regular coverage of global land masses; the 10 and 20 meter data would be gathered from limited areas.

This system would produce global coverage equivalent to about 40,000 MSS scenes at 60 or 80 meters resolution, plus 40,000 equivalent scenes at 30 or 40 meters resolution. About 40,000 scenes of areas about 90 km square would be produced at the full resolution of 10 or 20 meters.

This system would provide a level of service far in excess of the Landsat D system.

A supplement to this system would be necessary to meet the need for data from a single panchromatic spectral band at a resolution of 2 meters. Such a system would require a much lower orbit than is planned for the other missions and thus could not be a shared satellite. The ground system would be specially designed for data at 2 meter resolution, with an output of 40,000 scenes 20 km square per year.

Stereo capability might be provided in one of two ways:

- o Stereo adaptation of the multilinear array imaging system in TM spectral band 3, or the addition of electronic camera systems similar to the Return Beam Vidicon to the Middle or Maximum System spacecraft; or

- o Separate spacecraft specially designed for stereo coverage, with either film or electronic imaging, which could be flown as infrequently as every 10 years.

The minimum capability of the stereo system would be coverage of the Earth's land mass with 30 meter stereo heighting capability once every 10 years. This coverage could be improved to include imagery acquired in each of the four seasons and to raise the stereo heighting capability to 15 meters.

3. Cost Estimates

Only approximate estimates can be made of system costs at this time. They do not include NASA and NOAA system development, market expansion, or planning and management costs, nor do they include the cost to add a longwave thermal infrared or advanced microwave sensors to the operational system. Rough estimates of ten-year capital and operating costs of the full systems at each level are:1/

- o $2.0 billion for Landsat D continuation;

- o $1.0-$1.5 billion for the Minimum System;

- o $1.5-$2.5 billion for the Middle System;

1/ All costs are in FY 1980 dollars.

- o $3.0-$5.0 billion for the Maximum System; and
- o $4 to $5 billion additional for the 2 meter system.

While any estimate at this time is premature, the thermal infrared capability, with a resolution on the order of 100-200 meters, probably can be added to an existing operational spacecraft without exorbitant cost. The additional cost to produce one global set of satellite stereo data is estimated to be $200 to $400 million for 30 meter stereo heighting capability and $300 to $700 million for 15 meter stereo heighting capability.

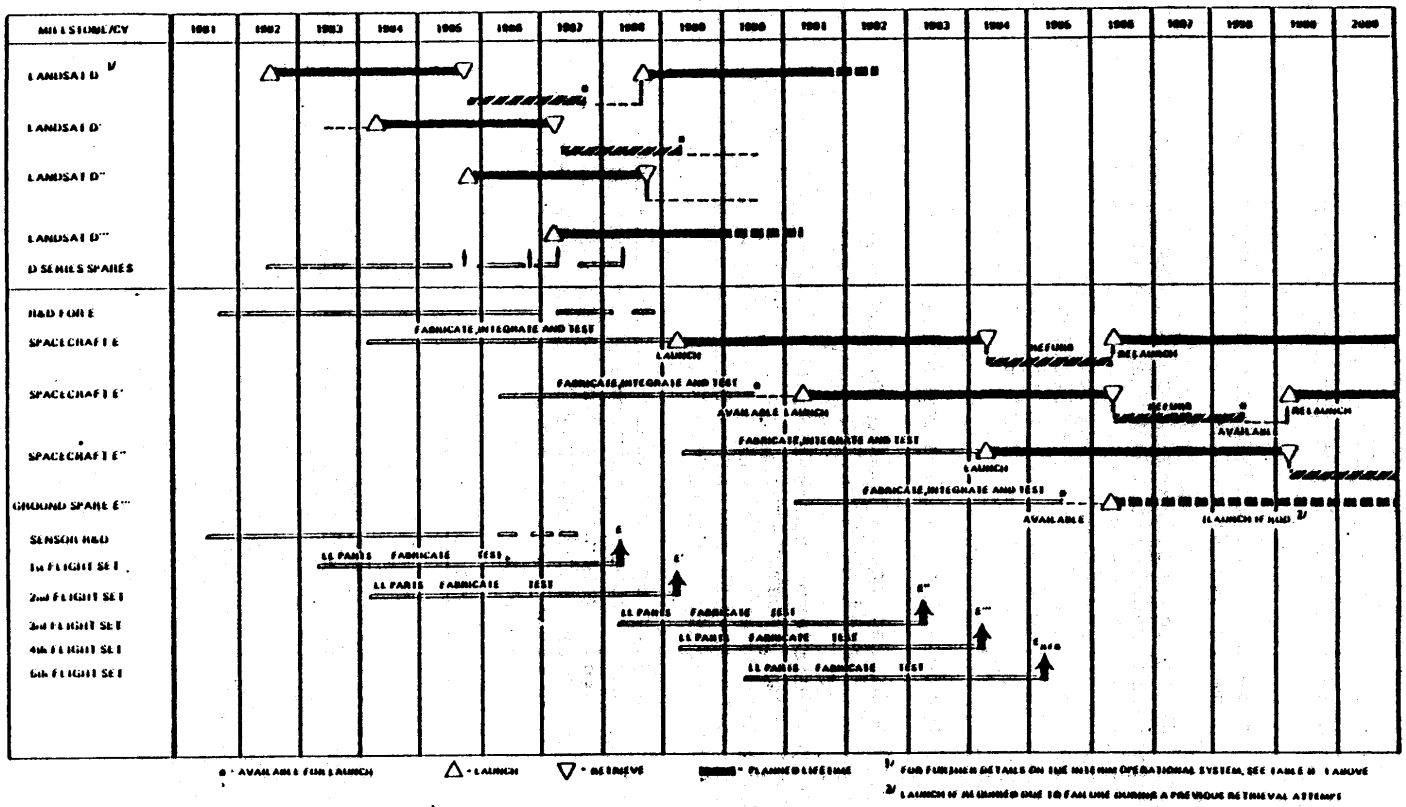
These estimates assume that:

- o The spacecraft will be launched and retrieved by shuttle;
- o Retrieved spacecraft will be refurbished for reuse;
- o Data will be relayed to ground via geostationary satellites; and
- o Highly reliable, all solid state sensors and onboard data storage devices will be used, with sufficient redundancy to achieve a goal of five-year life for each spacecraft mission before the end of the ten-year operational period.

4. Timing Considerations

Initiation of any of these operational system alternatives is highly dependent on the development of reliable sensor and other spacecraft subsystem components needed to achieve long life for each spacecraft and initiation of detailed system trade-off studies and system design. The Minimum or Middle System probably could be launched by the end of this decade if necessary R&D and initial system studies are initiated in the next few years. A tentative schedule based on a new spacecraft appears in Table IV-3. This development period might be one year less if the shortwave infrared channels are omitted on the first spacecraft and a shorter life for the initial spacecraft is

TENTATIVE FULLY OPERATIONAL SYSTEM UTILIZING NEW SPACECRAFT AND SENSORS



accepted. The improved Landsat D system could also be launched in 1989, as soon as the solid state sensors have been developed and integrated into the Landsat D spacecraft, as shown in Table IV-4. The Maximum System would take at least two additional years to implement.

Stereo capability can be included in the same general time frame. If existing technology is used with a dedicated spacecraft and ground system for stereo capability and full funding is made available for design in FY 1982 and construction in FY 1983, a launch as early as 1988 may be feasible.

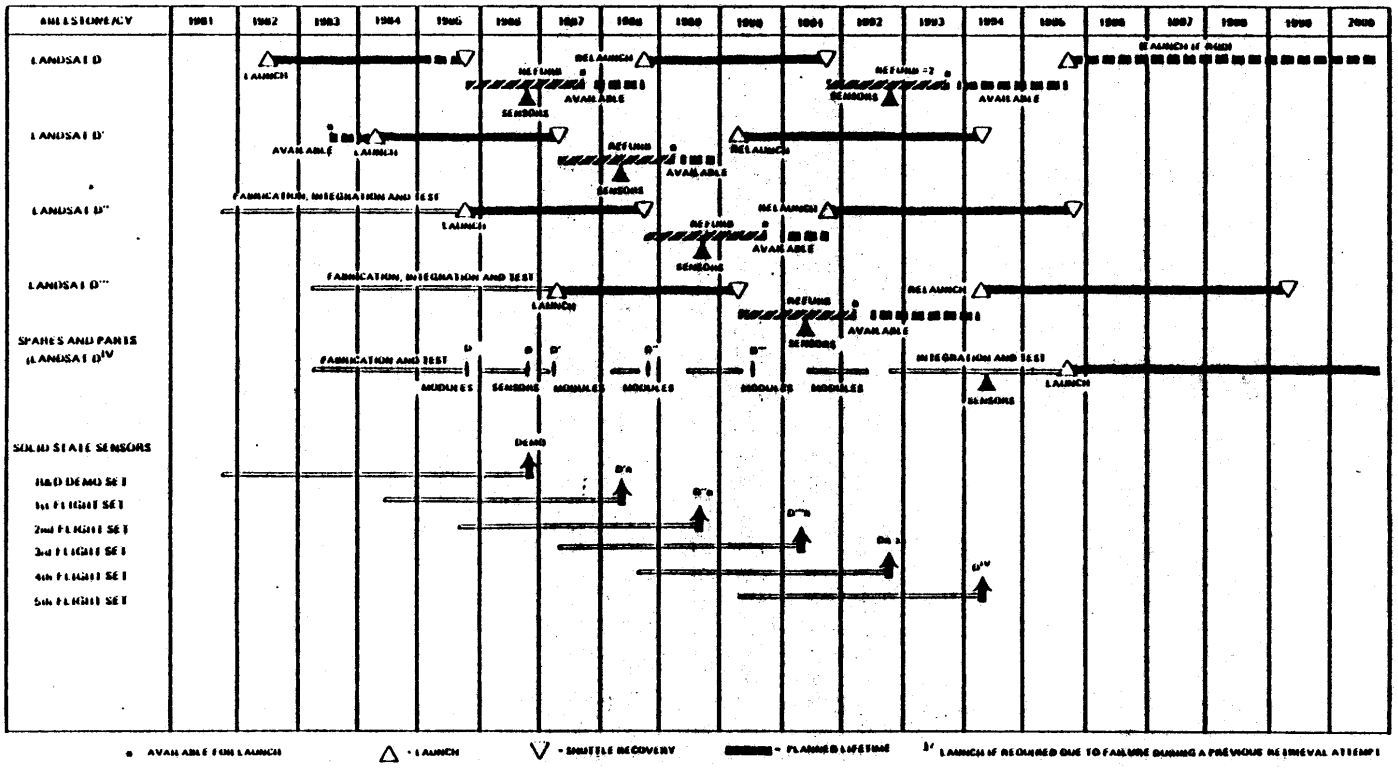
B. Initial Evaluation

The following provides an initial, very tentative evaluation of the hypothetical options. Decisions on performance specifications will only emerge from the lengthy interactive process between preliminary system design, user requirements analysis and cost estimating that will be a part of the ongoing planning process for the Fully Operational System.

The Minimum System does not appear to meet the currently stated needs of the majority of users, especially with respect to resolution, which is particularly important for the renewable resources and environmental management user groups. It has lower performance characteristics than even the Landsat Thematic Mapper, which will be used for the Interim Operational System, and would amount to a regression in the quality of available data. It would not come close to meeting the competition that may be provided by the French and the Japanese systems, so both U.S. technological leadership and a large part of the market for U.S. data and standard data products could be lost. A system with this level of performance probably would not be worth the investment.

The upgraded Landsat D system and the optimum Middle System are relatively similar in cost and performance. Indeed, additional system study may show that the basic multi-mission modular spacecraft (MMS) used for Landsat D can be improved to serve as the optimum Middle System spacecraft. These systems would have to provide higher operational reliability, incorporate the latest technology and lower average annual costs through longer spacecraft life if users are expected to forego other data sources in favor of land remote sensing satellite data. A 15 meter

TENTATIVE FULLY OPERATIONAL SYSTEM UTILIZING CONTINUED LANDSAT-D SERIES SPACECRAFT (NEW SENSOR INTRODUCED ON REFURBISHMENT)



TM band 3 with twice the resolution offered by the 30 meter TM band 3 on the Landsat D could be desirable. In addition, the development by 1989 of an all solid-state multilinear array system with a 15 meter TM band 3 would place the U.S. at least on a par with the French and Japanese systems, which are scheduled to begin operation in the mid-1980s.

