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Report to Congressional Requesters

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SATELLITE DATA ARCHIVING

U.S. and Foreign Activities and Plans for Environmental Information

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Resources, Community, and
Economic Development Division

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September 29, 1988

The Honorable Ernest F. Hollings, Chairman
The Honorable John C. Danforth,
Ranking Minority Member
Committee on Commerce, Science, and
Transportation
United States Senate

The Honorable James H. Scheuer, Chairman
Subcommittee on Natural Resources,
Agriculture Research, and Environment
Committee on Science, Space, and Technology
House of Representatives

In response to your request, this report describes the environmental satellite data archiving activities and plans of three federal agencies—the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), and the Department of the Interior's U.S. Geological Survey (USGS). In addition, it provides information on international environmental satellite data archiving activities.

As arranged with your offices, unless you publicly release its contents earlier, we plan no distribution of this report until 30 days after the date of this letter. At that time, we will send copies to other appropriate congressional committees; the Administrator, NOAA; the Administrator, NASA; the Director, USGS; the Director, Office of Management and Budget; and other interested parties upon request.

This work was performed under the direction of John H. Luke, Associate Director. Other major contributors are listed in appendix IV.

J. Dexter Peach

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Executive Summary

Purpose

Over the last three decades, satellites have been used to generate information about the earth and its environment. This information is considered valuable by experts and government officials and is being kept, or archived, for future use. Satellite data is expected to be particularly important in researching the changes occurring in the earth's environment. Over the next decade, data generated by satellites are expected to increase perhaps a hundredfold.

Because of the increase expected in satellite data and their scientific importance, the Senate Committee on Commerce, Science, and Transportation and the Subcommittee on Natural Resources, Agriculture Research, and Environment of the House Committee on Science, Space, and Technology asked GAO to examine the principal U.S. and international archives of civilian environmental satellite data and their archiving plans for handling future data.

Background

Since the 1960s, numerous civilian satellites have been launched to obtain environmental information. The most familiar are the satellites that provide information to help make weather forecasts. The United States has launched more than 50 weather satellites. Other satellites provide images of the earth's surface that are useful in agriculture and energy and mineral exploration; five U.S. Landsat satellites launched since the early 1970s have provided such earth images. In addition, numerous experimental satellites have been launched providing information on specific research issues. Because of their historic and scientific value, much of the data generated by environmental satellites have been archived on reels of magnetic tape and on photographs.

Archived satellite data are expected to be increasingly important in the future. Federal researchers have begun a number of new research programs that will rely heavily on archived satellite data. Collectively known as earth system science, these efforts are directed at understanding the earth on a global scale by describing how its component parts interact, evolve, and function and how human activities have affected the components.

Results in Brief

The three U.S. agencies primarily responsible for archiving environmental satellite data—the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), and the U.S. Geological Survey—obtain, maintain, and disseminate large amounts of varying types of data. While each agency has a number of

efforts underway directed at improving archive operations, some concerns exist about how the agencies will archive future data. For example, because of budgetary constraints, NOAA is examining the possibility of private firms taking over its archiving functions, and NASA, which may in the next 10 years have a 15-fold increase in data, is planning on significant technological advances and interagency cooperation to archive the large amounts of data. The Geological Survey is facing a possible future reduction in archiving responsibilities and funding.

Foreign activities in the environmental satellite area have been growing rapidly. Since 1977, at least nine environmental satellites have been launched by Japan, France, India, and a group of 13 European countries. These and other countries, such as Canada, have plans to launch at least 30 additional environmental satellites between 1988 and 1997. In discussing satellite data archiving with foreign officials, GAO found that most believed that archived data will be important to future research and that opportunities exist for increased levels of international cooperation. Many of the U.S. experts viewed the foreign data as important but raised concerns about the future availability of these data. NOAA and NASA have begun activities to address the concerns raised.

GAO's Analysis

U.S. Satellite Data Archiving

NOAA is primarily responsible for archiving data from its weather satellites. Since the early 1970s, NOAA has accumulated over 145,000 magnetic tapes and 6 million photographic images of weather data. It is currently examining the possibility of private firms taking over some or all of its archive operations without government financing and developing criteria for determining what types of data should be kept. NOAA officials said their future archiving role will be largely influenced by two items—improvements to the existing archive and the results of the privatization examination. NOAA officials believe that improvements in computer capacity, storage space, and user access will be needed to allow them to effectively archive increased amounts of data in the early 1990s. Agency officials said, however, that before any major improvements are considered, the privatization issue needs to be resolved.

NASA also has been archiving satellite data for many years in support of its research scientists. NASA's principal environmental data archive is responsible for over 110,000 magnetic tapes of satellite data. NASA has

been developing systems directed at improving the way the data are used and archived and ensuring that the NASA researchers, who often have sole access to certain data as they are generated, provide them to the NASA archives so that others may use them. In addition, NASA has started a program to restore and preserve its older archived tapes because some have begun to deteriorate. NASA's future involvement in archiving data is expected to be largely affected by the Polar Platforms, planned for the mid- to late 1990s, which are to orbit the earth and generate environmental data at up to 15 times today's levels. NASA recognizes it needs significant technological advances to help handle the expected increase in data. In addition, because of the magnitude of the data expected, NASA has begun working with other agencies, such as NOAA and the Geological Survey, to participate in collecting and archiving data from the platforms.

The U.S. Geological Survey's Earth Resources Observation System Data Center has served as the archive for Landsat satellite data since the early 1970s. It contains about 47,000 magnetic tapes of land images. In addition, through agreement with NOAA, the Data Center is to be the location of the legislatively mandated National Satellite Land Remote Sensing Data Archive. This archive is to preserve irreplaceable, global land remotely sensed data collected in the past or the future. The Data Center's role is expected to change because its Landsat archiving function is expected to be undertaken by the private operator of Landsat satellites. In addition, the Data Center has not received funds to create the national land archive from NOAA, which legislatively is responsible for its establishment and funding. Officials said they are not planning on providing funds because of higher funding priorities. Without the national land archive, there is some question about what will happen to the data generated from the Landsat satellites. The extent to which future data might be kept would depend on the views of the private operator regarding the costs and economic benefits associated with doing so.

Foreign Satellite Data Archiving

Many foreign countries, in addition to the data generated from their satellites, collect and archive data generated by other countries' satellites. Foreign officials agreed that archived satellite data are important from a scientific standpoint in examining areas such as forestry, agriculture, water pollution, ocean currents, temperature change, and weather phenomena. In addition, these officials said that some international cooperation is occurring but that more needs to be done to help ensure

that the various countries archive data in a way that is useful to all and that minimizes duplication of holdings.

The U.S. experts said that the foreign data have been useful in research and will become increasingly important in the future as additional foreign satellites are launched. However, some experts were concerned that the data from the foreign satellites may not be available because, for example, foreign catalogs and directories of available data may be limited. NOAA and NASA officials said they have begun working to overcome these concerns by participating in joint satellite missions, negotiating agreements to obtain certain foreign data, and participating in international organizations that have interest in such issues.

Matters for Congressional Consideration

Because funds have not been requested nor provided for the establishment of the National Satellite Land Remote Sensing Data Archive and NOAA does not plan on doing so in the future, the Congress, if it still wants the archive to be created, may want to provide specific funding for the archive.

Recommendations

GAO is making no recommendations.

Agency Comments

GAO discussed this report with the principal federal agencies and included their comments where appropriate. These officials generally agreed with the information presented. However, as requested, GAO did not obtain official agency comments on a draft of this report.

Contents

Abbreviations

EOSAT	Earth Observation Satellite Company
EROS	Earth Resources Observation System
ESA	European Space Agency
CODMAC	Committee on Data Management and Computation
DOD	Department of Defense
GAO	General Accounting Office
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NSSDC	National Space Science Data Center
PDMP	Project Data Management Plan
POSEIDON	Poseidon
RADARSAT	Radar Satellite
SDSD	Satellite Data Services Division
SPOT	Systeme Probatoire d'Observation de la Terre
TOPEX	Ocean Topography Experiment
USGS	U.S. Geological Survey
WMO	World Meteorological Organization

Introduction

Over the last three decades, numerous satellites have been used to obtain environmental data by scanning the earth and its surrounding atmosphere. Information generated from these satellites is widely used in making weather forecasts and performing numerous research studies. Satellite-generated information is stored or archived for future use. Many researchers and businesses use these archived data to provide scientific or historical information in such areas as weather and atmospheric research, and mineral and energy exploration.

A number of different kinds of environmental satellites have been launched since 1960, when the first weather satellite was placed in orbit. Over the coming decade, an increase is expected in launches of civilian environmental satellites from U.S. and foreign sources. Scientists expect that a "data explosion" will result, with perhaps a hundredfold increase in data being transmitted to earth.

Basically, three U.S. agencies have responsibility for collecting and archiving these data—the National Aeronautics and Space Administration (NASA), the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), and the Department of the Interior's U.S. Geological Survey (USGS).

Environmental Satellites

Satellites gather environmental information over wide areas of the earth. In general, the instruments on the satellites obtain information on (1) atmospheric weather conditions, (2) surface features of the earth (land and oceans), and (3) various scientific research questions.

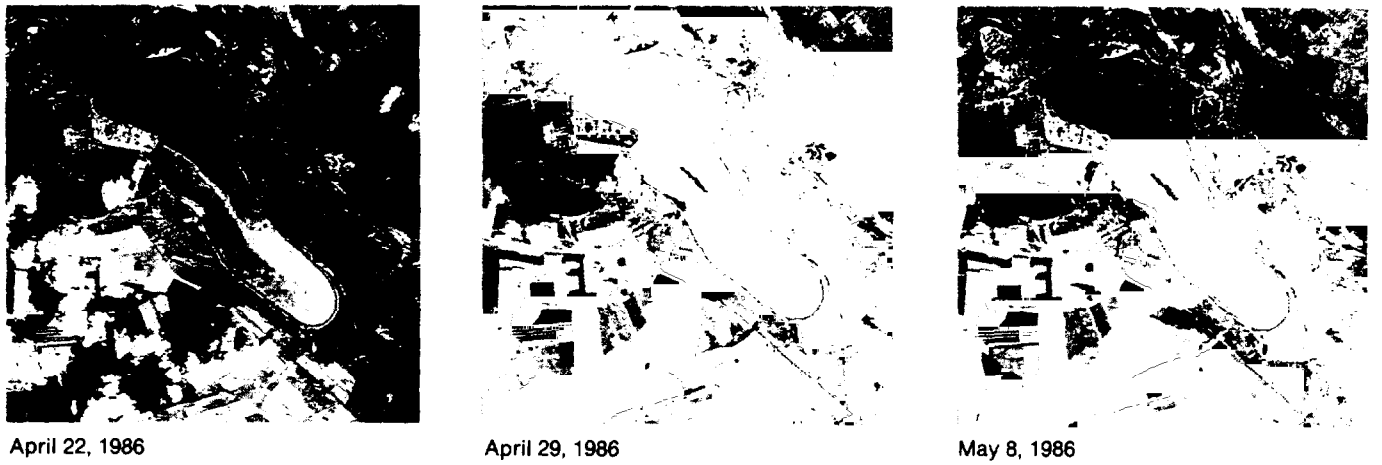
Since the United States launched its first weather satellite in April 1960, more than 50 such satellites have been launched. There are basically two types of weather satellites—geostationary satellites and polar orbiting satellites. The geostationary weather satellites are in a fixed, or stationary, position relative to the earth below. The United States currently has two such geostationary weather satellites, one above the East Coast and one above the West Coast. Polar orbiting weather satellites move around the earth, going over the North and South Poles, providing images as they orbit. Two civilian U.S. polar orbiting satellites make about 14 orbits around the earth each day. Information provided by these satellites is used by the National Weather Service in making weather forecasts. In addition, data generated are collected and archived and used for improving forecasts and researching cloud formations, atmospheric temperature changes, and wind actions. Figure 1.1 shows the image of a hurricane taken from a weather satellite.

Figure 1.1: Hurricane Gloria Off the Southeastern United States, 1985

Source: NOAA

Other environmental satellites also provide information on the earth's surface features—land masses and oceans. These satellites provide images of the earth that are useful in applications such as mapping, agriculture, energy exploration, and mineral discovery. Primary examples of these types of satellites are the U.S. Landsat satellites, capable of sensing features 30 meters or larger. The United States has launched five of these satellites since the early 1970s. Figure 1.2 shows images of the 1986 Soviet Chernobyl nuclear reactor site before and after the accident, processed from Landsat satellite data.

Figure 1.2: Chernobyl Nuclear Reactor Site, 1986



April 22, 1986 | April 29, 1986 | May 8, 1986

Note: The large body of water shown is the cooling pond for the Chernobyl nuclear plant at the northwestern end. The red color indicates the warmest water temperature while the dark blue indicates the coolest temperatures. The figure shows that on April 22, 1986 before the accident, the nuclear plant was operating as indicated by the red and yellow colors in the cooling pond. The April 29, 1986 image, after the accident, shows that the plant was not operating. The May 8, 1986 image shows that the plant was still not operating and that the water has further cooled. Photo courtesy of the U.S. Geological Survey.

In addition to weather and surface observing satellites, a number of experimental satellites have been used to obtain information on various scientific questions. For example, the Nimbus-7 and Seasat experimental satellites were used to study, among other things, the oceans.

In addition to U.S. environmental satellite activities, many foreign countries are involved in launching and using similar satellites. Table 1.1

identifies some of the U.S. and foreign environmental satellites in orbit as of June 30, 1988.

Table 1.1: Examples of Current U.S. and Foreign Environmental Satellites and Their Applications

Country and satellite name	Satellite application
United States	
Geostationary Operational Environmental Satellite	Meteorological
Polar-orbiting Operational Environmental Satellite	Meteorological
Landsat Satellite-5	Land imaging
Earth Radiation Budget Satellite	Radiation monitoring
European Space Agency[a]	
Meteosat	Meteorological
France	
Systeme Probatoire d'Observation de la Terre (SPOT)	Land imaging
India	
Indian National Satellite System	Meteorological
Indian Remote Sensing Satellite	Land imaging
Japan	
Geostationary Meteorological Satellite	Meteorological
Marine Observation Satellite	Ocean observations
Soviet Union	
Meteor	Meteorological
Cosmos 1870	Land imaging

[a]The European Space Agency is made up of 13 member countries: Austria, Belgium, Denmark, France, the Federal Republic of Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. Finland is an Associate Member and Canada has an agreement for close cooperation with the European Space Agency.

Undoubtedly many countries will launch additional environmental satellites in the future. U.S. and foreign scientists expect satellite data to be generated at a far greater rate over the next decade than in the past. Advanced data collection techniques and more complex scientific instruments will markedly increase the amount of data available. The President's Office of Science and Technology Policy has estimated that over the next decade the flow of earth science data from space could increase a hundredfold.[1]

[1]Earth Science Research in the Civil Space Program, Executive Office of the President, Office of Science and Technology Policy, Oct. 1985. The Office of Science and Technology Policy is the President's advisory group on science matters and conducted this study to identify the roles and activities of the various federal agencies involved in earth science research.

Archiving Satellite Data

Three basic functions are performed in archiving satellite data: obtaining data, storing data to help ensure it is available for future use, and disseminating data to users.

Archiving agencies, such as NOAA, NASA, and USGS, obtain data generated from environmental satellites in a number of ways. They receive the data directly from the satellites if they have the necessary receiving equipment, or data may be supplied by others, such as the Department of Defense. In addition, studies and data produced by the scientists or analysts working with the satellite data are provided to the agencies for storage and dissemination.

The archiving agencies have the goal of storing the information obtained to ensure it is available to future users, including government scientists or researchers, university researchers, private industry, or the general public. Data are usually stored in two basic forms—magnetic tapes and images. Magnetic tapes need to be stored in a controlled temperature and humidity environment to ensure that they do not deteriorate. Images are stored as photographs, film reels, transparencies, and microfiche, which also may require special storage facilities.

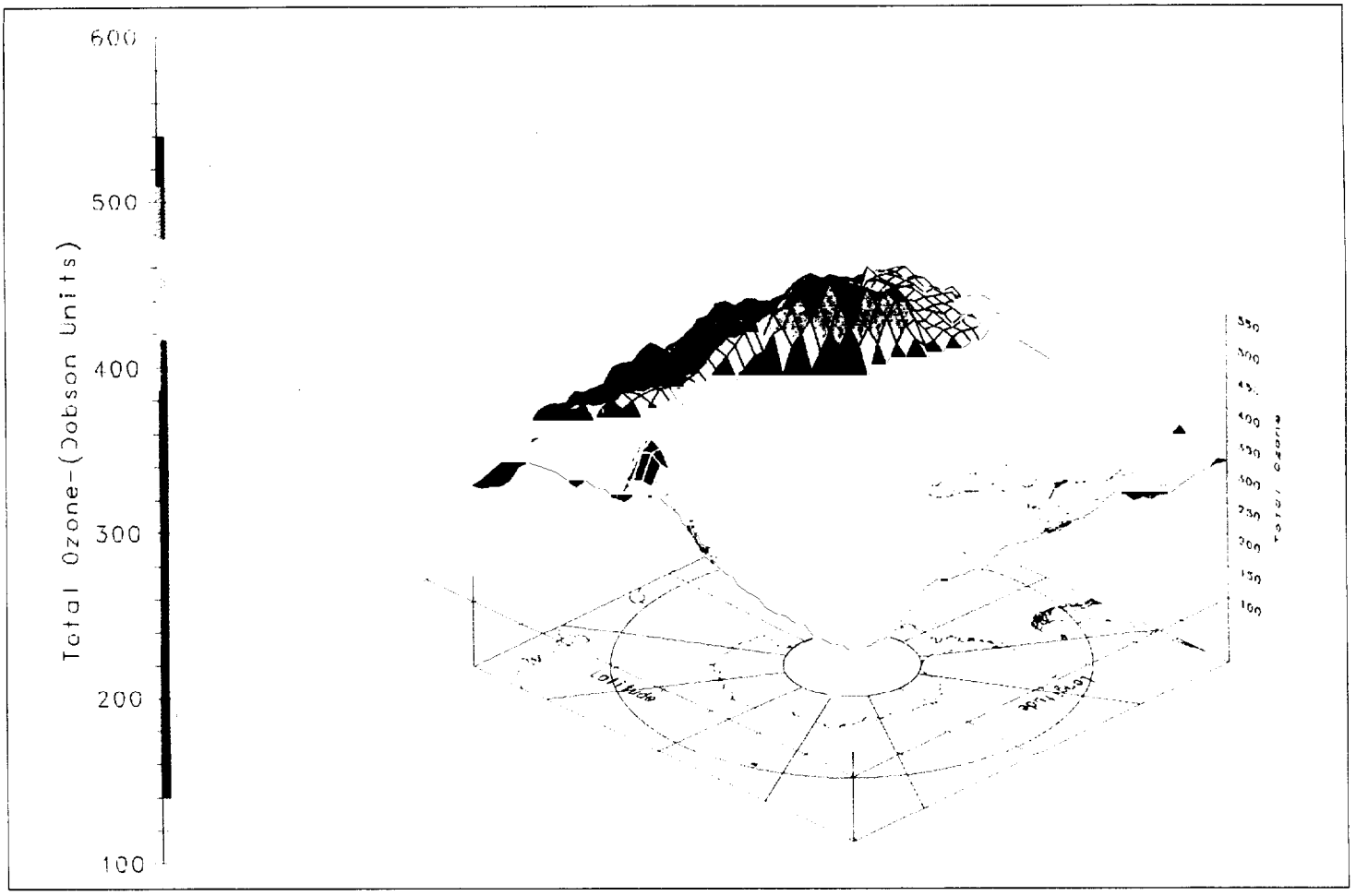
Each of the federal agencies charged with archiving also needs to have the means available to provide the data to those who need them. This includes having the ability to identify data that are available (catalogs and directories) and to fill orders for needed data.