The Maximum System meets virtually all stated user needs, but at a cost that users will probably not be willing to pay. Until experience is gained with the data from the TM system and more widespread use of land remote sensing satellite data develops, the additional value of the refinements offered by this system is somewhat speculative. Moreover, the development of the Maximum System will take at least an additional two years.

To reach firm decisions on system specifications will require further analysis of user requirements, including stereo requirements, the marginal costs of various additional capabilities, the establishment of budget priorities and the mechanisms for system financing.

CHAPTER V

REVENUES, PRICING POLICIES AND FINANCIAL ASSISTANCE

The Administration has established as a national goal eventual ownership and operation by the private sector of our civil land remote sensing activities, and directed NOAA to plan for system financing including pricing policies for the users sharing of costs. Accordingly, marketplace objectives should play a significant role in the design and management of the Interim and Fully Operational Systems, although a number of other considerations, such as the desire to assure U.S. technological leadership, will also shape the final decisions.

This chapter examines the Interim and Fully Operational Systems from a business point of view that requires the generation of revenues to recover capital and operating costs and to provide a reasonable return on capital through the provision of a valuable service to users. The chapter identifies the policy choices involved and the nature of the Federal financial commitment that may be required for private sector ownership, reviews the revenue currently projected to result from new pricing policies and potential market expansion activities and discusses alternative mechanisms for capital and operating assistance. Finally, the chapter examines alternative approaches to sharing the burden of Federal financial assistance among the Federal agencies.

A. Projected Revenues and Costs

Revenues of the operational system will be generated by sales of data and standard data products and by foreign ground station access fees. The current price of data and standard data products is based upon the cost of reproduction, with no attempt being made to control additional reproduction by users, so that a computer compatible tape costs $200 and various types of Landsat images cost between $8 and $50.1/ The current access fee is a nominal annual payment of $200,000 per station. In 1978, the current Landsat system generated $4 million from sales and access fees of $1.8 million for a total of nearly $6 million in annual revenues. Of the $4 million, $2.7 million was derived from sales and $1.3 million is the value attributed to the data distributed without charge.

1/ All revenues are in FY 1980 dollars.

A hypothetical five to ten fold price increase, phased in over a period of some years, assuming the increases are absorbed without any significant overall loss of sales to competing sources of data (such as aerial photography, field party surveys and foreign land remote sensing satellite systems) could increase revenues over time to $30-60 million per year simply by raising prices.1/ In addition, assurance of data continuity and reliable delivery of data and standard data products, combined with a market expansion program discussed in Chapter VII, should enhance the prospects for growth in unit sales volume. If one assumes a hypothetical 10% growth in data sales per year and only a hypothetical 5-fold increase in both the price of standard data products and foreign station direct reception fees, then by the year 2000, annual revenues of $140 million would be generated by the system. Unfortunately, reliable projections of market growth and price elasticity are not possible at this time. However, the doubling of current unit sales at higher prices is a possible goal.

The tentative estimates for the hypothetical Fully Operational System options, described in Chapter IV, indicate that approximately $100 million to $400 million or more in annual revenue would be necessary, depending on the technical capabilities of the system selected, to cover total annual costs. They include operating and maintenance costs, replacement of capital equipment, dividends, taxes, interest on debts, marketing, insurance, and a reasonable return on initial capital.

Similar tentative estimates covering the remaining total annual costs for the Interim Operational System indicate that approximately $150 million in annual revenue would be necessary to cover total annual costs.

B. Pricing Policies

1. Standards

The pricing of data and standard data products from the Interim and Fully Operationals System should conform as much as possible to the following standards:

1/ Whether subsequent reproduction of dissemination of data products by Federal agencies and other users would need to be conditioned upon payment of fees to make prices well above cost of reproduction meaningful remains to be seen. This matter is addressed under the heading Control Over Data and Standard Data Products in Chapter VI, Section B.1.

a. Consistency.

Pricing policies should be developed that are consistent for foreign and domestic users. Foreign and domestic users, with the possible exception of the Federal agencies who might pay higher prices as a form of financial assistance (as discussed below), should pay the same price for the same product and associated services. Fees charged to foreign ground stations receiving data directly should be set to encourage consistency between prices for domestic and foreign standard data products.

b. Assistance to Special Users.

Certain classes of users whose data usage is in the public interest may be driven out of the market by higher prices. While the policy of consistency precludes discounts, such users could seek direct Federal grants to enable them to purchase needed land remote sensing satellite data at established prices, in special and selected circumstances.

c. Market development.

Especially during the Interim Operational System, prices should be established in a manner to increase the volume of unit sales without losing major customer demand. Price changes should be announced well in advance so that users, especially those dependent on governmental appropriations processes, can plan their budgets accordingly.

2. Fee Structure

Examples of the types of fees the operator of the Interim and Fully Operational Systems could charge for data and standard data products are:

- o Basic Fee. A fee paid by each user on each standard data product it purchases from the U.S. system operator. These fees would vary in proportion to the cost incurred in producing that product. They would be paid by users of both real-time and retrospective data. Other factors such as timeliness, the placing of special orders and special handling could be reflected in a surcharge schedule.

- o Royalty Fee. A fee paid by each U.S. and foreign user and foreign ground station operator on the reproduction or resale of Landsat standard data products.

- o Direct Reception Fee. One or more fees paid by foreign ground station operators receiving data directly from U.S. land remote sensing satellites. Examples of such fees are: (1) an annual access fee like the $200,000 fee per station per year currently being paid by Landsat station operators, and (2) a transmission fee paid by foreign ground station operators for data transmitted to and received by the foreign ground stations. This latter fee would be based on the amount of data requested.

A further study of pricing options will be made during FY 1980 and FY 1981 for review by the Program Board and the Land Remote Sensing User Advisory Committee.

3. Price Levels

The objective of users sharing of the costs of the operational system precludes a continuation of the present policy of limiting prices to the cost of reproduction and leaving user reproduction completely uncontrolled.1/ While specific price levels for specific products cannot reasonably be established without more detailed study, two approaches to pricing during the Interim Operational System are being considered:

Option 1. Price Increases Designed to Maximize Revenues

NOAA would raise prices when it assumes responsibility for the Interim Operational System to levels designed to maximize immediate revenues from sales. For instance, price increases effective in FY 1983 would be announced in FY 1981 as a result of preliminary pricing studies, and would be confirmed through contracted market studies in FY 1982.

1/ Some users oppose increasing prices above the present cost of reproduction level, which they believe maximizes the public benefit.

Pros: o Generates revenue to help offset recurring costs of the Interim Operational System.

o Tests the market for land remote sensing data at relatively high prices early enough to provide some feedback to decisions with respect to the Fully Operational System, including the potential for private sector investment.

Cons: o Foregoes introductory pricing to develop the market; could price some users out of the market and discourage new users.

o Creates an opportunity for market penetration by foreign land remote sensing satellite systems.

o Factual information on price elasticity for data and standard data products cannot be obtained until the Interim and Fully Operational Systems are more clearly defined.

Option 2. Price Increases Phased to Promote Development

NOAA would raise prices on a phased basis when it assumes responsibility for the Interim Operational System. Data and standard data products would be priced at levels initially designed to encourage potential users to invest in support equipment and to reduce the use of competing methods of data collection.

Initial price increases effective, for instance, in FY 1983 would be announced in FY 1981 as a result of preliminary pricing studies. Price increases for FY 1984 and subsequent fiscal years would be developed through contracted market studies in FY 1982 and announced in late FY 1982. Notification of price increases well in advance would be provided to test demand without distortion from temporary budget shortfalls resulting from unanticipated price changes.

Pros: o Factual information on price elasticity for data and standard data products cannot be obtained until the Interim and Fully Operational Systems are more clearly defined;

- o Users acquire data at rates that will allow them to assess its utility to their operations and make long-term commitments; and

- o Long-term increases in market volume, through encouragement of new users and avoidance of pricing some existing users out of the market, may generate greater revenues for the Fully Operational System.

Cons:
- o A lower revenue flow may result during the early phases of the Interim and Fully Operational Systems, possibly discouraging private sector investment.

C. Financial Assistance

The Federal government could reduce the gap between the revenues and the total annual costs that likely would be experienced by a private operator or a government corporation in a number of ways, ranging from providing some or all of the initial capital to agreeing to pay higher prices for the data and standard data products it uses. To the extent that the Federal government chooses to provide or underwrite initial capital, the level of operating assistance can be correspondingly reduced, and vice versa. Actual outlays for operating assistance unlike capital assistance, can be deferred until the system begins to deliver products, if an advance commitment guarantees the operator a market for its products.

The following paragraphs briefly identify the primary capital and operating assistance techniques:

1. Capital Assistance

a. Grants -- The Federal government could give one or more grants to a private operator or a government corporation, which would require neither the payment of dividends or interest nor repayment of principal, and would thereby directly reduce the revenues required to meet costs. Federal grants as direct payments might be unattractive in tight budget times as compared with equity or loan guarantees.

b. Equity Guarantees -- A private operator could raise capital in the private financial market by issuing stock at a Federal government-guaranteed minimum

price. The Federal government could purchase any unsold stock at the end of a specified period at the guaranteed price and could stand ready thereafter to repurchase that stock at that same price. Such a price guarantee might make the stock offering of a private operator attractive enough at the outset so that all stock would be purchased by private investors.

c. Government Loans and Loan Guarantees -- The Treasury Department or the Federal Financing Bank could make loans to a private operator by buying corporate bonds, or NOAA could guarantee loans made to a private operator or to a government corporation by the Treasury Department, the Federal Financing Bank, private investors, or all three. All such loans, except those from private investors, would involve interest rates at or near Treasury rates, which could be well below the market rate. The interest rates on private loans guaranteed by NOAA would be somewhat higher depending upon market conditions.

2. Operating Assistance

a. Federal Purchase Guarantees -- NOAA could contract with a private operator or a government corporation for a specific flow of land remote sensing satellite data and standard data products designed to meet the minimum data needs of all Federal users over a period of several years at prices that would ensure that revenues from these purchases cover virtually all the costs of operation. Other users probably would be charged lower prices, since the operator (and therefore the Federal government) would benefit from sales at any price above direct production costs for the additional standard data products. Federal users could purchase additional standard data products at current market prices at any time.

b. Overall Price Assistance -- The Federal government could agree to pay a private operator or a government corporation a fixed amount for each unit of data or standard data product sold to all or specific groups of users. The amount could be adjusted periodically based on an evaluation of the corporation's operations.

c. Appropriations -- The Federal government could provide funds to a private operator or to a government corporation to increase the revenue stream sufficiently to assure cost recovery. The amount could vary annually or be

fixed at the outset on the basis of a projection of long-term needs. In the latter case, the corporation would retain a full incentive to reduce costs and increase revenues.

d. Free Services -- The Federal government could provide launches, data transmission service from the satellite to the ground facility via TDRSS, or insurance for space hardware to a private corporation or a government corporation, thus reducing the corporation's costs substantially.

e. Tax Incentives -- Accelerated depreciation or additional investment tax credits could be granted to a private operator to reduce its taxes. Since this form of assistance is not useful if the private operator has no tax liability, tax incentives would be effective only for an operator with taxable income from land remote sensing or other operations.

The appropriate financial assistance mechanism may depend on the institutional option selected. Various institutional options and assistance mechanisms are considered in Chapter VI.

D. Appropriation of Federal Financial Assistance Costs

Three possible options exist for allocation of the Federal financial assistance costs among the budgets of NOAA and the Federal user agencies:

Option 1. NOAA Budgets all Funds

NOAA would be responsible for obtaining appropriations for that portion of the capital and operating costs of the "core" Interim and Fully Operational Systems not covered by revenues as an add-on to its existing budget. In addition, NOAA would seek funds for any optional components beyond the core system that are required to meet the special needs of users, such as, for example, stereoscopic or other special sensors, or more frequent coverage.

The pros and cons of Option 1 are:

Pros:

- Provides NOAA with leverage to establish priorities among users' technical requirements;
- Focuses responsibility for policy and budget development and presentation in a single agency; and
- Focuses policy and budget review in four Congressional subcommittees.

Cons: o Fails to provide adequate incentives for user agencies to make tradeoffs between satellite and other data sources, and between programs utilizing land remote sensing satellite data and other mission programs;

o Focuses program justification in NOAA's Congressional committees, thereby diluting the influence of the constituencies of user agencies;

o Requires justification of special system capabilities before Congressional subcommittees that are not necessarily knowledgeable about the specific requirements of the individual user agencies.

Option 2. NOAA Budgets "Core" System Funds: User Agencies Budgets Special System Capabilities

NOAA would obtain appropriations only for that portion of the capital and operating costs of the "core" Interim and Fully Operational Systems not covered by revenues as an add-on to its existing budget. These "core" systems would include the space and ground segment elements necessary to meet the common needs of the majority of users. The costs for any special system capabilities, such as stereoscopic or other special sensors or more frequent coverage, would be budgeted by the user agencies that want these capabilities.1/

The pros and cons of Option 2 are:

Pros: o Provides NOAA with leverage to establish priorities among users' technical requirements for the core system;

o Focuses responsibility for policy and budget development and presentation for the core system in a single agency;

1/ In addition, joint funding arrangements with the private sector could be negotiated.

- o Focuses policy and budget review of the core system in four Congressional sub-committees;
- o Provides incentives for user agencies to make cost tradeoffs with respect to the special system capabilities between satellite and other data sources, and between programs utilizing land remote sensing satellite data and other mission programs; and
- o Requires agencies with special needs to justify provision of any special system capabilities.

Cons:
- o Fails to provide incentives for user agencies to make cost tradeoffs between satellite core system and other data sources;
- o May require NOAA to coordinate budget presentations with one or more other agencies and complicates the budget approval process;
- o Requires justification of special system capabilities before additional sets of authorization and appropriation committees that are not necessarily knowledgeable about land remote sensing from space; and
- o Focuses program justification for the core system in NOAA, thereby diluting support from the constituencies of other agencies.

Option 3. User Agencies Fund All System Funds

The major Federal user agencies would obtain the appropriation of their proportionate share of that portion of the capital and operating cost of both the "core" and any special system capabilities of the Interim and Fully Operational Systems not covered by revenues.

The pros and cons of Option 3 are:

Pros:

- o Provides maximum incentives for Federal user agencies to make cost tradeoffs between satellite and other data sources, and between programs utilizing land remote sensing satellite data and other mission programs;
- o Most fairly distributes costs based on expected use;
- o Brings to bear the constituency influence of the user agencies;
- o Shows commitment of Federal user agencies to the benefits of this program; and
- o Gives participating agencies more leverage in setting priorities.

Cons:

- o Limits NOAA's effectiveness in establishing priorities between users' technical requirements;
- o Splits responsibility for program and budget review among many Congressional subcommittees;
- o If one Federal user agency withdraws from or loses Congressional support for the program, costs to the remaining agencies would increase unexpectedly, or the System could be jeopardized;
- o Makes NOAA's technical defense of the budget difficult due to the large number of concerned Congressional committees; and
- o Would lessen the probability of non-Federal user requirements being considered in the design of the system.

CHAPTER VI

INSTITUTIONAL APPROACHES TO PRIVATE SECTOR INVESTMENT AND MANAGEMENT

Four principal institutional alternatives are examined in this Chapter for meeting the goal of eventual operation by the private sector of the U.S. civil operational land remote sensing satellite activities. In addition to these alternatives, the need for legislative policies to guide a private sector owner in its operation and for the establishment of a regulatory framewrk to oversee any private owner's activities are discussed.

A. Institutional Alternatives

Four major options have been identified for achieving some degree of private sector operation of the U.S. civil land remote sensing satellite system. These options are:

- o A private corporation;
- o A legislatively established for-profit private corporation;
- o A government corporation with private sector operation and with a subsequent transfer to the private sector.
- o Federal agency ownership with private sector operation and with a subsequent transfer to the private sector.

These options were developed in part and reviewed at two workshops conducted with representatives of a broad cross-section of private corporations interested in the land remote sensing satellite program. An initial assessment of some pros and cons of these options is set forth below.

Option 1. Private Corporation

A private corporation or a consortium of private corporations would be selected to own and operate all or a

part1/ of the Fully Operational System. This arrangement would have the following attributes:

- o A private corporation would be selected through a competitive process to own and manage the system for a specific period of time. Re-competition would occur at the end of this period.
- o The private corporation's own management and board of directors would be responsible for managing the system.
- o The capital needed to develop and build the system would be provided through private equity, private debt investments and corporate retained earnings. No Federal loans or loan guarantees would be provided.2/

1/ Industrial interest in owning and operating the U.S. civil land remote sensing satellite system varies. Two companies have expressed interest in owning and operating both the space and the ground segments. Other companies, depending on whether they are aerospace or data processing companies, have expressed interest in either the space segment or the ground segment, with the Federal government owning and operating the other segment. In addition, interest has been expressed among mineral and petroleum companies in a specialized satellite system that would provide stereoscopic data.

2/ Industry representatives are in agreement that, in the absence of Federal data purchase guarantees, this option is not viable at this time because of the projected gap between system revenues and system costs and the uncertain market during the 1980s. Their preferred Federal assistance appears to be a long-term service contract by which the Federal government would guarantee a certain annual income to the private corporation, for perhaps a ten-year period, in return for having its requirements for standard data products met. The Department of the Navy's Leasesat is an example of this approach. The private corporation would be required to meet non-Federal user requirements and would assume the associated business risk.

- o A portion of the system's revenues would be provided by a long term Federal contract guaranteeing purchases of the standard data products required to meet the government's needs.1/
- o The private corporation would assume the risk of recovering the remaining percentage of its capital and operating costs, plus a profit, through an aggressive market development program.
- o The private corporation would be regulated by NOAA to ensure compliance with U.S. national and international policies.2/

The pros and cons of Option 1 are set forth below:

Pros:
- o Would achieve the goal of private sector ownership and operation at the earliest possible time;3/
- o Could place some of the financial risks in the private sector.

1/ The contract terms would provide the necessary financial assistance by setting the prices to be paid by the Federal government for its basic data needs at a sufficiently high level to make cost recovery feasible. Alternatively, the quantities of data, but not the prices, could be specified, with a separate fixed subsidy in addition.

2/ NOAA would need authorizing legislation to enable it to regulate any private system operator, to enter into a long-term service contract on behalf of Federal user agencies and appropriations to finance any long-term service contracts.

3/ Transfer of Federal land remote sensing equipment or designs to private ownership may be inhibited by the possible existence of contract restrictions protecting equipment suppliers against the transfer of such technology.

- o Would defer Federal outlays for the fully operational system through use of a long-term data purchase contract by whose terms control over the private owner's activities could be established.

- o Would provide a strong profit incentive for vigorous market development and system efficiency.

- o Might be more responsive to market demands than the Federal government since a private corporation is likely to spend more resources on market development.

- o Would permit Federal reassessment of this option at the end of the contract period.

Cons:

- o Would probably be infeasible unless long-term Federal purchase guarantees were given.

- o The Federal government would be able to appoint members to the private corporation's Board of Directors to ensure Federal participation in the day-to-day direction of a system largely serving Federal needs and largely funded with Federal monies.

- o Changing Federal information needs might not always be met by a private corporation.

- o A private corporation owning the space segment and the resulting data could cause foreign concerns about abuse, possibly leading to adverse foreign and space policy consequences.

- o Could make it more difficult to achieve the goal of complementarity with foreign operated satellite systems, since limited Federal control of the private corporation's satellite activities would exist.

- o Could make it more difficult to achieve potential savings by integrating atmospheric and oceanic operational remote sensing satellite activities with those for land remote sensing.

- o In the absence of sizeable Federal capital and operating subsidies, the competitive process for ownership and operation of the system would be limited to a few very large corporations.

- o Those large corporations who would respond to a competitive selection process might have potential

conflicts of interest as users or as system providers with the operation of a land remote sensing satellite corporation.

Option 2. Federal Establishment of a For-Profit Private Corporation

The Federal Government, through legislation, would establish a for-profit private corporation to own and operate all or a part of the U.S. civil land remote sensing satellite system. This corporation would have the following attributes:

- Federal and non-Federal representation would be provided on its Board of Directors.
- The capital needed to develop and operate the system would be provided through the sale of capital stock and debt obligations in the private financial market or through the Federal Financing Bank and the Department of the Treasury.1/ If all the corporation's stock were not purchased on the private market within a pre-determined period, the enabling statute could provide for government purchase of a limited percentage of the unsold stock or for the withdrawal of the stock offering and use of another option.2/
- Stock ownership by private corporations active in the aerospace, data processing and value-added service fields would be limited to a specific percentage of the corporation's stock.
- A portion of the corporation's revenue would be provided through a long-term Federal service contract guaranteeing purchase of the standard data products required to meet the Federal government's needs.

1/ NOAA would need authorizing legislation to enable it to obtain up-front appropriations covering any government loan.

2/ If necessary, the statute could authorize the Federal government to guarantee a base price for the shares of stock purchased by the general public. However, such a guarantee would significantly limit the assumption of risk by the private sector under this option. If not enough stock was purchased, the desirability of moving forward with such an institition would have to be reassessed.

- o The corporation would assume the risk of recovering the remaining percentage of its capital and operating costs, plus a profit, through an aggressive market development program.

- o The corporation would be precluded from itself building the space and ground segments and would be required to procure its hardware and software through a competitive bidding process.

- o The corporation would be regulated by NOAA to ensure compliance with U.S. national and international policies. The statute also could provide for periodic Federal review of the corporation's affairs.

The Pros and Cons of Option 2 are set forth below:

Pros:

- o Would achieve the goal of eventual private sector ownership and and operation earlier than Options 3 and 4.1/

- o Would ensure Federal participation in the day-to-day management of a system largely serving Federal needs and largely funded with Federal monies.

- o Would spread financial risks among private investors, private lenders and the Federal government.

- o Use of a long-term data purchase contract would defer Federal outlays for the Fully Operational System, although any Federal equity participation would require immediate outlays.

- o Would provide a strong profit incentive for vigorous market development and system efficiency.

- o Might be more responsive to market demands than the Federal government since a private corporation is likely to spend more resources on market development.

1/ Transfer of Federal land remote sensing equipment or designs to private ownership may be inhibited by the possible existence of contract restrictions protecting equipment suppliers against the transfer of such technology.

Cons:
- o Once the corporation is established, the Federal government might be committed to its continued support for an indefinite period of time if it turned out to be unsuccessful financially.
- o Would create a statutory monopoly, limiting entry into the market by other private corporations for the foreseeable future.
- o Although less likely to cause serious concern than Option 1, a legislated private corporation owning the space segment and the resulting data is more likely than Options 3 and 4 to raise foreign concerns about abuse, possibly leading to adverse foreign and space policy consequences.
- o Might make it more difficult to achieve the goal of complementarity with foreign operated satellite systems than under Options 3 and 4.
- o Might make it more difficult to achieve potential savings by integrating civil atmospheric and oceanic operational remote sensing satellite activities with those for land remote sensing than under Options 3 and 4.

Option 3. Federal Establishment of a Wholly-Owned Government Corporation with a Subsequent Transfer to the Private Sector

The Federal government would establish a wholly-owned government corporation to own and operate the U.S. civil land remote sensing satellite system. This corporation would have the following attributes:

- o The corporation would report to the Secretary of Commerce.
- o Federal and non-Federal representation would be provided on its Board of Directors.
- o The members of the Board of Directors would be appointed by the President or the Secretary of Commerce.
- o The capital needed to develop and operate the system would be provided through government purchase of the equity interest in the corporation and through the sale of

debt obligations in the private financial market or through the Federal Finance Bank and the Department of the Treasury.