Importance of Archiving Environmental Satellite Data

Archived satellite data are useful for scientific and/or historical purposes. Scientists believe that these types of data, collected over long periods of time, may help in understanding—and possibly contribute to overcoming—environmental problems on earth. Because satellites cover the entire earth, researchers believe the information obtained and collected will be important in understanding environmental problems on a global scale.

Archived environmental satellite data are important for scientific analyses. For example, as shown in figure 1.3, archived data from experimental satellites are being used to analyze the extent of a "hole" in the earth's ozone layer over the Antarctic.[2]

Figure 1.3: Thinning Ozone Layer Over the South Pole, October 1986



Note: Figure created by NASA using data from the Nimbus 7 satellite.

[2]The ozone layer is a section of the earth's upper atmosphere that provides protection from the sun's ultraviolet rays. A thinner ozone layer reportedly may contribute to increases in skin cancer, smaller crops, weaker plants, and an increase in global temperatures. Many scientists believe that the growing size of the ozone hole is caused, at least in part, by chlorofluorocarbons, which are used in such applications as cooling agents in air conditioners and refrigerators and propellants in spray cans.

Archived satellite data have also been used in documenting and studying the effects of destruction of forests, contamination of rivers and bodies of water, and proliferation of deserts. In addition, researchers use archived satellite data to help improve medium- and long-range weather forecasts.

Archived satellite data are expected to be increasingly important as U.S. and foreign scientists begin major programs to better understand the effects of human activities on the earth's environment. In using the earth's resources to meet human needs, large-scale agricultural and industrial activities have been accompanied by deforestation, diversion of fresh water systems, and introduction of chemicals into the atmosphere and oceans, each of which may have long-term adverse global impacts. Programs such as Earth System Science[3] are to help understand the earth on a global scale by describing how its component parts interact, evolve, and function. Archived environmental satellite data will be used to provide information essential to this research.

U.S. Agencies' Archives

In the United States, three federal agencies are primarily responsible for ensuring that environmental satellite data are collected, stored, and made available to users: NOAA, NASA, and USGS.

- NOAA has been primarily archiving weather-related environmental satellite data since the early 1970s. According to federal regulations it is responsible for making worldwide environmental data, data products, and science information available to all users. As of March 1, 1988, NOAA's archives contained about 145,000 magnetic tapes, cartridges, or cassettes and about 6 million photographic images.
- NASA, as part of its responsibilities to obtain data from space and provide wide dissemination of this information, archives much of the data generated by its satellites as well as other satellites for use by researchers and scientists. Most of its archived environmental data are managed by its National Space Science Data Center. As of March 1, 1988, the NASA archive managed about 110,000 tapes of satellite data.

[3]In November 1983, NASA's Earth System Science Committee was appointed to consider the direction of NASA's earth science program. It issued a report entitled Earth System Science: A Program for Global Change in January 1988, which included recommendations for a program to develop the capacity to predict changes that will occur in the next 10 to 100 years, both naturally and in response to human activity.

- USGS' Earth Resources Observation System (EROS) Data Center was established in 1972. In the environmental satellite area, it is primarily responsible for archiving and distributing Landsat data. As of March 1, 1988, the EROS archive contained about 47,000 magnetic tapes of Landsat data.

Chapter 2 provides a more detailed description of the archives and their current activities and plans.

Objectives, Scope, and Methodology

The Senate Committee on Commerce, Science, and Transportation and the Subcommittee on Natural Resources, Agriculture Research, and Environment of the House Committee on Science, Space, and Technology requested us to review U.S. and international satellite data archiving plans and activities. Specifically, we agreed to

- describe the principal U.S. archives of civilian environmental satellite data,
- identify U.S. and international archiving plans for satellite data, and
- obtain the views of a number of experts on the importance of these data and the future direction of satellite data archiving.

To identify the U.S. archiving activities, we conducted our work primarily at three U.S. agencies' satellite data archiving facilities: NOAA's Satellite Data Services Division located in Suitland, Maryland; NASA's National Space Science Data Center located in Greenbelt, Maryland; and USGS' Earth Resources Observation Systems Data Center in Sioux Falls, South Dakota. At these locations we interviewed agency archive officials and obtained information on their current operations and future plans for handling satellite data. We also visited the University of Wisconsin's Space Science and Engineering Data Center and the University of Colorado's National Snow and Ice Data Center to discuss their archiving operations and role as NOAA contractors for archiving satellite data.

We also met with NOAA, NASA, and USGS officials in Washington, D.C., to obtain information on agency archiving activities. In addition, we met with Department of Commerce and Office of Management and Budget officials and discussed the administration's plans for future satellite data archiving and past funding decisions and priorities. While we identified current activities and future plans, we did not, however, evaluate the adequacy of the agencies' actions. However, a separate GAO effort was recently initiated to examine NASA's policies and procedures for archiving space science data.

To obtain information on foreign countries' archiving practices and future plans, we visited Canada, England, France, Italy, and Japan. In these countries, we met with foreign officials and discussed their current and future environmental satellite activities and their archiving plans. These countries were selected because they have been identified as either currently operating environmental satellites or planning to launch environmental satellites. We also met in Washington, D.C., with an official from the Embassy of India to discuss India's current and future plans regarding environmental satellites and archiving policies.

To obtain views from experts on the importance of archived satellite data and the future direction of satellite data archiving, we selected 20 experts from various scientific disciplines that frequently use these types of data. In identifying experts, we developed a list of potential contacts, in part, by asking for recommendations from agency officials and various consulting or user groups in the environmental satellite area. We also included authors of recent studies involving environmental satellite data issues.

Our work was done, for the most part, between February 1987 and February 1988 in accordance with generally accepted government auditing standards. The views of responsible agency officials were sought during the course of our work and are incorporated in the report where appropriate. These officials generally agreed with the findings presented in this report. As requested, however, we did not obtain official comments on a draft of this report.

U.S. Satellite Data Archives: Current Activities and Future Plans

NOAA, NASA, and USGS, through various laws and regulations, are responsible for archiving environmental satellite data. Each agency independently acquires, maintains, and disseminates varying amounts and types of satellite data to serve its mission. In addition, each agency has work directed at improving its archiving program, ranging from preserving older data to establishing new archiving systems. In addition, a number of coordination groups have been established in recent years to address federal activities in archiving satellite data and issues of common concern relating to data generation, collection, archiving, and dissemination. Appendix I provides selected background information on each agency's archiving activities.

The three agencies expect a significant future increase in environmental satellite data and, to varying degrees, have begun planning for the expected increase. However, some concerns persist about how the agencies will archive future data. In this regard, for example, NOAA, because of budgetary constraints, is examining the possibility of private firms taking over its archiving functions, and NASA, which may in the next 10 years have a 15-fold increase in data, recognizes it needs significant technological advances and interagency cooperation to collect and archive the data. Similarly, USGS is looking for alternative funding sources for its EROS Data Center because its Landsat archiving function may be taken over by the commercial Landsat operator, and the legally mandated national land archive at EROS has not been funded. In addition to concerns about the agencies' roles, several experts expressed doubts about the federal government's commitment to fund future data archiving activities.

NOAA's Satellite Data Archiving Activities

According to Department of Commerce Organization Order 25-5B, dated September 1986, NOAA is to provide the data, information, and services needed to support, among other things, data archiving and dissemination. In this regard, NOAA operates and maintains a system for the acquisition, storage, and dissemination of worldwide environmental data relating to land, ocean, atmospheric, and solar conditions. NOAA's environmental satellite data have been collected largely from a number of NOAA and Department of Defense (DOD) weather satellites as well as from certain NASA experimental satellites that NOAA determined were needed for its mission. NOAA's archived data are used in areas such as meteorology, oceanography, and land science. As discussed further in appendix I, NOAA's primary archive for environmental satellite data is the Satellite Data Services Division of the National Climatic Data Center, part of NOAA's National Environmental Satellite, Data, and Information Service.

NOAA has a number of efforts underway involving its archiving operations and is beginning to examine its future role in archiving satellite data.

Current NOAA Efforts

In addition to obtaining, storing, and disseminating data, NOAA is currently involved in a number of other satellite data archiving activities. For example, NOAA is examining the possibility of allowing private firms to take over its archiving functions (without government financial assistance), reducing its photographic services, and establishing criteria to help determine what satellite data should be kept in the future.

Privatizing NOAA Archives. In the fall of 1987, NOAA initiated work to determine whether or to what extent private firms would be interested in performing its archiving activities, without government financial assistance. This activity started as a result of Commerce's (NOAA's parent agency) review of NOAA's fiscal year 1989 budget request. NOAA requested $7.5 million to upgrade its archive to handle the sharp increase in data being planned for the 1990s. In rejecting the funding request, Commerce directed NOAA to explore the extent to which the archiving functions would be of interest to private firms. Commerce's Director of Budget said he wanted this study completed before any major funding increases for NOAA's archiving activities would be considered. According to the Director, if private firms view some or all of the archiving activities as being profitable, they may be willing to perform the archiving function and reduce the cost to the government for the service.

NOAA is currently developing a Request for Information to determine the level of private sector interest in performing the archiving function. As of July 1, 1988, NOAA and Commerce were reviewing a draft Request for Information. NOAA expects to issue the request in the summer of 1988. NOAA officials said they do not expect that any private firm would be willing to perform the entire archiving function without federal assistance, but added that certain portions of the archiving duties may be profitable to the private sector.