- o A portion of the corporation's revenue would be provided through a long-term Federal service contract guaranteeing purchase of the standard data products required to meet the Federal government's needs.

- o The corporation would assume the risk of recovering the remaining percentage of its capital and operating costs through an aggressive market development program.

- o The corporation would be precluded from itself building the space and ground segments and would be required to procure its hardware and software through a competitive bidding process.

- o The corporation would be managed so as to ensure compliance with U.S. national and international policies. The statute also would provide for periodic review of the corporation's affairs.

- o The corporation would be transformed into a for-profit private corporation through the sale of its stock or the disposition of its assets to a private corporation or consortium as system revenues warrant.

The Pros and Cons of Option 3 are set forth below:

Pros:

- o Transition to private sector financing and management of the system could occur when system revenues so warrant.

- o Would continue close Federal management and control of a system for which Federal entities are currently the largest users.

- o Could make it easier than Options 1 or 2 to achieve the goal of complementarity with foreign operated satellite systems.

- o Foreign concerns about abuse would be less likely than with Options 1 and 2.

- o Offers greater potential for integration of atmospheric, oceanic and land remote sensing satellite activities than Options 1 and 2.

Cons:

- o Would not immediately achieve the goal of private sector ownership.
- o Would create another government program, restricting participation by private corporations to equipment or service contracts.
- o Would place all financial risks on the government.
- o Would not provide as strong an incentive for recovering all costs through data and product sales since, historically, the market development programs of Federal agencies have been unsuccessful.

Option 4. Federal Agency Ownership With Private Sector Operation with a Subsequent Transfer to the Private Sector

As the Federal program manager, NOAA would develop and own the U.S. civil land remote sensing satellite system and private corporations would operate all or a part of the system under contract with NOAA. When the system becomes financially viable, it would be transferred to the private sector. The option involves the following:

- o A private corporation would be selected through a competitive process to operate all or a part of the system for a specific period of time. Re-competition would occur at the end of this period. period.
- o The government would be responsible for the capital and operating costs of the system.
- o Users would pay the Federal government fees for data and standard data products.
- o Transfer to private sector ownership would take place when the system becomes financially viable.

The Pros and Cons of Option 4 are set forth below:

Pros:
- o Would ensure maximum Federal control of a system largely serving public needs and largely funded with Federal monies during the period of Federal ownership.
- o Could make it easier to achieve the goal of complementarity with foreign operated satellite systems during the period of Federal ownership.
- o Could minimize foreign concerns about abuse during the period of Federal ownership.
- o Could enhance potential for savings through integration of atmospheric, oceanic and land remote sensing satellite activities during the period of Federal ownership.
- o Would permit Federal reassessment of private sector ownership options after the implementation of the Interim Operational System.

Cons:
- o Would achieve the goal of eventual private sector operational involvement, but would not do so now.
- o Transition to private sector financing and management of the system would be deferred at least until the early 1990s or until an industry proposal is accepted.
- o Would place all financial risks for development of the first Fully Operational System on the government.
- o Would require appropriations of initial Federal outlays for the Fully Operational System in 1982.
- o Would not provide as strong an incentive for recovering all costs through data and product sales since, historically, the market development programs of Federal agencies have been unsuccessful.

These options will be carefully examined by the Administration over the next several months to determine which alternative best serves Federal, state and local government and private sector interests.

B. Factors Affecting Industry's Decisions on Investment

Private sector representatives tentatively have identified a number of factors that will have a strong

influence on the willingness of private individuals and organizations to invest in land remote sensing satellite operations. This section reviews these factors and some initial Federal responses. Inevitably, the Federal government, in considering the national interest, may not give a private operator all of the advantages it might want.

The information with respect to these concerns comes from discussions with industry representatives. In a June 1979 report, an interagency task force led by the Department of Commerce and NASA reported on the results of its discussions with fifty people in aerospace, financial, and other companies on the issues, opportunities and options for private sector investment. NOAA discussed the issues raised in this report individually with companies known to have given additional thought to the investment questions since the June 1979 report and at two investment workshops convened in April, 1980. While the private sector does not speak with a single voice, the issues discussed below were considered important to many, if not all, of the companies.

1. Control Over Data and Standard Data Products

Fees for data and standard data products, including revenues from foreign ground stations, represent the primary source of income for the private operator, other than some form of government data purchase guarantee. Reproduction or resale of standard data products by a user without additional payments could reduce the revenue of the private system operator and make the system less viable financially. Three areas are of major concern:

- o Data or standard data products purchased by a private organization or a government agency may be reproduced for use in-house;
- o Data or standard data products puchased by a user may be reproduced or resold for use by other users; and
- o Data or standard data products purchased by a Federal agency may have to be provided at private request under the Freedom of Information Act (FOIA) at the cost of reproduction.

To address these concerns the Federal government would probably have to enact legislation to enable the system owner-operator to own the data and standard data products and condition their dissemination on the payment of appropriate fees. The protections of the United States copyright laws would apply for a private owner and purchasers would not be able legally to reproduce or resell the data or standard data products without permission or payment of royalties to the copyright owner. Reproduction by foreign purchasers would be governed by international copyright agreements. The system operator could require all users to sign a sales agreement at the time of purchase prohibiting unauthorized resale or reproduction, and similar protection could be incorporated in the agreements with the operators of the foreign ground stations.

Under the FOIA, Federal agencies may be required or allowed to produce or reproduce the data or standard data products for external users at the cost of reproduction. Legislation limiting this authority and providing for the exemption of land remote sensing satellite data and standard data products from the "cost of reproduction" pricing provision of the FOIA is one way to resolve this concern.

Finally, the value of copyright protection may be significantly diluted if minor modifications to the format of the data or standard data products would free the derived product from the reproduction prohibition. If additional study indicates that legislation is required to preserve the value of the original copyright, it could be sought.

2. Equal Access to Data and Consistent Pricing Policies

Present U.S. policy requires nondiscriminatory availability of land remote sensing satellite data and consistent pricing policies applicable to both foreign and domestic users. The information extracted from certain data can have a particularly high economic value when it is used, for example, in commodities trading and in mineral exploration activities, particularly if it is not generally available. Some users would therefore be willing to pay a premium for privileged access.

While the practices of public nondiscriminatory availability of data and consistent prices may

discourage some investors, they represent a carefully considered U.S. policy and no recommendation for change is made.

3. Cost Recovery through Data Sales

A primary concern for a potential private operator is the large gap between present system revenues and system costs. Opportunities for data ownership, Federal financial assistance and sales of data to the Federal government, in addition to implementation of a realistic pricing program (see Chapter V) and a market expansion program (see Chapter VIII) will be important elements in establishing private sector confidence in the future profitability of land remote sensing satellite activities.

4. Federal Regulation

Federal regulation of a private operator of the land remote sensing satellite system will be necessary to some extent because of treaty obligations and national security interests, in addition to the national and foreign policy considerations discussed below in Section D. Regulation should be kept to the minimum required to implement these obligations. Regulatory policy for the Fully Operational System should be established well in advance of the private operator's assumption of responsibility for the system, and to the maximum extent possible remain constant for the useful life of the system.

5. Competition with Data from Federal R&D Systems

The concern has been expressed that data freely available from Federal R&D land remote sensing satellite systems will compete with the data from the private operational system, reducing private system revenues. NASA probably will continue, however, to develop some advanced experimental sensors and spacecraft systems for land remote sensing because:

- o National policy requires maintenance of U.S. technological leadership, a function assigned to NASA under the 1958 Space Act, to be in a favorable competitive position with respect to foreign systems; and

- o High costs and high risks are associated with these developmental systems, and experience in the satellite communications arena indicates that the private sector may not fund R&D activities to the extent necessary to maintain national leadership.

Since NASA currently is required by its enabling statute to ensure the widest practicable and appropriate dissemination of information concerning its activities and the results thereof, one solution could be to establish procedures under which the private operator would distribute NASA's experimental land remote sensing satellite data to potential users other than those directly engaged in programs in cooperation with NASA. Fees compatible with those from the Fully Operational System could be charged for the experimental data. In addition, NASA could limit its R&D in land remote sensor technology to those areas where the most advanced technological efforts are involved.

6. Federal Competition in Services

Federal agencies prepare information products derived from standard data products provided by the system operator to meet the needs of the agencies and their constituents. Such activities present two potential problems to the private sector:

- o In-house preparation of information products could hamper transfer of the resulting technology to non-Federal users and the value added service industry; and

- o Distribution of information products by Federal agencies could preclude development of markets for similar private sector information extraction services, thus reducing the consumer market available to the value-added service industry.

Although transfer of technology to non-federal users is essential if the full range of benefits to the nation from the operational land remote sensing satellite system is to be achieved and private sector investment is to be encouraged, some agencies have missions that require them to produce information products for constituent groups. Land remote sensing satellite data are often only one of

many inputs into these products. Thus, the in-house production of derived information products for governmental purposes should not be prohibited, but should not compete with the private sector where at all possible.

Federal agencies already are required to use private sector services whenever the private sector can provide them rather than compete with it. OMB Circular A-76, "Policies for Acquiring Commercial or Industrial Products and Services Needed by the Government", reaffirms the Federal government's general policy of reliance on the private sector for goods and services, while recognizing that governmental functions must be performed by government personnel. This Circular establishes the policy that the Federal government should not be in competition with the private sector where the capacity exists to meet Federal needs. As private sector capabilities in the field of land remote sensing satellite data analysis and information extraction expand, Federal and non-Federal users can be encouraged to locate and make use of these commercial capabilities.

7. Federal Government's Role in Technique Development and Training

Federal agencies conduct certain large, high-cost demonstration projects, such as LACIE and AgRISTARS, to meet their needs. However, these programs often are conducted by government personnel using government facilities. Consequently, they may not contribute directly to the development of the value added services industry and to the expansion of its capability to deliver these new services to other potential users.

Major portions of the federally funded training programs now are conducted at government centers through workshops, "hands-on" training programs, and other activities under the technology transfer programs. Little use is now made of the training and demonstration capabilities of the not-for-profit or value added services companies in these Federal programs to train users in Federal, state and local governments, industrial concerns and foreign organizations.

The Federal policy expressed in OMB Circular A-76 applies to demonstration and training programs and provides that, if cheaper, they should be performed under contract by the private sector. As discussed in Chapter

VII, A-76 analyses can be used to determine if private sector provision of these services is cost effective. If so, Federal agencies should contract with private firms to provide demonstration and training programs on a reimbursable basis, for a wide range of users.

8. Coordination with Foreign Satellite Operators

Present U.S. civil space policy requires that the U.S. promote development of complementary nationally-operated satellite systems so as to increase benefits for all nations. Industry representatives share this view that duplication in spacecraft and ground systems should be avoided whenever possible. Potential private system operators are concerned, however, that this policy may preclude the development of U.S. satellite systems which could provide high market value standard data products, such as stereoscopic data, similar to those produced by foreign systems.

Foreign land remote sensing satellite systems have both competitive and cooperative aspects. The prospects for competition and cooperation with foreign land remote sensing satellite operators are discussed in Chapter VIII.

A related industry concern is that the U.S. system would be in competition with foreign owned systems that may be assisted financially by their governments, putting the U.S. industry at a competitive disadvantage unless the U.S. operation is similarly treated. Since financial assistance in some form may be needed until a reasonable return on investment can be realized by a private operator, the impact of possible foreign government assistance to foreign systems should be addressed in that context.

9. Long-Term Government Financial Commitments

The Federal government is currently the major user of land remote sensing satellite data and standard data products and is likely to continue to be a major user, at least during the 1980s. As discussed in Chapter V, the extent to which the Federal government is willing and able to provide financial assistance to the operator of the land remote sensing satellite system may be a key factor in the private sector's decision to invest. Of concern to industry is the duration and binding nature of any Federal commitments.

The private sector wants to avoid making substantial initial capital investments in spacecraft and ground facilities only to find that changed policies or economic conditions have eliminated the anticipated revenues from Federal data purchases or assistance.

C. Policies to Involve the Private Sector During Federal Ownership of the Interim System

During NOAA's management of the operational system, substantial efforts should be made to encourage private sector investment through:

(1) Expanding opportunities for the value-added service industry by:

- o Encouraging large users of data products to arrange for their own special processing capability;
- o Assisting customers in occasional need of special processing to locate appropriate capability in the private sector; and
- o Providing only two types of special services, for which extra fees will be charged:
  - (a) special tasking of the satellite to provide data on areas not in the archives and not normally observed in routine operations, and
  - (b) accelerated preparation of standard products when the need for data is urgent.

(2) Use of the private sector to the fullest extent possible to conduct market expansion activities described in Chapter VII below.

(3) Contracting with private corporations to operate all or part of the operational system on terms that allow a fair rate of return. Such contracts might include suplying retroactive data or operating all or a part of the ground system under general NOAA supervision.

D. Regulation of Private Sector Operation

When NOAA's responsibilities as the system operator are transferred to another entity, the implementation of international obligations, adherence to national policies and achievement of national goals will require a continuing Federal regulation of land remote sensing satellite activities that extends beyond the Federal government's concerns as a user of data and standard data products.1/

1. Federal Policies Applicable to the Civil Land Remote Sensing Satellite System

The necessary Federal regulatory framework must be established in any legislation authorizing private sector ownership and operation of our civil operational land remote sensing satellite activities. The following are the major policy areas expected to require regulation:

a. Compliance with Treaties

The United States is a party to several treaties and agreements that apply to the space activities of the civil operational land remote sensing satellite program. The principal treaties and agreements are (1) the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the Outer Space Treaty), (2) the Convention on International Liability for Damage Caused by Space Objects, (3) the Convention on Registration of Objects Launched into Outer Space, and (4) treaties and agreements reached in the International Telecommunications Union.

The Outer Space Treaty stipulates in Article VI that States bear international responsibility for outer space activities whether carried on by governmental agencies or non-governmental entities, and for assuring that such activities are carried out in conformity with the Treaty's principles in support of the use of outer space for peaceful purposes and for the benefit of all peoples irrespective of the degree of their economic or scientific development.

1/ In May 1978, the President called for supervision and regulation of any private sector entity's space activities to ensure, inter alia, that advances in land remote sensing from space will be permitted under controls and when such needs are justified and assessed in relation to civil benefits, national security and foreign policy.

The Liability Convention and the Registration Convention implement the broad principles of the Outer Space Treaty by requiring, respectively, (a) that each State which launches a space object be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight, and (b) that each launching State register with the Secretary-General of the United Nations information identifying the space objects, launching State, registration number, date and location of launch, basic orbital parameters and general function. The International Telecommunications Union, a UN Organization, controls the allocation of the radio frequency spectrum to satellite services throughout the world.

b. National Space Policy Considerations

In addition, U.S. civil space policies that reflect significant national interests should be applied to the activities of nongovernmental entities in enabling legislation or implementing regulations. These policies require, among other things:

- o The widest practicable dissemination of data and results from civil space programs, except where specific exceptions are established by legislation, Executive Order, or directive;
- o The monitoring and, if necessary, control of technological advances and capabilities in accordance with national policies;
- o General support of nondiscriminatory direct readout to foreign ground stations under specific conditions;
- o Pricing policies that are consistent with respect to foreign and domestic users, and
- o Pursuit of complementarity with foreign-operated satellite systems so as to limit U.S. program costs, but protect against unwarranted technology transfer.

c. Provision of Adequate Data for Governmental Use

National policy should establish that a private owner of our civil operational land remote sensing satellite system be required to meet the data requirements of government users because of the importance of this data to the missions of Federal agencies and the responsibilities of state and local governments, many of which derive from Federal statutes.

d. Improper Use of Inside Information

When the system is transferred to the private sector, private investors and corporations will have control over the land remote sensing satellite system and the initial data stream. This data, as discussed above, can be particularly valuable to anyone who has exclusive rights or advance access to it. Continued implementation of existing policy for equal access to the data and standard data products is recommended. In addition, appropriate steps must be taken to ensure that the data is not improperly used for the financial advantage of a private owner, investor or corporate board member. In addition to direct legislative prohibitions of these abuses, prohibitions or restrictions on stock ownership or board membership by those with potentially conflicting obligations or interests may be necessary.

e. Preservation of Competition and Pricing Policies

Another important public policy, expressed in the Federal antitrust laws, is the preservation and promotion of a free competitive economy. Although Federal governmental action may grant an exclusive license or give a statutory monopoly to a private operator, the operator's pricing policies, procurement, data production and dissemination policies should not be allowed to restrain competition beyond the scope of the government grant. For instance, Federal regulation should insure that the private operator's procurement of major facilities, such as satellites or ground stations, is accomplished by competitive bidding, and that small and minority businesses are given an opportunity to compete. All users should have nondiscriminatory use of and equitable access to the data and standard data products generated by the System. The Federal government should regulate the operator's pricing policies to prevent abuse of its monopoly position. The fees charged by a private

operator should provide a reasonable rate of return and be structured to avoid discrimination or undue preference to any class of users.

2. Selection of Lead Regulatory Agency

An agency must be identified to take the primary responsibility for the regulation of the private operator. This designation should be timed so that appropriate administrative arrangements can be established and any necessary regulations can be adopted before the transfer of system operation to the private operator.

As part of its on-going management responsibilities, NOAA should assume primary responsibility for the implementation of this Federal regulatory role, with other agencies maintaining specific regulatory roles in areas of their particular responsibility, such as the foreign and antitrust aspects of the System.

CHAPTER VII

MARKET EXPANSION

Land remote sensing data obtained from spacecraft have been used to help meet user decisionmaking needs for only a few years, often on a limited, trial basis. If the system is to pay for itself and be transferred to the private sector, strong efforts must be initiated to stimulate new uses of the data products and to evaluate the domestic and foreign markets that develop.

This chapter briefly states the prerequisite for a market expansion and evaluation program, summarizes efforts to date to develop uses for Landsat data and standard data products, and suggests actions that could be taken to ensure an agressive program of market growth and evaluation during the 1980s.

A. Prerequisite for a Market Expansion Program

As noted in Chapter II, continuity of land remote sensing data is a prerequisite to the increased use of land remote sensing satellite data. Users will not rely on satellite data until its continuity, with adequate reliability and timeliness are assured. Only then can users confidently invest in the personnel, training and processing equipment necessary to utilize the data and standard data products in their operational programs. Without these assurances, growth in the utilization of the data will be limited and any new efforts at market expansion might be inappropriate and unsuccessful.

B. Current Market Expansion Activities

Within the Federal government, the primary responsibility for market expansion activities for Landsat data and standard data products has been shared by NASA and the EROS Data Center (EDC) of the Department of the Interior.

NASA, in addition to providing Landsat data from the R&D program, has been engaged in substantial technique development and test programs made up of several components:

- o The Application Systems Verification and Transfer Program, consisting of over 20 large scale feasibility projects directed at testing, demonstrating, and transferring Landsat applications in representative operational settings, with the direct participation of user organizations. These projects serve as detailed prototypes for large, relatively homogeneous user markets and provide a major stimulus for more widespread use of the demonstrated application.

- o The Regional Remote Sensing Applications Program, through NASA's three regional centers, is conducting a national scale technology demonstration and training effort to develop capabilities within the states to apply Landsat data to their every day resource management problems. State-wide programs have been undertaken in approximately 30 states, and more than 1500 state agency personnel have been trained.

- o The University Applications Program, designed to build university capabilities for the conduct of research, education, and public service activities supporting the transfer of Landsat technology, primarily to state and local governments. In addition to developing recognized centers of expertise in Landsat applications, the University Applications Program serves to stimulate the development of basic specialized remote sensing courses in the university curriculum and the creation of the body of trained people that are critical to any successful long-term technology transfer program. Over 25 such university programs have been established.

About 160 Federal and contractor support personnel are engaged in these efforts. The NASA FY 1980 budget for these programs totals $10 million.

The EROS Data Center also has played an active role in the development of user capability. It has:

- o Conducted about 20 seminars per year, primarily for Interior personnel, which also serve as the primary medium of training for students sponsored by other government agencies, state governments, and foreign organizations;
- o Sponsored approximately 30 cooperative projects, primarily for DOI investigators, with six more planned for FY 1980; and
- o Encouraged curriculum development for post graduate studies, primarily at the University of Michigan, Harvard University, and the University of California.

About 10 Federal contractor support personnel and $1.0 million were devoted to training and technology transfer activities in FY 1980.

Other Federal agencies have focused primarily on the development of users within their own organizations. To date, USDA, the U.S. Army Corps of Engineers, and the Department of Commerce, through the Census Bureau and NOAA, have been most active in this regard. The Agency for International Development has conducted a grant program designed to increase Landsat technology awareness in developing countries and has supported the establishment of regional training and user assistance centers in Africa and Asia.

The private sector has been involved in the development and sale of devices for visual interpretation and computer analysis of remote sensing data, the provision of processing and analysis services that add value to the data products, and contract support to NASA and the EROS Data Center in data dissemination and the transfer of remote sensing technology. In addition, some 178 colleges, universities, and nonprofit organizations are providing instruction in remote sensing or photogrammetry. A number of professional societies conduct symposia designed to inform their members about scientific and technical developments and operational applications of land remote sensing from space.

Several international organizations have been active in helping foreign users of Landsat data. The United Nations and some of its specialized agencies have sponsored training programs and are helping to develop Landsat data analysis programs in developing countries. The Inter-American Development Bank makes loans for development projects using Landsat data and has funded training programs for Latin American users. Similarly, the World Bank makes loans for Landsat analysis activities in connection with development projects in Africa and Asia. Finally, certain foreign countries -- among them Canada, Japan, the Federal Republic of Germany, France, and Italy -- utilize Landsat data and related analyses in connection with their own foreign assistance programs.

C. Some Suggestions for a Market Expansion Program

In order to expand the beneficial use of land remote sensing satellite data and thereby enhance the market for system products two factors should be considered: tailoring the system to user needs, and helping users benefit from the products. Ways to implement these objectives are suggested below:

1. Tailoring the System

Continuing attention to user requirements through market surveys and other studies is essential for the system to be refined and for detection of new markets as they emerge and develop. Particular study of the user requirements of local governments, the private sector, international organizations, and foreign nations is necessary, since these market areas are so far the least well understood.

By its compilation of preliminary user requirements, NOAA has already initiated a significant step in marketing the system to user needs over the long term. These preliminary user requirements will play a key role in determining the characteristics of the Fully Operational System. Other actions that could be taken in order to validate these requirements are:

- Developing standard data products which will be made available over for long periods of time, e.g., data in the MSS format;

- o Adding new data products designed to satisfy most nearly the requirements of all users; and

- o Evaluating systematically the response of users to the products of the Interim Operational System in order to refine the practices being followed and to shape the characteristics to be offered by Fully Operational System.

2. Helping Users Benefit From the Products

The three main categories of assistance to users are training, the development of new techniques and applications, and the demonstration of existing and new applications in the users' operations. For all three, user participation and investment are important factors in realizing the benefits of the new technology embodied in satellite remote sensing. This can be encouraged by NOAA's undertaking joint ventures in working with users, wherever that is possible.

a. Training. The Department of the Interior has developed successful training equipment and course materials in support of departmental interests, as have other major Federal government users. Major Federal users can be encouraged to arrange for specialized or on-the-job training for their employees to enhance their successful utilization of land remote sensing data. In addition, NOAA could arrange through the private sector for general training on a reimbursable basis for Federal, state, and local government personnel and for foreign students. Specialized training programs can be arranged whenever sufficient demand arises. NOAA also could assist universities and private sector organizations in developing course materials to be used in training students from the private sector.

b. Applications Development. NASA probably will continue to develop and share with users technology and techniques for acquiring, processing, and interpreting land remote sensing satellite data as part of its basic responsibility for R&D in space-related technology. NASA also could continue testing new techniques and potential new applications in joint projects with users in all sectors. As part of this program, NASA could undertake the development of a broad array of information extraction procedures aimed at specific applications.