Reduction of Photographic Services. NOAA's Satellite Data Services Division, in addition to its magnetic tape archive, operates a film archive

facility. The film archive stores and sells satellite photographic images.[1] It has collected about 4.4 million images from geostationary and polar orbiting weather satellites, the earliest dating back to 1960. NOAA reported that in 1987, it provided about 6,000 photographic products to its customers.

In November 1987, NOAA announced plans to stop producing and selling the photographic products by April 1, 1988. A NOAA official said the agency was eliminating this activity primarily because sales of images had been declining. He estimated that in fiscal year 1987, operational costs for the film archive exceeded sales revenues by $100,000. In November 1987, NOAA sent a questionnaire to 700 users of the facility to determine their reaction to the planned reduction in photographic services. About 175 users responded to the questionnaire. According to NOAA officials, about 86 percent of the respondents indicated that closing the archive would adversely impact their organizations.

As a result of the survey response, NOAA decided to continue producing and selling its photographic products but plans to reduce the staffing level and examine ways to reduce costs of producing the photographic products. In this regard, NOAA plans to reduce the staffing level at the film archive from 4 to 2 staff. In addition, it is planning to purchase a new optical disk system by January 1989 that will enable it to produce facsimile images at a reduced cost. Higher quality images will continue to be provided through a system that converts the data on magnetic tapes to a photograph.

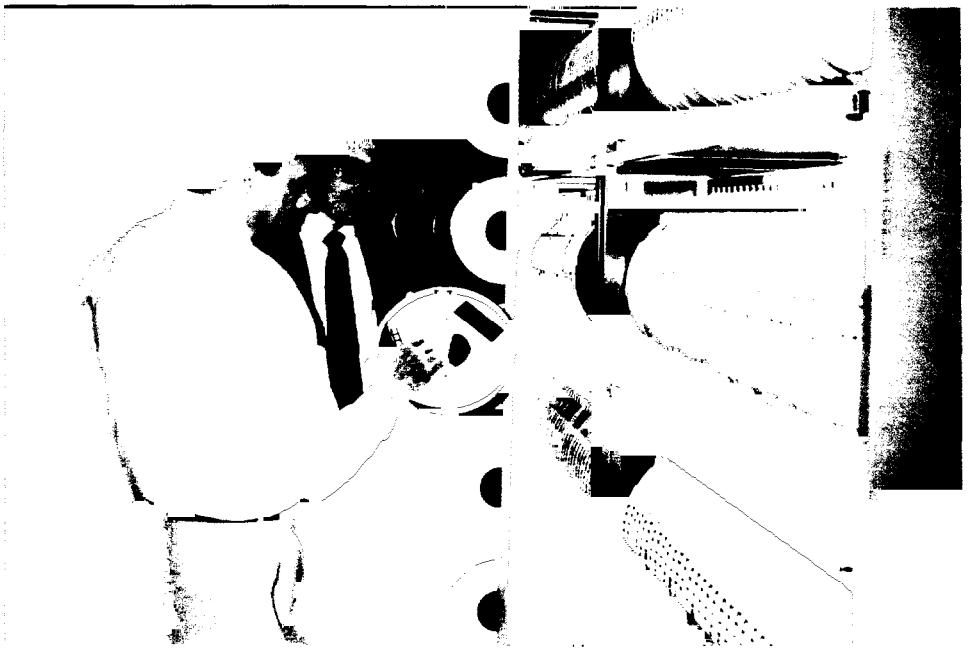
Developing Criteria for Keeping Data. In late 1987, NOAA began discussing a proposal with the National Academy of Science's Committee on Geophysical Data[2] to develop criteria to help NOAA decide what future data to acquire and what past data to retain. NOAA officials said they are approaching a point where it may not be practical to archive all the data they receive. In addition, some older data on magnetic tape is over 10 years old—a point at which data should be recopied if they are to be kept. NOAA officials said that after the committee develops the criteria,

[1]NOAA's film archive produces and sells such products as high-quality photographs from film negatives and facsimile prints. Over the past several years, NOAA has been phasing out making high-quality film negatives of weather satellite images primarily because of cost constraints and has been producing a cheaper but lower quality facsimile print. Photographic products can still be obtained, but the process requires using either facsimile prints, which result in lower quality products, or magnetic tapes, which is a more expensive process.

[2]The Committee on Geophysical Data was established in 1967 to address data problems in such geophysical areas as atmosphere, oceanography, solid earth, and solar-terrestrial.

they may also ask it to apply the criteria to their current and future data holdings and make recommendations on what data to keep. The committee's Executive Secretary told us that they expect to begin their work in September 1988 and anticipate a written report by July 1989.[3] Agency officials said any decisions regarding recopying old data or keeping new data will be open to public comment by other federal agencies and interested parties.

Figure 2.1: Satellite Data Stored on Magnetic Tape



NOAA's Future Satellite Data Archiving Role

NOAA's Assistant Administrator, National Environmental Satellite, Data, and Information Service, said he sees NOAA continuing as a valuable participant in satellite data archiving. He added that NOAA's future responsibility includes archiving weather data and other selected satellite data to meet the needs of a new program in global and climate change, as well as other researchers' needs. However, he also recognized that the current archive facilities are not adequate to handle the expected increased requirements and that the results of NOAA's privatization study could have an effect on its future archiving plans.

[3]The work agreement will be between the committee and NOAA. The cost is expected to be about $240,000; NOAA and other federal agencies (NASA and USGS) interested in the study results will fund the effort.

NOAA officials said archiving satellite data will increase with the launch of a new series of geostationary and polar orbiting weather satellites in the early 1990s. For example, the geostationary satellites are expected to produce data at about twice today's rates. In addition to data from NOAA satellites, officials said they expect to continue archiving data from certain DOD, NASA, and foreign satellites to meet program missions. For example, NOAA recently began to archive certain data from a new DOD weather satellite and disseminate the data to those who want it. In addition, NOAA officials said they plan on archiving weather-related data from NASA's Polar Platforms[4] that are expected to be launched in the mid- to late 1990s. Although exact figures are not available, NOAA officials estimate that the platform may increase their archiving requirements tenfold compared with the current rate for polar orbiting weather satellites.

Agency officials said satellite data archiving functions may also be affected if the Congress approves a new program being proposed by NOAA's Oceanic and Atmospheric Research activity. In this regard, the President's fiscal year 1989 budget contains a $15 million request for a program called Climate and Global Change. According to NOAA's budget, the broad goal of this program would be to establish the foundation for a national information service based on providing reliable predictions of global climate change and associated regional implications on time scales ranging from seasons to a century or more. While the specifics of NOAA's global change program will not be fully defined until the program is approved and further developed, NOAA officials said it may affect their archiving activities because much of the data needed to understand global change are to be maintained in their archives.

NOAA officials told us that their plans for archiving this future data are contingent upon two items—improvements in the current archives and results of the privatization study. Their current archive, they say, is not sufficient to effectively handle the data increase expected in the early 1990s. According to the Deputy Assistant Administrator, National Environmental Satellite, Data, and Information Service, the archives are approaching a critical point at which improvements will need to be funded or operations will need to be restricted. He identified improvements needed in areas such as computer capacity, storage space, and

[4]NASA is planning to develop two Polar Platforms, which will orbit the earth generating large amounts of information from their instruments. The platforms are expected to be ready in the mid-to late 1990s and carry a number of instruments generating information on the weather, land, ocean, and atmospheric conditions.

user access (including better directories, catalogs, and services). In addition, NOAA's draft privatization Request for Information states that "Currently available resources are inadequate to support replacement and upgrade of older technology computer systems, to assure the integrity of data presently in and arriving at the data centers, much less to handle the increased future data volume." NOAA officials said that before any major improvements are considered, the privatization issue needs to be resolved, which may require at least a year.

NASA's Satellite Data Archiving Activities

As part of its responsibilities under the National Aeronautics and Space Act of 1958 (P.L. 85-568), as amended, to obtain data from space and provide wide dissemination of this information, NASA has been archiving satellite data for many years. NASA's archives contain data on astronomy; astrophysics; atmospheric, land, ocean, and planetary sciences; and solar-terrestrial physics. In the environmental satellite data area, NASA archives data primarily from its research satellites but also archives certain data from NOAA's weather satellites and foreign satellites when it determines that the data may be needed to support its research projects. The National Space Science Data Center (NSSDC) is the principal archive for NASA's environmental satellite data. It is a component of the Communications and Information Systems Division in NASA's Office of Space Science and Applications. (See app. I for further background information.)

Current NASA Efforts

NASA has a number of current initiatives underway directed at improving its archiving operations. For example, it is (1) developing discipline-oriented data systems to better use and archive data, (2) working to ensure that NASA researchers, who have sole access to certain data as they are generated, will provide them to the NASA archives so others may use them, and (3) initiating a program to restore and preserve older archived data that, in some cases, have started to deteriorate. This report does not address the adequacy of these activities.

Developing Discipline-Oriented Data Systems

As part of its efforts to facilitate researcher use of archived satellite data, NASA began in 1980 to develop discipline-oriented data systems. These systems, initially called pilot data systems, were designed to be interactive, on-line, computerized information systems that allow scientists to identify, access, and manipulate certain satellite data in their areas of interest. NASA has been developing these systems in four scientific areas—land, oceans, climate, and planets. As described in appendix

II, each data system has its own particular goal and special emphasis. NSSDC is responsible for developing and managing the climate and land data systems while the Jet Propulsion Laboratory is responsible for the ocean and planetary data systems.[5]

NASA officials view these discipline-oriented data systems as an important adjunct to their overall archiving activities because they provide selected segments of NASA's scientific user community with ready access to the specific space science data. In addition, they allow new technologies for data management to be developed and tested, such as optical disks and computer networks. Further, in the future, these systems are expected to provide a central control point for data generated from certain new satellite missions. In this regard, certain new data will be placed under the control of these systems as they are generated. In this way it is hoped that scientists will be able to better use the data. As an example of how these systems will work, the Director of NSSDC cited the Ocean Topography Experiment (TOPEX)/POSEIDON satellite mission,[6] in which the NASA Ocean Data System will be responsible for collecting and making available the mission's data.