The NASA budget devoted to continuing its program of remote sensing technology transfer and applications testing is approximately $5.7 million for FY 1981.

c. Applications Demonstration. A series of joint demonstration projects with users in all sectors, including other Federal agencies and state and local governments, could enhance the market for land remote sensing satellite data. As part of such a program NOAA could:

- o Work with the major Federal user agencies to help them expand their development of new applications of the data;
- o Demonstrate the utility of land remote sensing data in meeting Federal requirements for information imposed on state and local governments;
- o Explore the uses of government extension programs such as the USDA county agent system, to reach potential users throughout the country; and
- o Assist the Agency for International Development and other organizations in demonstrations to foreign users.

In these joint demonstrations, private sector firms could be used so that they can repeat the demonstrations with additional potential users after each joint demonstration project is successfully completed.

3. Other Actions

More general support to develop the field of land remote sensing from space could be provided in the following ways:

- o Information dissemination activities could be conducted to develop public awareness of the potential benefits of land remote sensing satellite data;

- University centers of excellence could be supported and universities could be assisted in developing research and instructional capabilities in the use of land remote sensing satellite data so as to expand the cadre of trained professionals;

- The Small Business Administration and the Economic Development Administration could be involved in assisting new entrepreneurs in entering the land remote sensing satellite field; and

- The International Development Cooperation Agency, the International Trade Administration, the Overseas Private Investment Corporation, and the Export-Import Bank could assist in expanding opportunities abroad for U.S. vendors of land remote sensing equipment and services.

CHAPTER VIII

INTERNATIONAL ASPECTS

The U.S. land remote sensing satellite program has included significant international participation since its inception. This chapter reviews the history and current objectives of this participation and discusses relationships with foreign data users and with operators of foreign land remote sensing satellite systems.

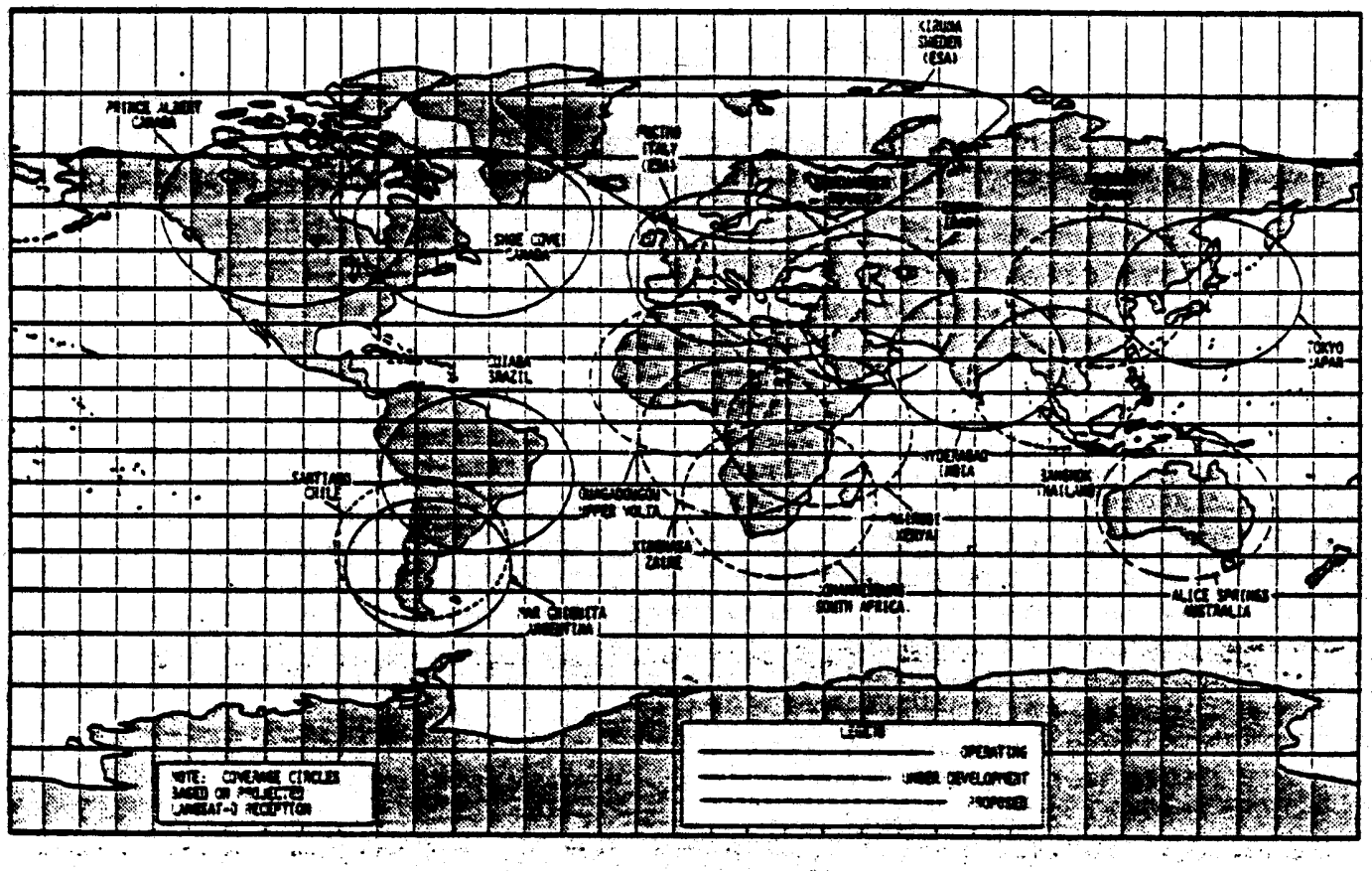
A. History and Objectives

International participation in the U.S. experimental land remote sensing program was stimulated by U.S. efforts in the late 1960s and early 1970s to acquaint potentially interested countries and international organizations with NASA's plans for the development of land remote sensing satellites and their prospective benefits. As a result, investigators from some 50 countries took part in three NASA research programs designed to assess the usefulness of land remote sensing satellite data. In addition, agencies in thirteen foreign countries made arrangements with NASA for direct reception of data from the current experimental Landsat satellites. Table VIII-1 lists the status and depicts the coverage of the foreign receiving stations currently operating as well as those being planned. These foreign Landsat stations operate under agreements concluded between NASA and a cooperating foreign government agency which provide for: (a) foreign agency funding and operation of the ground station, (b) public availability of all Landsat data acquired by the station, (c) support for NASA in the event of a Landsat onboard tape recorder failure, and (d) the payment to NASA of an annual access fee (currently set at $200,000 per station per year).

The U.S. should continue to ensure international participation in the Interim and Fully Operational Systems under arrangements that contribute to the objectives of:

- Fostering international receptivity to and acceptance of U.S. space remote sensing activities;

TABLE VIII-1
FOREIGN LANDSAT GROUND STATION COVERAGE



LANDSAT GROUND STATION STATUS

Country	Agreement Signed	Data Reception	Data Processing
Argentina	1976	1980	1980
Australia	1979	1980	1980
Brazil	1973	1973	1974
Canada			
Prince Albert	1972	1972	1972
Shoe Cove	1976	1977	1977
Chile*	1975	TBD	TBD
China	1980	TBD	TBD
India	1978	1979	1980
Iran*	1974	TBD	TBD
Italy (ESA)	1974	1975	1976
Japan	1979	1979	1979
Sweden (ESA)	1978	1978	1979
Thailand	1979	TBD	TBD
Zaire*	1975	TBD	TBD

Other countries contemplating Landsat Stations: Kenya, New Zealand, Romania, South Africa, and Upper Volta

*Note: Chile and Zaire have thus far been unable to fund the establishment of their proposed Landsat stations. The Landsat station in Iran was largely completed and began receiving some test data in late 1978. However, the station ceased operations in early 1979 as a result of the political situation in Iran.

TBD = To Be Determined

- o Developing a world-wide market for U.S. commercial data products and associated hardware and services;

- o Enhancing the technical quality and scope and reducing the cost of the U.S. land remote sensing satellite program;

- o Encouraging utilization of land remote sensing satellite data and techniques in the national and regional development programs of developing nations; and

- o Maintaining U.S. commercial and technological leadership in the field of space remote sensing.

In pursuing these objectives, the U.S. should concentrate its efforts on the further development of an international community of data users and on the establishment of constructive relationships with those foreign countries also planning to operate land remote sensing satellite systems.

B. Relationships with Foreign Users

Since the first experimental Landsat was launched in 1972, foreign use of Landsat data has grown steadily. This trend is evident in the growing list of countries establishing Landsat stations (see Table VIII-1) and in the data sales statistics of the EROS Data Center, which currently receives 36% of its sales revenues from users with foreign addresses. A further indication of this trend and the long term foreign market potential for land remote sensing satellite data is the increasing use of remote sensing techniques by national and international development assistance organizations. The Agency for International Development, for example, has worked closely with its counterparts in Canada and France to help the African countries establish three regional training and user assistance centers which are making extensive use of Landsat data. The World Bank, the Inter-American Development Bank and a number of UN entities such as the Food and Agricultural Organization and the UN Development Program are increasingly using Landsat Data in support of national development projects. These activities are likely to continue to expand and, as they do, so too will the demand for land remote sensing satellite data.

1. Availability of Data to Foreign Users

In recognition of the growing international demand for land remote sensing data, the U.S. should continue to provide for the availability of data from the Interim and Fully Operational Systems through:

- o Direct readout of data to foreign ground stations. This will carry forward the long-standing U.S. practice of permitting direct foreign reception of data from U.S. civil Landsat satellites; and

- o Public nondiscriminatory availability of data from one or more U.S. distribution facilities. This practice will assure foreign users access to data acquired outside the coverage zones of foreign ground stations and give them the option of obtaining data either from a foreign-operated ground station or from the U.S. via mail or communications satellites.1/

Under current U.S. civil space policy, the U.S. generally supports direct readout of data from the Interim and Fully Operational Systems; however, if a special purpose remote sensing mission were undertaken, such as the Stereosat mission currently being discussed by a number of U.S. Government and private users, the U.S. could make a separate, specific determination of whether and under what conditions direct readout would be available.

In connection with these U.S. data distribution plans, NOAA, along with other interested U.S. agencies, should participate in the discussions of the United Nations Committee on the Peaceful Uses of Outer Space concerning land remote sensing satellite data acquisition and dissemination. These U.N. Committee discussions, which began in the

1/ Communications satellites offer the prospect of relaying data in near real time from distribution centers to users. Though the current cost of such service is high, it may become a viable alternative to direct readout in the next decade should be taken into account as plans for the Fully Operational System are developed.

early 1970s, have included consideration of a draft set of legal principles to guide such remote sensing activities. A key question concerning these principles is whether they should embody restrictions on dissemination of data. Some countries have expressed the view that dissemination of data without the consent of the sensed country would constitute infringement of a sensed nation's sovereignty. A number of countries are also arguing that the principles should embody priority access to both data and derived information relating to their territory.

In the U.S. view, no legal justification exists for contending that the principle of national sovereignty over resources should be extended to include control over data or derived information relating to those resources. The U.S. considers that public nondiscriminatory dissemination of space remote sensing data does not require the consent of the sensed state. On the contrary, the U.S. view is that such public nondiscriminatory dissemination of data is fully consistent with the obligation in the Outer Space Treaty requiring satellite-operating nations to share the benefits of space use as widely as possible and is the most practical and effective way to adhere to this obligation.

2. Pricing Policies -- International Considerations

Pricing policies that are developed for the Interim and Fully Operational Systems for users sharing of the costs of acquiring and processing data will apply to foreign and domestic users through sales of standard data products and through fees for the reception by foreign ground stations of data transmitted directly from the satellites. As these pricing policies are developed, the following factors will be considered in light of their potential impact on foreign users:

- o Development of consistent pricing policies for domestic and foreign users alike.
- o Phasing of price increases to encourage continued growth in the demand for land remote satellite sensing satellite data; and
- o Adequate lead time for price increases so that foreign station operators can be consulted and so station operators and their user communities can arrange for funding of the added data costs.

As NOAA develops policies for sharing the cost of acquiring and processing land remote sensing data, several other considerations will be taken into account. One of these is the concern of many foreign users that future cost-sharing arrangements may result in prices which are so high as to inhibit the widespread use of land remote sensing data. Another consideration is the possibility that future U.S. data sales prices -- set to achieve a reasonable amount of cost-sharing -- will be undercut by the prices established by foreign satellite system operators. NOAA will recognize and weigh these considerations as it shapes a realistic and viable pricing structure that encourages the development of a world-wide market for land remote sensing satellite data and helps reduce U.S. expenditures for the Interim and Fully Operational Systems.

3. Next Steps

As plans for the Interim and Fully Operational Systems are undertaken, NOAA, working closely with the Departments of State, NASA, AID and other interested U.S. agencies, should:

- o Consider foreign user requirements -- particularly those of developing country users -- in planning the Fully Operational System. One step in this direction should be the holding of informal regional meetings to determine user data requirements within the various regions. At these meetings, representatives from the U.S. and other countries operating satellite programs could discuss their respective plans and learn the data requirements of foreign users;

- o Conclude agreements with those foreign agencies wishing to receive data directly from the Interim and Fully Operational Systems at foreign Landsat-type ground stations. These agreements should establish conditions for direct reception which will support the international participation objectives listed above;

- o Establish pricing policies for direct reception and U.S. sale of land remote sensing data that take into account the considerations noted above; and

- o Continue the NASA-established Landsat Ground Station Operations Working Group which consists of those foreign agencies operating or planning to operate Landsat ground stations and which provides a useful forum for the exchange of technical information and experience.

C. Relationships with Foreign Satellite Operators

As discussed in Chapter I, the European Space Agency, France, India, Japan and the Soviet Union have initiated land remote sensing satellite programs. A number of these foreign programs (which are outlined in Table VIII-2) offer the prospect of both competition and cooperation with the U.S. program.

1. Foreign Competition

The potential competitive impact of planned foreign land remote sensing satellites is a subject of considerable significance to the U.S. as it pursues plans for the Interim and Fully Operational System. This competitive challenge to U.S. land remote sensing satellite program leadership occurs in several areas:

- o Sensor Technology Development. France, Japan and the European Space Agency are developing multilinear array sensor systems for use on their land remote sensing satellites. The French multilinear array is scheduled to fly on SPOT in 1984, and the Japanese multilinear array will fly on an ocean observations mission in 1985. NASA is planning an experimental multilinear array sensor, which could be tested on the Space Shuttle in the mid-1980s. A U.S. operational multilinear array sensor could probably not be available for U.S. use before 1989 at the earliest.

- o Ground Equipment and Services. Though the market for Landsat-type ground station equipment is quite limited, the prospects for sales of equipment, software and services associated with analyzing land remote sensing satellite data are considerable. Other countries are well aware of

TABLE VIII-2
DEDICATED FOREIGN LAND SATELLITE MISSIONS

MISSION	LAUNCH DATE	SPONSOR	OBJECTIVES	PROGRAM STATUS	SENSORS	ORBITAL PARAMETERS	DATA HANDLING
SPOT-1 (System Probatoire d'Observation de la Terre)	1984	France (Centre Nationale d'Etudes Spatiales)	Develop satellite renewable and non-renewable resource observations techniques. Develop a stereo and cartographic data archive. Test possible configurations for a future operational system.	Funded	Two 3-channel multispectral/ panchromatic visible spectrum multilinear array sensors	832 km Sun synchronous 26 day repeat cycle (pointing capability permits 1 to 5 day coverage repeat)	Direct readout to foreign ground stations 2 on-board recorders
LOS-1 (Land Observations Satellite)	1987	Japan (Science and Technology Agency/ National Space Development Agency)	Develop capability for agricultural, land use, geological and water resources observations. Test usefulness of data for disaster, coastal and harbor observations.	Mission definition studies funded	4-channel visible and near infrared multilinear array. 4-channel visible and thermal infrared mechanical scanner. Additional sensors under study.	Approximately 800 km Sun synchronous 14-17 day repeat cycle	Direct readout to foreign ground stations planned
LASS (Land Applications Satellite System)	Late 1987/ early 1988	European Space Agency	Develop space observations techniques for agricultural, land use and water resources monitoring.	Mission definition studies funded	6-channel multispectral/panchromatic visible spectrum multilinear array. 2-channel mid-infrared multilinear array 5.3 GHZ synthetic aperture radar.	675 km (baseline orbit) Sun synchronous 17-day repeat cycle (baseline orbit)	Direct readout to foreign ground stations planned. No on-board recorders planned.
IRS (Indian Remote Sensing Satellite)	To be determined	India (Indian Space Research Organization)	Develop space observations system for monitoring agriculture, soils, water resources, forestry, coastal areas, and geological features.	Under study	To be determined	Sun synchronous	To be determined
LOS-2 (Land Observations Satellite)	To be determined	Japan (Science and Technology Agency/ National Space Development Agency)	Develop capability for agricultural, land use, geological and water resources observations. Test usefulness of data for disaster, coastal and harbor observations.	Under study	4-channel visible and near infrared multilinear array. 4-channel visible and thermal infrared mechanical scanner. Additional sensors under study.	Approximately 800 km Sun synchronous 14-17 day repeat cycle	Direct readout to foreign ground stations planned
MERES (Mineral and Energy Resources Exploration Satellite)	To be determined	Japan (Ministry of International Trade and Industry/ National Space Development Agency)	Develop techniques for satellite observations of non-renewable resources.	Under study	To be determined	To be determined	To be determined

these prospects and are likely to compete extensively with the U.S. in these markets.

- o Data Sales. Foreign land remote sensing satellite systems undoubtedly will have an impact on the world-wide market for data products. The degree to which foreign data sales would penetrate this market and consequently have an adverse impact on the U.S. market share would depend on the U.S. commitment to produce superior data and standard data products.

2. Complementarity with Foreign Satellite Systems

While competition undoubtedly will exist between U.S. and foreign land remote sensing satellite systems during the next two decades, their development also offers prospects for cooperation.

Drawing on its considerable experience in the coordination and harmonization of foreign operated geostationary meteorological satellites, NOAA (working closely with NASA, the Department of State and other interested U.S. agencies) is initiating discussions with prospective foreign land satellite system operators with a view towards encouraging complementarity and compatibility among future operational land satellite systems. These discussions will focus on prospects for:

- o Complementary system characteristics, such as
  - spacecraft orbits
  - coverage patterns and repeat cycles
  - types of sensor systems
- o Compatible system outputs, such as
  - common spacecraft downlink frequencies
  - standard data product formats
  - standard data cataloging and archiving procedures to facilitiate data exchanges.

The U.S. objectives in these discussions (in addition to the overall objectives listed at the beginning of this Chapter) include:

- o Maximizing the potential usefulness of U.S. and foreign land remote sensing satellite data for U.S. users as well as users in other countries;

- o Minimizing the duplicative aspects of foreign satellites by encouraging the development of foreign capabilities that complement U.S. programs; and

- o Limiting U.S. space segment costs by avoiding unnecessary expenditures for missions that will be undertaken by other countries, so long as this does not result in undesirable U.S. dependence on foreign space capabilities.

3. Next Steps

With respect to the development of foreign land remote sensing satellite systems, NOAA, working closely with other interested U.S. agencies, should:

- o Encourage the expansion of world-wide markets for U.S. equipment, services and data products. This is important for maintaining U.S. leadership in the land remote sensing satellite field.

- o Conduct discussions with other satellite operators. Several preliminary consultations with prospective land remote sensing satellite system operators have already taken place, the most recent of which was a meeting involving Canada, the European Space Agency, France, India and Japan that took place in Ottawa, May 8-9, 1980. This meeting resulted in a decision to create an informal, technical consultative group which will be comprised of the program managers from those countries that are in the process of establishing land remote

sensing satellite systems that may move into an operational phase. This group is intended to provide a forum for close coordination and harmonization of U.S. and foreign land remote sensing satellite program plans.

CHAPTER IX

ADDITIONAL LEGAL AUTHORITY

As part of developing the Administration's FY 1982 legislative program, the Administration is examining areas where legislation may be needed to implement the civil operational land remote sensing satellite program. Likely areas for additional legislation are:

- o To establish and protect the property interests in the data and standard data products produced by the operator of the land remote sensing satellite system;
- o To provide NOAA the authority to develop, own and operate the U.S. civil operational land remote sensing satellite system until the responsibility is transferred to another entity;
- o To establish and specify the institutional framework, and authorize appropriate financial assistance, for eventual private sector ownership and operation of the civil operational land remote sensing satellite system; and
- o To authorize NOAA to regulate the activities of, and to coordinate Federal user relationships with, any commercial operator of all or any part of the U.S. operational land remote sensing satellite system.

The Administration plans to introduce the required legislation in the 97th Congress.

A. Proprietary Interests in Satellite Data and Products

The data and standard data products produced by the experimental Landsat program have been disseminated widely through a decentralized distribution system at prices that reflect the cost of reproduction or at no cost. The data itself is in the public domain, free of any of the controls associated with copyright or ownership.

To accomplish the objectives that users share in the costs of the system and that the private sector should

eventually own and operate the U.S. civil operational land remote sensing satellite system, this approach to data dissemination may need to be changed, as discussed in Chapter VI, Section B.1. The system operator may require the authority to establish ownership rights in the data and to condition subsequent reproduction and distribution of the data and standard data products on payment of a fee, either directly or through higher direct reception fees, so it can assure effective application of any schedule of fees that exceeds the cost of reproduction. Otherwise secondary distribution at prices below those charged by the system operator but above the cost of reproduction could undercut the system operator's market.

This control would have to be limited so as to require any system operator or foreign ground station operator to comply with the Federal policy of widest practical dissemination of data and standard data products on a public nondiscriminatory basis.

The parameters for authorizing ownership and proprietary controls of land remote sensing data and standard data products are still under review and will be outlined in an Administration bill authorizing the operational system.

B. NOAA Enabling Legislation

Since no clear legislative mandate exists for any Federal agency to develop, own and manage a civil operational land remote sensing satellite system, legislation authorizing the Department of Commerce to develop, own and operate the Interim and eventual Fully Operational Systems, until such time as this responsibility is transferred to some other entity, will be required to succeed the one-year authorizing legislation that was introduced in the Congress earlier this year.

This legislation can authorize the Secretary of Commerce, inter alia, to:

- o Develop, own and operate U.S. civil operational land remote sensing satellite systems, including the functions of procuring and operating the satellites, and preprocessing, processing, archiving and diseminating the data and standard data products;

- o Conduct applications demonstration and training programs; and

- o Engage in a program of international cooperation under the foreign policy guidance of the President and working closely with the Department of State, NASA, the International Development Cooperation Administration/Agency for International Development, and other interested U.S. agencies.

C. Institutional Framework for Eventual Private Sector Operation

This document identifies several options for eventual transfer of primary responsibility for ownership and operation of all or a part of the land remote sensing satellite program to the private sector. Until the mechanism for private sector ownership and operation becomes effective, NOAA will operate the program in order to carry out the President's commitment to continuity of data during the 1980s.

If the Federal government adopts Option 2 or 3 in Chapter VI for legislative creation of a new corporation, consideration should be given to authorizing its establishment sufficiently in advance of its target "takeover" date so that it can play a role in the technical design and establishment of the operational system that it will manage.

Legislation that authorizes the creation of a new corporation should contain the following elements:

- o Powers of the corporation to develop,1/ own and operate the U.S. civil operational land remote sensing satellite system;

- o Composition of the Board of Directors, including the appropriate mix of Presidentially-appointed and privately-elected board members;

1/ The authority to conduct research and development may not be exclusive. As noted in Chapter VI.B.5., NASA probably will continue to conduct such activity in the interest of maintaining U.S. technological leadership.