Obtaining Data From NASA Researchers

In many cases, NASA's satellite data have not been directly placed in its archives but have been provided to NASA-sponsored researchers, called principal investigators, on an exclusive basis, to perform certain experiments or research. After the work is completed—generally in about 2 years—the principal investigators are supposed to provide the data to a designated NASA archive so that they will be available to others. However, GAO and the National Academy of Sciences have reported that NASA has not taken action to ensure that the principal investigators return the data to NASA archives.[7,8]

[5]The Jet Propulsion Laboratory is a government-owned/contractor-operated facility. Its primary role is in the exploration of the solar system. However, it also has activities in areas such as the earth's atmosphere, geosciences, and oceanography.

[6]The TOPEX/POSEIDON satellite mission has the objective of enhancing the understanding of the circulation of the global oceans. The joint NASA and French project is expected to be launched in 1991.

[7]More Emphasis Needed on Data Analysis Phase of Space Science Programs (GAO/PSAD-77-114, June 27, 1977).

[8]Data Management and Computation, Volume 1: Issues and Recommendations, National Academy of Science's National Research Council, Committee on Data Management and Computation, 1982; Issues and Recommendations Associated with Distributed Computation and Data Management Systems for the Space Sciences, National Academy of Science's National Research Council, Committee on Data Management and Computation, 1986; and Critical Issues in NASA Information Systems, National Academy of Science's National Research Council, Committee on NASA Information Systems, 1987.

NASA has recently initiated some action to help ensure that its satellite data are promptly returned. These efforts include (1) ensuring that project data management plans are developed and approved for each satellite mission that specify the archiving arrangements, (2) working more closely with satellite project scientists to provide data to NASA, and (3) inventorying data currently being held by the principal investigators to determine what data have not been returned and taking steps to obtain such data.

Project data management plans (PDMPS) are required by NASA Management Instruction 8030.3A, dated May 1978. Plans are to be prepared for each satellite mission and are to specify agreements between the satellite project office, the principal investigators, and the archiving facility on such issues as the delivery of data, dissemination of results, and retention of data. As of May 1, 1988, two project data management plans had been approved and seven others were under development. However, a number of other satellite missions have occurred since 1978 that should have had a plan. The NSSDC Director said that other plans were not prepared because the project managers were not aware of the requirements for a PDMP and NSSDC did not have the resources to aid in PDMP development. He said they are taking the following steps to help ensure that plans are developed in the future: (1) establishing guidelines for plan preparation, (2) including a requirement in the memorandums of understanding between NSSDC and the discipline-oriented data centers that plans be completed at least 6 months before a satellite launch, and (3) revising NASA Management Instruction 8030.3A to clarify the requirement for preparing plans.

In addition to preparing these plans, NASA officials said they are working more closely with the satellite mission's project office and principal investigators to ensure that the data from current and future NASA projects will be provided to the NASA archive. NASA officials said they plan to assign staff to work with each project's staff to help ensure useful data are provided to the archive. NSSDC officials intend to have a representative at each meeting of the satellite mission's project team to discuss data archiving issues. The NSSDC Director and the Office of Space Science and Applications Associate Administrator told us that, by exerting this type of "peer pressure" at these meetings, they hope to identify data that are not being received and work with the project team to obtain the data. NASA officials said obtaining these data will be more important in the future because they will become increasingly useful to multidiscipline research.

At the request of the National Academy of Science's Committee on Data Management and Computation (CODMAC),[9] NSSDC initiated a survey to determine if the principal investigators are holding data that should be archived. On June 29, 1987, NASA sent a questionnaire to 214 principal investigators in four basic disciplines—astrophysics, space physics, and planetary and earth sciences—asking for a description of the NASA data that they are holding. In June 1988, NASA presented the results of its examination at a CODMAC meeting. In the earth science area, NASA reported that some missions have not yet made all their important data, appropriately processed and formatted for easy use, openly available. For example, NASA cited the lack of processing of data from such satellites as the Heat Capacity Mapping Mission; Nimbus-4, -5, and -6; and Seasat. NASA and CODMAC are looking at what additional activities are warranted to improve the availability of data.

A survey of earth science principal investigators is also being made for NASA's Earth Science and Applications Division[10] to determine how much earth science satellite data were produced, who received them, and how much were returned to NASA archives. In this survey, a NASA contractor is sending questionnaires to 80 principal investigators concerning their holdings. NSSDC's Director said they coordinated with the contractor to ensure that there was no unnecessary duplication between the two surveys. As of July 1, 1988, this survey was still in process.

In addition to the above, NASA officials believe that the problems with receiving data from principal investigators will be reduced in the future as NASA makes wider use of discipline-oriented data systems to control the data. In addition, a NASA official said that principal investigators will not be permitted to exclusively hold data from the Polar Platforms.

Restoring and Preserving Data

According to a NASA official, for several years NSSDC has recognized that some magnetic tapes from the 1960s and early 1970s were beginning to deteriorate because of age and that if corrective action was not taken the data would be lost. In response, NSSDC initiated a data restoration and preservation project. The project includes (1) evaluating and ranking data according to its long-term scientific value and (2) restoring and

[9]This committee was created in 1978 to examine, among other things, the management of existing and future data acquired from spacecraft and make recommendations for improvements from the scientific user perspective.

[10]The Earth Science and Applications Division is part of NASA's Office of Space Science and Applications. As part of its activities, it is involved in efforts to understand the processes that affect the earth's habitability, particularly biological productivity and air and water quality.

converting data from old magnetic tapes to new tapes or other new recording media, such as optical disks.

To help evaluate the data and make initial ranking decisions on which data to restore, NSSDC will be using advisory panels made up of scientists from universities and governmental agencies. These panels will examine the importance of the data and make recommendations on what data they believe should be restored. Since funds are not expected to be available to restore all the tapes, the rankings are considered important. NSSDC decided to start with atmospheric sciences because a large number of the data center's tapes (about 40,000) are in this area. NSSDC formed the atmospheric panel at the beginning of 1988. Once the panel decides on the ranking of the data to be restored, NSSDC will prepare a summary report of the panel's recommendations, along with an evaluation of the process used. The panel's recommendations will then be reviewed and commented on by NASA officials, other federal agencies, and interested parties. The panel's rankings may be adjusted based on the comments provided.

While the advisory panel was being established, NSSDC was testing procedures for restoring and recopying tapes to determine the most effective approach. As of August 1, 1988, NSSDC reports that about 1,200 tapes have been restored. According to a NSSDC official, the experience to date indicates that it has been harder to restore the data than was anticipated because there were a significant number of deteriorated tapes. He explained that various changes and adjustments in procedures and facilities are being considered as the testing continues to try to increase the number of tapes that can be recopied from the current 25 per day to 100-150 tapes per day. NSSDC has been copying the old tapes onto new tapes. The NSSDC official explained that while the data center may later use other advance storage technologies, such as optical disk storage, it is hesitant to make a commitment to such technologies until they are well proven and standards for their use are established.

The total NSSDC cost of the effort, as of May 1, 1988, has been $50,000. NSSDC's current plans are to spend $100,000 in fiscal year 1988 and $200,000 in fiscal year 1989. However, NSSDC officials said the amounts may vary depending on the recommendations of the scientific advisory panel and further NASA consideration of the program.

NASA's Future Satellite Data Archiving Role

NASA officials see a continuing and growing role in archiving environmental satellite data. Much of NASA's increased archiving activity will be in response to the needs of the Polar Platforms. In addition, NASA officials plan to obtain and archive selected data from non-NASA sources, such as NOAA and foreign countries.

The Communications and Information Systems Division Director said NASA's major future efforts in environmental satellite data archiving will result from the Polar Platforms scheduled for launch in the mid- to late 1990s. The Polar Platforms are expected to have a number of different instruments generating data and may increase the data that NASA receives by 5 to 15-fold.

In addition to the data generated from the Polar Platforms, NASA also has plans to obtain and archive certain future foreign satellite data. NASA has agreements to participate in satellite missions with some foreign countries. For example, NASA has agreements with the French to participate in the TOPEX/POSEIDON satellite mission. In addition, NASA is working to reach agreement with Canada on NASA's participation in the launch of the Canadian RADARSAT satellite.[11] Also, NASA officials said they are interested in obtaining data from certain Japanese and European satellites. In this regard, NASA is working on data interchange agreements for some of their data.

To handle the expected increased volumes of data, NASA officials said they will, among other things, (1) continue developing the discipline-oriented data systems and (2) experiment with new data storage media such as optical disks. In this regard, NASA officials said that new technologies will need to be developed to effectively collect, archive, retrieve, and disseminate the large increase in data. In addition, NASA expects that NOAA and USGS will archive portions of the data from the Polar Platforms. For example, NASA and USGS signed a memorandum of understanding in March 1988 which provides that the EROS Data Center will archive land-related data from the Polar Platforms. In addition, NASA and NOAA officials are discussing NOAA's future role in archiving data from the platforms.

[11] RADARSAT is a Canadian satellite that is expected to be launched in 1994. This satellite will use an instrument that can provide images of the earth regardless of the weather or light conditions. It is expected to be useful for monitoring, assessing, and forecasting in such areas as sea ice, ocean waves and winds, and renewable and nonrenewable resources. NASA is to launch the satellite and, in return, will share in the information generated.

USGS Satellite Data Archiving Activities

The Department of the Interior's U.S. Geological Survey's EROS Data Center has served as the archive for Landsat satellite data since the early 1970s, even though the Landsat satellites were operated by others. NASA was responsible for developing and operating the first three Landsat satellites, but in 1979, Presidential Directive 54 assigned the Landsat satellites to NOAA, which was responsible for operating Landsats 4 and 5. In 1985, the Landsat system was turned over to a private operator—the Earth Observation Satellite Company (EOSAT).[12] Currently, EROS continues to process, archive, and distribute Landsat data because EOSAT does not have the capability to perform these functions. However, EOSAT has indicated that it plans to take over the information distribution functions that EROS has been performing. Although a decision has not been made regarding its timing, EOSAT officials said this could occur as early as mid-1989.