- o Authority of the corporation to issue capital stock in prescribed amounts, with voting and nonvoting rights, and debt obligations either privately or through the Federal Financing Bank;

- o Establishment of procedures for the corporation's international business activities and for ensuring compliance with United States foreign policy; and

- o Authorization of an appropriate combination of financial assistance mechanisms, including procedures for its administration and appropriate techniques for protecting the Federal government's financial interests.

D. Regulatory Authority

The Administration's proposed legislation establishing the institutional framework for private sector operation will identify the agency or agencies responsible for regulating the activities of any private operator or operators or government corporation in accordance with international obligations and national space policies applicable to land remote satellite sensing, as set forth in Chapter VI D. above.

Such a bill would designate NOAA to regulate the activities of a private sector owner, including, but not limited to, data dissemination and pricing practices, technical standards and provision of services to Government purchasers, as described in Chapter VI D. The Federal government also will have to regulate the private entity's international business arrangements, establish the necessary agreements for direct readout to foreign ground stations, and participate in complementarity discussions with foreign satellite operators.

GLOSSARY

Access Fee -- The charge paid by operators of ground stations for the right to receive the data transmitted from land remote sensing satellites.

AgRISTARS -- Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing. Large, cooperative, multi-year development program of the Departments of Agriculture, Interior, and Commerce, NASA, and AID. Will develop, test, and evaluate ways to use remotely sensed data to produce early warnings of crop stress, crop assessments and forecasts, small area land cover and water evaluation, and renewable and nonrenewable resource inventories.

AID -- Agency for International Development, United States International Development Corporation Agency.

Basic Fee -- The charge paid by each user for each standard data product purchased from the U.S. system operator.

CCTs -- Computer Compatible Tapes. Magnetic tapes containing digital data in appropriate format.

Core System -- The space and ground segment elements necessary to meet the common needs of the majority of users.

Data -- In this document, "data" is used to specify the sensor voltage readings that are transmitted in digital format and received at the ground station. These readings must be interpreted and converted to other dimensions for most applications purposes.

Direct Readout -- The capability that allows ground stations to collect and interpret the data messages that are transmitted from satellites.

DOC -- Department of Commerce

DOI -- Department of the Interior

DOMSAT -- Domestic Communications Satellites

EROS -- Earth Resources Observation Systems

EROS Data Center -- A facility that collects, processes, archives, and distributes data obtained from satellite, aircraft, and other systems, operated by the Geological Survey, DOI, at Sioux Falls, South Dakota.

ESA -- European Space Agency

FOIA -- Freedom of Information Act

Fully Operational System -- The future operational system with space and ground segments designed to meet authenticated and agreed user needs.

Frequency of Observation -- The normal period, usually measured in days, elapsing between two sequential times at which a point on the Earth falls within the field of view of one of the spacecraft of the system.

GSFC (or Goddard) -- NASA's Goddard Space Flight Center, Greenbelt, Maryland

HDDT -- High Density Digital Tape

HDT-A -- High density digital tapes of either MSS or RBV data that have been radiometrically but not geometrically corrected.

Heighting -- A term referring to the ability to resolve the height of objects by means of stereoscopic imagery.

IFOV -- Instantaneous Field of View. The field of view of a scanning instrument with the scan motor stopped. In this document, IFOV is equated to the geometric size of the Earth-area of least size that is discernible by the sensor and which is referred to as the " resolution" of the sensor.

Interim Operational System -- The land remote sensing satellite system to be operated by NOAA and based upon the Landsat D series of spacecraft and the Landsat D ground segment, including any modifications to meet initial operational reliability and performance standards.

IR-Infrared -- That part of the spectrum from the red end of visible light to the microwave region; that is, from about 0.7 m to 1 mm.

IRS - Indian Remote Sensing Satellite. Proposed by Indian Space Research Organization.

LACIE -- Large Area Crop Inventory Experiment. A demonstration program (1974-1977) that used Landsat and weather data to provide estimates of wheat production.

Landsat -- Land remote sensing satellites (formerly ERTS; Earth Resources Technology Satellites) of the series currently operated by NASA.

Landsat D -- The next generation of NASA's land remote sensing satellites. Follow-on spacecraft of this series will be sequentially designated Landsat D', Landsat D'', etc.

LASS -- The Land Applications Satellite System under consideration by ESA for a 1987/88 launch.

LOS -- Land Observations Satellites being considered by Japan for 1987 launch.

Land Remote Sensing Satellite Advisory Committee -- Proposed advisory committee to NOAA, with representatives from state and local governments, other domestic non-Federal users, and interested domesitc private sector groups.

Maximum System -- An operational land remote sensing satellite system with TM bands 1, 2, 3, and 4 at 10 meter resolution, as well as TM bands 5 and 7 at 20 meter resolution. This system would provide service at a level considerably in excess of that of Landsat D.

MERES -- Mineral and Energy Resources Exploration Satellite proposed by Japan.

Middle System -- An operational land remote sensing satellite system with a resolution of 30-40 meters in TM bands 1, 2, 3, 4, 5 and 7 when technologically possible, and the possible inclusion of TM band 3 at 15 or 20 meter resolution. This system would provide service essentially equivalent to the Landsat D system.

Minimum System -- An operational land remote sensing satellite system providing overage in four or five bands at a resolution of 80 meters. The spectral intervals would be similar to those used in TM visible bands 1, 2, 3 and 4 plus either TM shortwave infrared band 5 or 7 -- when technologically feasible. This system would provide service at a level less than that of the Landsat D system.

MLA -- Multi-Linear Array -- solid state technology to support the development of a new sensor on future Landsat spacecraft.

MMS - Multi-mission modular spacecraft.

MSS -- Multispectral Scanner -- an instrument which provides data in four bands of the visible and near-infrared portions of the spectrum. The MSS scans a swath 185 km wide and has an instantaneous field of view (IFOV) of 80 meters.

NASA -- National Aeronautics and Space Administration

NESS -- National Environmental Satellite Service

NOAA -- National Oceanic and Atmospheric Administration

NOSS -- National Oceanic Satellite System

OMB -- Office of Management and Budget

Outer Space Treaty -- Outer Space Treaty is the abbreviated name for the multilateral Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, which establishes in seventeen Articles general principles governing the activities in outer space of State parties to the Treaty in support of the use of outer space for peaceful purposes and for the benefit of all peoples. The United States is a party to the Outer Space Treaty which was entered into force October 10, 1967.

PRC (Space) -- Policy Review Committee on Space -- established by Presidential directive in May 1978, to provide a forum for discussion of proposed changes to national space policy and for rapid referral of issues to the President for decision.

Program Board -- An Assistant Secretary level body to be established and chaired by the Commerce Department for continuing Federal coordination of land remote sensing and to consider issues related to regulation and private sector establishment.

Resolution -- Identical (in this document) with instantaneous field of view.

RBV -- Return Beam Vidicon -- cameras which essentially provide black and white TV images. Each RBV image from Landsat 3 covers an area 90 km on a side (180 km total swath) and has an equivalent IFOV of 40 meters.

Royalty Fee -- A fee that could be paid by each U.S. and foreign user and foreign ground station operator on the reproduction or resale of Landsat standard data products.

S-Band -- A frequency band over which MSS data are transmitted to foreign ground stations directly from the spacecraft.

Spectral Bands -- Portions of the electromagnetic spectrum of energy radiated or reflected by the Earth to which spacecraft sensors are sensitive.

SPOT -- Satellite Probatoire d'Observation de la Terre. This system is scheduled for launch by France in 1984 and is to contain two 3-channel multispectral/panchromatic multilinear visible spectrum array sensors. Its objectives are to develop satellite renewable and nonrenewable resource observation techniques and to develop a stereo and cartographic data archive.

Standard Data Products -- Data in prescribed form that are put through additional computer processes at the satellite ground processing facility. Two classes of standard data products are currently available -- film imagery, which is convenient for those accustomed to working with maps and photographs, and computer compatible tapes (CCTs). The tape form is suitable for input to standard computers and lends itself to automated or specialized data handling and analysis.

Stereo Coverage -- Refers to the availability of data from which the variation in the height of the surface being viewed can be determined.

TDRSS -- Tracking and Data Relay Satellite System -- a communications system to be used for the relay of data direct from Landsat to a single U.S. ground station at White Sands, New Mexico.

Timeliness -- The length of time between the observation itself and the delivery of suitable processed data to users or to the archive.

TM -- Thematic Mapper -- an instrument containing seven spectral bands, including three in the infrared region, with an instantaneous field of view (IFOV) of 30 meters for all but the thermal infrared band which has an IFOV of 120 meters.

Transmission Fee -- A fee that could be paid by foreign ground station operators for data transmitted and received by the foreign ground stations, based on the amount of data requested.

USDA -- United States Department of Agriculture

USGS -- United States Geological Survey (DOI)

Value added products -- These are products derived from standard data products that are manipulated by computers and/or interpreted in various ways to provide information that is valuable to those who wish to make decisions involving knowledge about or changes on the surface of the Earth.

WBTR -- Wide-Band Tape Recorder

X-band -- A frequency band over which a combination signal of MSS and TM data from Landsat D will be transmitted directly to foreign ground stations.

ZBB - Zero Based Budgeting

Zone of Exclusion -- An area over the Indian sub-continent and south-central USSR where direct satellite transmission to the TDRSS is physically impossible.

FOR IMMEDIATE RELEASE November 20, 1979

Office of the White House Press Secretary

THE WHITE HOUSE

The President today announced the designation of the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) to manage all operational civilian remote sensing activities from space. This designation is one of several policy decisions announced today after a review of civilian space policy mandated by a Presidential Directive in October, 1978.

Early in his administration, the President directed a comprehensive review of space policy. The review, completed in May, 1978, resulted in a Presidential Directive that established a national space policy framework. It created a Policy Review Committee on Space, chaired by the Director of the Office of Science and Technology Policy, Frank Press. One of the tasks of the Policy Review Committee has been to assess the Nation's future civil space remote sensing requirements. That review was the basis for the policy decisions announced today.

Designation of a single agency, NOAA, to manage all civil operational satellite activities will lend itself to further integration and potential cost saving in the future. NOAA's experience in successfully operating and managing three generations of weather satellites prepares it to assume the responsibility for land remote sensing in addition to its ongoing atmospheric and oceanic activities. NOAA's first action will be to develop a transition plan in coordination with other appropriate agencies for moving to a fully integrated satellite-based land remote sensing program.

Initially, our operational land remote sensing efforts will rely on experience derived from the LANDSAT program. LANDSAT was begun in 1972 by NASA as a satellite effort specifically designed to observe surface features of the earth.

The President's decision established a three part framework to serve remote sensing activities:

-- Integration of civilian operational activities under NOAA.

-- Joint or coordinated civil/military activities where both parties' objectives can be best met through this approach.

-- Separate defense activities which have no civilian counterpart.

Other space policy decisions developed by this review and announced today are:

-- The Commerce Department will seek ways to further private sector opportunities in civil land remote sensing activities, through joint ventures with industry, a quasi-government corporation, leasing, etc., with the goal of eventual operation of these activities by the private sector.

-- We will continue the policy of providing LANDSAT data to foreign users, and promoting development of complementary and cooperative nationally operated satellite systems so as to increase benefits for all nations.

-- The Department of Commerce will establish and chair a Program Board for continuing federal coordination and regulation of civil remote sensing activities. The involved federal organizations will be represented (i.e., the Departments of Defense, Interior, Agriculture, State, Transportation, and Energy, and NASA, CIA, AID, and EPA). The National Governors' Association and the National Conference of State Legislatures will be invited to participate.

-- Separate weather programs for the military and civil sectors will be maintained under the Departments of Defense and Commerce because of their differing needs. We will continue procurement of current spacecraft until development of a new system design is justified. Future polar orbiting satellite development and procurement will be jointly undertaken by Defense, Commerce and NASA to maximize technology-sharing and minimize cost.

-- Ocean observations from space can meet common civil and military data requirements. Accordingly, if we decide to develop ocean satellites, joint Defense/Commerce/NASA management of the program will be pursued.

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