In addition to its Landsat activities, the EROS Data Center is also to house the legislatively mandated National Satellite Land Remote Sensing Data Archive when it is created.[13] However, NOAA, which is responsible for establishing and funding the archive, has not provided funds for its creation because of higher funding priorities. Largely because of the possible reduction of funds for its Landsat activities and the lack of funding for the creation of the land archive, USGS recently completed a study of the future options for the EROS facility given its funding constraints.

EROS Funding Problems

EROS funding problems come from several sources:

1. EROS' funding from its Landsat archiving and distributing operations is expected to decrease significantly. NOAA, which provides EROS funds for its Landsat operations, plans to stop funding EROS after the two current satellites—Landsats 4 and 5— stop operating. These two satellites are currently operating past their designed life expectancy, and NOAA has not requested funds for their operation in the fiscal year 1989 budget. In addition, EOSAT has announced plans to perform the EROS data distribution functions for Landsat 6 data. In this regard, EOSAT, on April

[12]The Land Remote-Sensing Commercialization Act of 1984 (P.L. 98-365) provided that the transition to a fully commercialized land remote sensing program should begin. In 1985 NOAA awarded a contract to the Earth Observation Satellite Company for the operation of the Landsat system.

[13]In addition to privatizing the Landsat system, the Land Remote-Sensing Commercialization Act of 1984 called for the establishment of an archive for satellite land data. The act directed that the Department of Commerce lead an effort to plan for such an archive. It also directed that the archive use existing facilities to the extent practicable. NOAA and USGS prepared a memorandum of understanding that EROS will be the location of the archive.

1, 1988, signed a contract modification with NOAA that provides, in addition to the launch of Landsat 6, for the construction of a ground station that would allow EOSAT to collect, process, store, and market Landsat data. An EOSAT spokesman said that they could be ready to perform some of these functions by mid-1989.

2. EROS funding is expected to be affected by USGS budget cuts. In this regard, USGS reduced EROS' budget by $1.5 million in fiscal year 1988. However, congressional action restored these funds. USGS officials said, given current budget constraints, they expect that they will be required to continue to operate at reduced levels over the foreseeable future.

3. As discussed in the following section, funding has not been provided to establish the National Satellite Land Remote Sensing Data Archive.

Planning for the Land Archive

USGS, in cooperation with NOAA, has been planning for the establishment of the National Satellite Land Remote Sensing Data Archive at EROS. In passing the Land Remote-Sensing Commercialization Act of 1984, the Congress charged the Department of Commerce with establishing this archive with the objective of preserving irreplaceable, global land remotely sensed data collected in the past and in the future. EROS, through a memorandum of understanding with NOAA, was designated as the site for the archive. However, as of July 1988, funds for establishing the archive had not been provided by NOAA because of higher funding priorities.

As of July 1, 1988, the archive was still in the planning stage. NOAA and USGS have jointly been working on determining what data should be in the archive and what is needed for archiving the data. To assist in this effort, the Earth Satellite Corporation was contracted to examine some of the issues related to the archive. Earth Satellite Corporation's final report, The Creation of a National Satellite Land Remote Sensing Data Archive, dated July 15, 1987, provides information and recommendations on such items as

- the data to be archived along with the criteria that could be used to decide which data should be collected and in what priority order;
- the satellite remote sensing systems that could provide data to the archive;
- the methods of storing and accessing the data (e.g., optical disks); and
- the geologic or other frames of reference needed for acquiring and recalling the data from the archive.

EROS and NOAA have not made a final decision on these matters. Officials involved in the archive planning said that they would like to have the archive in place in 1989. However, both agencies see funding difficulties hindering this goal.

According to NOAA officials, because of the current administration's position on limiting support for constructing future Landsat satellites, they have not been able to obtain funds for the land archive. NOAA requested $8 million and $12 million in fiscal years 1987 and 1988, respectively, but these amounts were eliminated in the Department of Commerce budget review process. Commerce's Budget Director said that the Department will not request future funds for this activity because of higher funding priorities. USGS officials said they do not intend to request funds for this activity because it is NOAA's responsibility.

On July 26, 1988, the Senate approved an amendment to the Commerce, Justice, State, the Judiciary, and related Agencies Appropriations, Fiscal Year 1989 (H.R. 4782) that would provide $4 million to the Department of the Interior's USGS for establishing the national land archive at EROS. The differences in the Senate and House versions of the appropriations bill are to be resolved by a conference committee which is expected to complete its actions in September 1988.

EROS' Future Satellite Data Archiving Role

USGS officials maintain that the EROS Data Center is well suited to continue and expand its archiving of environmental satellite data. They cite their experience in archiving data since the early 1970s, available space to store data and room to expand if needed, and experienced personnel to carry out such activities. They view this facility as one of the best available for these types of functions.

EROS' future role in archiving environmental satellite data, however, is yet to be determined. Although EROS and USGS officials told us that they would like EROS to continue and expand its activities in archiving satellite data, the potential loss of Landsat activities and lack of funding for the land archive raise questions about EROS' future role.

The questions regarding EROS future role also have implications for the continued availability of Landsat data in the long term. Without NOAA funding of EROS archiving of existing Landsat data, EROS may have difficulty in continuing to archive the data. In addition, with EOSAT taking over the EROS activities in the future and the lack of a national land archive, it is not certain what future Landsat data will be archived for

long-term use. When EOSAT assumes EROS' functions, it will collect and store the data. However, EOSAT officials view their role as a business rather than an archive. Thus, the extent to which they will keep data for long periods depends on the cost associated with doing so verses the economic benefit. They noted that it may not be cost effective to archive large amounts of data because the likely purchasers of older data would be researchers, who may find it difficult to pay for the data. While NOAA and USGS are examining options for archiving the past and future Landsat data, they both cite budgetary constraints as hampering a solution.

Another factor that will affect EROS' future role is NASA's Polar Platforms. As discussed earlier, NASA is examining how it will handle the large volume of data expected from this system. One of the approaches it is examining is using EROS to collect and archive the land-related data. In this regard, NASA and USGS on March 16, 1988, signed a memorandum of understanding that EROS will archive some of the land data from the Polar Platforms. Some of the specifics of the arrangement have yet to be worked out. For example, it is not clear what specific data EROS would be responsible for and what the funding arrangements will be. A NASA official said that these items will be more fully addressed by the end of 1988.

The USGS Internal Study

In April 1987, USGS, recognizing potential future funding problems, established a program review team to examine EROS' current programs and future funding options. The team was comprised of personnel from USGS, EROS, NOAA, NASA, and DOD's Defense Mapping Agency. USGS reported its findings and recommendations on July 1, 1988.

USGS' Report to Congress on Program Alternatives for the EROS Data Center presents three options for the future of EROS. Option 1, the multiagency approach—USGS' preferred approach—would involve the support and participation of other agencies.[14] According to the report, EROS is already actively pursuing this approach by working to enhance and expand its current efforts on behalf of the Department of the Interior/USGS, NOAA, NASA, and the Departments of State (Agency for International Development), Defense, and Agriculture. The archive's future

[14]The report's other two options are to (2) fund EROS from the current USGS budget and (3) close EROS and transfer its USGS-critical activities to other locations. According to the report, option 2 would create financial and management problems and option 3 would result in the loss, to USGS and other agencies, of EROS' valuable personnel, services, and products. In addition, USGS and other Interior offices would have the expense of relocating critical activities EROS now performs.

funding therefore would depend on its activities related to current programs and future initiatives of these agencies, as well as private firms such as EOSAT. USGS believes that the key to this funding approach is the cooperation and support of the agencies concerned, as well as the administration and the Congress.

Interagency Coordination of Satellite Data Archives

A number of interagency working groups and committees have been created to help coordinate the activities of those involved in producing, acquiring, using, and archiving satellite data. Recently, additional groups have been created to address federal activities in archiving satellite data. Three such coordination groups are (1) the NOAA/NASA Data Management Working Group, (2) the NASA/USGS Coordinating Committee For Data Management, and (3) the Interagency Working Group on Data Management for Global Change.

In summary, these groups provide a forum for agency officials to discuss issues of common concern. For example, various groups have been working on such issues as uniform archiving nomenclature, interagency archiving directories, common catalog formats, computer networking, and duplicate data being held by more than one agency. (A description of their activities is provided in app. III.)

Agency officials told us that they view the working groups as important in ensuring that the various efforts are properly coordinated. As some also noted, coordination will become increasingly important in the future as the requirements for data archiving grow because of the expected increase in data being generated and because satellite observations will be increasingly used in the study of global change.

Expert Views on U.S. Archiving Activities

The 20 experts we contacted generally stated that archived satellite data are important to scientific research and should be maintained. However, many of these experts expressed concern about the government's financial commitment to ensuring that essential future data are archived.

There was almost unanimous agreement that U.S. environmental satellite data archives contain information that is important to scientists' work and should be preserved. For example, a former National Weather Service Assistant Administrator told us that archived data are very important in trying to understand environmental phenomena that occur

on earth. In addition, a NASA Jet Propulsion Laboratory research scientist said that the use of environmental satellite data is still a relatively young science and that the focus should be on improving data and getting the best scientific measurements to increase our understanding. A number of experts also said their work would be greatly affected if the data now available were no longer archived because a history of data is needed to determine long-term environmental effects. They identified the following as some of the areas of research that use archived environmental satellite data:

- rainfall analysis
- pollution analysis
- desertization
- topography
- population movement
- energy discovery
- mineral discovery
- urban change analysis
- deforestation
- surface winds
- cloud generation
- global climate study
- oceanography
- polar analysis
- climatology
- ozone research
- soil erosion
- sea ice studies

Most of the 20 experts told us that, in general, it was relatively easy to obtain environmental satellite data from the various U.S. archives. In addition, about half said that the data were provided promptly. However, some experts raised some concerns about the timeliness of receiving data and the difficulty of locating data or determining if the data are available. In this regard, about half of the experts said that they had not always received the data in a timely manner. In addition, many said that at present, because of limited directories and catalogs, it is not possible to determine what is available at the agencies without contacting each individually or knowing other researchers who are involved in using the data. Further, they expressed some concern that the technology currently being used at some agencies to identify and retrieve data is out of date. They said that technology has progressed to allow the data to be more easily stored, accessed, and used.

Following are examples of some of the comments expressed:

- A Chief of research at a NASA research center said the United States developed remote sensing technology and that it is frustrating to see us lose that leadership. He said that fewer resources are being committed by U.S. satellite archives to obtaining, storing, and analyzing the data at a time when these activities should be getting greater support.
- The Chairman of a joint federal/university planning committee said there seems to be too much indecision between the executive branch and the Congress regarding archiving environmental data. He noted that there are barely enough federal funds to launch new satellites let alone to properly retrieve, analyze, and archive the data that result. He said NOAA has historically been underfunded given its responsibilities for data archiving and distribution.
- A scientist at the Air Force Geophysics Laboratory said that as a nation we are going to have to clearly define our data needs and determine the agency and the resources that will be required and dedicated to this purpose.
- The President of an organization that represents interests in geological exploration and remote sensing said that a national space council needs to be established with one of its purposes being to set policy for federal agencies that archive data. This body could ensure that there is an adequate U.S. archive and that data will be available to all users. He pointed out that archived data need to be more readily available to U.S. industrial users, and explained that his organization is currently in negotiations with NASA to obtain better access to NASA data.

Conclusions

The three agencies responsible for archiving environmental satellite data—NOAA, NASA, and USGS—obtain, maintain, and disseminate large amounts of varying types of data. While performing similar functions, each agency does so independently and to meet different agency missions.

Each agency has initiatives underway directed at improving archiving operations. For example, some actions have been initiated to evaluate what data should be archived and examine some of the changes in technology and recording media that may be needed to archive the larger amounts of data expected in the future. Further, the agencies have increased their coordination through interagency groups and memorandums of understanding in an attempt to develop more uniform approaches to archiving data.

Our work showed that several concerns persist about how the agencies will archive the expected future increase in the volume of environmental satellite data. For example:

- NOAA is examining the extent to which private firms may be interested in taking over its archive operations. NOAA officials anticipate that their privatization Request for Information will be issued in the summer of 1988. If NOAA decides to continue in its present role as an archive, agency officials said they may need to examine the funding priority given archiving in recognition of its limited ability to handle future data.
- NASA recognizes that technological challenges exist to archiving the large amounts of data expected from the Polar Platforms and has begun examining new methods for handling the data. In addition, it has initiated some agreements with other agencies to assist in archiving these data, but many of the specifics regarding agency involvement and funding have yet to be worked out. NASA officials said that these items will be more fully addressed by the end of 1988.
- USGS views EROS as a good facility for archiving satellite land data and is exploring ways for it to continue doing so. EROS' role is affected by NOAA's funding decisions for the legislatively mandated National Satellite Land Remote Sensing Data Archive. NOAA said it has not provided funds for this activity and does not anticipate doing so because of higher funding priorities.

Matter for Congressional Consideration

Considering that the Department of Commerce has not requested nor provided funds for creating the National Satellite Land Remote Sensing Data Archive and that officials told us that they do not anticipate doing so in the future, the Congress, if it still wants the archive to be created, may want to provide specific funding for the archive.

Foreign Environmental Satellite Data Archiving

Between 1977 and 1987, at least nine environmental satellites were launched by Japan, France, India, and the European Space Agency (ESA). These and other countries, such as Canada, have plans to launch over 30 additional civilian environmental satellites between 1988 and 1997.[1] In addition to the data from their satellites, many foreign countries also archive data generated from other countries' satellites that fly over their areas.

In discussing civilian environmental satellite data archiving with foreign officials, we were informed that (1) archived satellite data are important for both current and future research, (2) few countries have experienced major problems with archiving data, and (3) opportunities exist in the future for increased levels of international cooperation in archiving data.

The U.S. experts we spoke to generally said that foreign satellite data are important for scientific purposes and will become even more important as additional foreign satellites are launched. Some experts expressed concern about the future availability of foreign data for research purposes. NOAA and NASA officials said they are working to ensure that as much foreign data as possible will be available to U.S. scientists.

Foreign Environmental Satellites

As shown in table 3.1, a number of environmental satellites have been successfully launched by foreign countries since 1977 and many more are planned for the future. The earliest foreign civilian efforts were launches of weather satellites in the late 1970s. More recently, some countries have launched other types of earth observing satellites and still others have announced plans to do so.

[1]Because of limitations on available information about their efforts, this report does not include a discussion of the Soviet Union's activities.

Table 3.1: Foreign Environmental Satellites

Year	Satellite name	Satellite type	Country
1977	Meteosat-1	Weather	ESA
1977	Geostationary Meteorological Satellite 1	Weather	Japan
1981	Meteosat-2	Weather	ESA
1982	Indian National Satellite System-1a	Weather	India
1982	Geostationary Meteorological Satellite-2	Weather	Japan
1983	Indian National Satellite System-1b	Weather	India
1984	Geostationary Meteorological Satellite-3	Weather	Japan
1986	Systeme Probatoire d'Observation de la Terre-1 (SPOT-1)	Earth observing	France
1987	Marine Observation Satellite-1	Ocean observing	Japan
1988	Indian Remote Sensing Satellite-1a	Earth observing	India
1988	Meteosat-P2	Weather	ESA
1988	Indian National Satellite System-1c	Weather	India
1988	Meteosat Operational Programme-1	Weather	ESA
1989	SPOT-2	Earth observing	France
1989	Geostationary Meteorological Satellite-4	Weather	Japan
1989	Indian Remote Sensing Satellite-1b	Earth observing	India
1989	Indian National Satellite System-1d	Weather	India
1989	Earth Resource Satellite	Earth observing	China
1990	Meteosat Operational Programme-2	Weather	ESA
1990	Marine Observation Satellite-1b	Ocean observing	Japan
1990	European Remote Sensing Satellite-1	Earth observing	ESA
1990	Indian National Satellite System-IIa	Weather	India
1991	Remote Sensing Satellite	Earth observing	Brazil
1991	TOPEX/POSEIDON	Ocean observing	France/U.S.
1991	Meteosat Operational Programme-3	Weather	ESA
1991	Indian National Satellite System-IIb	Weather	India
1992	Indian Remote Sensing Satellite-1c	Earth observing	India
1992	SPOT-3	Earth observing	France
1992	Japanese Earth Resource Sensing Satellite-1	Earth observing	Japan
1993	European Remote Sensing Satellite-2	Earth observing	ESA
1993	Laser Geodynamics Satellite-2	Earth observing	Italy/U.S.
1993	Advanced Earth Observation Satellite	Earth observing	Japan
1993	Geostationary Meteorological Satellite-5	Weather	Japan
1993	Tropical Rainfall Explorer Mission	Weather	Japan
1994	RADARSAT	Earth observing	Canada
1995	SPOT-4	Earth observing	France

(continued)

Year	Satellite name	Satellite type	Country
1995	Meteosat-Next	Weather	ESA
1996	Magnetic Field Explorer	Earth observing	France/U.S.
1997	ESA Polar Orbiting Platform	Earth observing	ESA
1997	Japanese Polar Orbiting Platform	Earth observing	Japan

Note: This list of past and future foreign satellites was created through discussions with foreign officials and by using available reports and other documents. Some of the future satellites shown may require additional approvals by the countries. In addition, some of the launch dates are subject to change.

Foreign satellites have provided a wide range of data for many uses. For example, foreign weather satellites are used, in association with U.S. weather satellites, to help support a worldwide weather forecasting network known as the World Weather Watch. In addition, the French Systeme Probatoire d'Observation de la Terre-1 satellite, launched in 1986, generates images of the earth's surface much like the U.S. Landsat satellite. The SPOT satellite has the capability to sense images of smaller size than Landsat, with a 10-meter resolution capability compared to Landsat's 30-meter resolution. Also, in early 1987, Japan launched its first ocean observing satellite—the Marine Observation Satellite-1. Further, ESA's European Remote Sensing Satellite-1, Japan's Earth Remote Sensing Satellite, and Canada's RADARSAT are all expected to use a new instrument that can take images of the earth regardless of cloud or light conditions.

Many foreign countries have been receiving, using, and archiving environmental satellite data since the early 1970s. The early data came from the U.S. Landsat and polar orbiting weather satellites. About 13 countries have the capability to receive Landsat transmissions, and over 100 countries receive U.S. polar orbiting weather satellite data. A number of foreign countries also receive and archive data from other foreign countries' satellites.

Foreign Views on Archiving Environmental Satellite Data

In our meetings with foreign officials, we discussed (1) the importance of environmental satellite data, (2) the problems they are experiencing in archiving the data, and (3) the possibility of expanded international cooperation in satellite data archiving.

Importance of Archiving Data

Foreign officials generally agreed that archived environmental satellite data are extremely important from a scientific point of view. Many stated that archived environmental satellite data will be used in the future to help discover new information about the earth.

Japanese officials, for example, said they are using satellite data for important research in such areas as forestry, agriculture, water pollution, ocean currents, temperature change, fishing conditions, hurricanes, typhoons, and cyclones. In addition, they are studying the effects of the El Nino[2] on Japanese weather. They also told us that their new Marine Observation Satellite-1 will be useful in helping them study the oceans. They are also participating in international studies on global cloud climatology and precipitation, which are using satellite data to help address the issues.

Canadian officials said it is important that satellite data be kept because of the possibilities of finding new information that could help solve some of the earth's problems. For example, Canadian scientists are studying the effects of industrial plant emissions on forests; older archived data are compared to newer data and used to help understand plant emissions' effects. In addition, the Director General of the Canadian Climate Centre told us he expects that satellites will provide the data needed to clearly show the changes occurring in the earth's temperature. He also said that data from satellites are central to the whole issue of studying global change. However, Canadian officials do not advocate that their government organizations keep everything that has been generated, but only selected data that they believe will have some future value. For example, rather than archiving the weather data that it receives from U.S. satellites, Canadian officials said they keep the data for a 30-day period. If during that time the researchers want the data, the government will provide it; after the 30-day period, researchers are advised to go to NOAA to buy the data. Canadian officials said that while the data are considered important, it is not necessary for both countries to hold identical data.

ESA also supported keeping satellite data for scientific reasons. Its organization, called Earthnet, acts as a European network for acquiring, preprocessing, archiving, and distributing satellite data. It has acquired

[2]The El Nino is an oceanographic phenomenon that generally occurs about every 3 to 7 years. It is characterized by unusually warm water temperatures in the Pacific and changes in barometric pressure and wind patterns over large areas of the globe. Scientists believe that the El Nino affects the weather around the world.

data from various U.S. satellites such as Landsat, Heat Capacity Mapping Mission, Seasat-1, and Nimbus-7. ESA's research efforts in this area are largely focused on examining oceans, ice, and land, and on meteorology and solid earth physics, using precise measurement techniques for earth-oriented research. In addition, ESA is also examining the problems of the upper atmosphere and climatology.

The French officials of SPOT Image expressed the importance of archiving satellite data. They pointed out that older data can be used to detect changes in urban development and to explore a number of scientific or environmental issues. However, they said that they have not as yet decided how long to keep the data their satellites generate. Their decision will essentially be based on the costs and commercial value of the data. They noted that it is unlikely that large commercial orders would be received for old data; such orders would, in their view, come from researchers.

Archiving Problems

Overall, foreign officials said they were having no major difficulty in archiving satellite data that they receive. However, Canada and Japan are facing certain constraints in their ability to continue to store the data.

Canada's archive, which dates back to the early 1970s, has grown to about 7,000 magnetic tapes (primarily Landsat data but some Seasat, NOAA weather, and French SPOT data). Canadian officials said they were spending more than $600,000 a year to purchase tapes and realized that they could not continue to keep such a high volume of data. Therefore, they evaluated their policy on holding data and in 1986 established a revised policy and plan for archiving satellite data. This plan establishes criteria for keeping existing data as well as obtaining new data. The new archiving policy is to ensure that representative and useful satellite imagery of Canada exists, is maintained, and is available for future studies. Canada also intends to reduce storage costs and make greater use of modern equipment for image production.

In implementing this policy, a major activity is evaluating and recopying existing tapes. The tapes will be examined to determine if they should be retained. In making these decisions, a principal consideration is the amount of cloud cover in the scenes on the computer tape. Only those satellite orbits that have a reasonable number of good scenes are to be

saved. As a result of this effort, Canadian officials expect that the present archive of 143,000 scenes on 7,000 magnetic tapes will be reduced to about 49,000 scenes on 1,000 tapes.

In addition to this effort, Canadian policy will affect the new data that are to be added to the archive. Future U.S. Landsat and French SPOT data of Canadian territory will be held for 9 months, during which time users will be able to access the data. After 9 months, the data will be examined to determined if they will be kept longer. Canadian officials said that this policy may change as new developments in archiving technology, such as optical disks or tapes, allow more data to be kept in less space.

Japanese officials said they have been facing some storage space limitations because they have used almost all available archiving space. Accordingly, they developed disposal guidelines for satellite data. In general, the guidelines show disposal time periods of 2, 3, 5, or 10 years for various data. However, some data will be kept permanently, such as certain U.S. Landsat satellite images taken over Japan. Japanese officials said that these schedules were developed through compromise, recognizing that some data are more important than others.

Although they have developed certain retention guidelines, Japanese officials have not disposed of the data according to their scheduled time periods. The Director of the Meteorological Satellite Center of the Japan Meteorological Agency said the agency is finding it difficult to dispose of data that took significant efforts to generate and may still be valuable. Rather than disposing of the data, Japan is looking for ways to store additional data. For example, for Landsat, SPOT, and its new satellites, Japan has constructed a new environmentally controlled room. In addition, a new storage medium is being tested.

Officials of other countries did not cite the kinds of problems noted by Canada and Japan. In general, they said that they were not having storage space or age problems with their archives. They recognized that at some future point, they may face these problems. However, they said new technology may help them solve such problems in the future. In general, they view the cost of archiving as a very small part of the cost of launching satellites and, although unable to provide specific figures, stated that the potential value of these data for historical and research purposes far outweighs the relatively small costs associated with this activity. Also, officials at the European Center for Medium Range Weather Forecasts in the United Kingdom indicated that they have

given some thought to disposing of derived data (data that are developed as a result of some experimentation or modeling) after 7 to 10 years but would be very reluctant to dispose of the raw data that they archive and store for future use. ESA officials in Italy said that each member country keeps information which it considers essential to its individual needs and, because each country has contributed financially to the program, each has the authority to maintain or archive the data it wants.

International Cooperation

The foreign officials said that generally there was some international cooperation in the environmental satellite area but more could be done. They also said that they were involved in various international organizations and specific research projects dealing with environmental satellites. For example:

- The United Nations World Meteorological Organization (WMO). This organization facilitates international cooperation in the free exchange of weather information from the various sources, including satellites. More than 100 member countries are capable of obtaining data from the U.S. polar orbiting weather satellite through the WMO's World Weather Watch program. WMO also supports a number of research projects. Two frequently cited efforts are the World Climate Research Program and the International Satellite Cloud Climatology Project. The climate program is to determine the extent to which climate can be predicted and the extent of man's influence on climate. The cloud project is to create a cloud climatology data set for the years 1983-87 using the global coverage provided by international polar orbiting and geostationary meteorological satellites.
- The International Council of Scientific Unions. This council's principal objective is to encourage international scientific activities for the benefit of mankind by initiating, designing, and coordinating scientific research. This union is a nongovernmental organization comprised of 18 international scientific unions, 65 national members, 17 scientific associates, and 4 national associates. One of its more notable efforts in this area is the International Geosphere-Biosphere Program, which involves examining, among other things, global temperature changes.
- The Committee on Earth Observation Satellites. This organization's overall objective is to enhance the benefits of space-borne earth observations. In this regard, it is to act as a forum for the exchange of technical information to encourage compatibility among space-borne earth observation systems that are in service or being developed. The members of the committee are Canada, France, ESA, India, Brazil, Japan, the

United Kingdom, Federal Republic of Germany, Italy, and the United States.

- The International Polar-Orbiting Meteorological Satellites Group. This organization was established to examine administrative, legal, technical, and financial issues regarding international contributions to the system of polar orbiting weather satellites. Participants in the group include Australia, Canada, France, Federal Republic of Germany, Italy, Japan, Norway, the United Kingdom, ESA, the European Communities, and the United States.

These groups and other similar organizations provide opportunities for the various participants to address issues of common concern. They meet periodically to discuss such issues in an effort to reach joint solutions. Some foreign officials said that such meetings would be a good forum to address some of the concerns about international archiving of satellite data.

In addition to international organizations, foreign officials mentioned a number of specific examples of cooperation between countries on specific projects. For example, the Director General of Canada's Space Policy Sector said their RADARSAT satellite is to be launched by NASA in return for sharing in the data generated. In addition, Japan is considering the inclusion of a NASA instrument on one of its upcoming satellites. Further, Japan and ESA officials cited their participation with the United States on the space station and polar orbiting platform as an example of international cooperation. The French and the United States are cooperating in a joint project called TOPEX/POSEIDON that will use satellite observations to examine the oceans.

While foreign officials cited a number of instances of international cooperation, there was general agreement that more could be done in the future. In this regard, some said that additional cooperation could be beneficial in areas such as making the formats the data are kept in more consistent, lessening the amount of duplicate holdings among the various countries, increasing joint research projects using the data, and increasing the amount of data shared between countries. These issues will be increasingly important in the future as the amount of data from environmental satellites significantly grows.

Expert Views on Foreign Data

The U.S. experts we spoke to generally said foreign data have been important for research purposes. Most said that they regularly used foreign data in their work. The experts had mixed views regarding their

experiences in obtaining foreign data. Some said they had no problems obtaining the wanted data while others cited problems with being able to identify what was available and difficulties in obtaining it.

The experts generally viewed future foreign data as being increasingly important for research purposes, particularly those involving global issues such as earth system science. However, some experts expressed concern about the future availability of foreign data. For example, concerns were cited that

- foreign countries may exclusively hold data for a period of time to perform research, delaying its availability;
- foreign catalogs and directories of data being archived may not be adequate to readily identify available data; and
- foreign satellites may be converted to commercial operations, causing higher prices to be charged and thus limiting the data's availability for science.

NOAA and NASA officials said they are working to overcome these concerns and ensure that foreign data are as widely available as possible. For example, NASA officials noted that they will be participating with foreign countries in such satellite missions as TOPEX/POSEIDON and the Magnetic Field Explorer (France), Laser Geodynamics Satellite (Italy), and the Polar Orbiting Platforms (several countries). In addition, officials are negotiating specific agreements to obtain certain foreign data from such satellites as ESA's European Remote Sensing Satellite, Japan's Marine Observation Satellite and Earth Resources Sensing Satellites, and Canada's RADARSAT. Further, agency officials said that their participation in a number of international organizations is lessening these concerns. For example, the Committee on Earth Observation Satellites has established a Working Group on Data, which has been tasked to address such international issues as archiving strategies and practices; catalog content, format, and media; user product definitions and formats; and international networks for data exchange. In addition, in early 1988, the U.S. Interagency Working Group on Data Management for Global Change created the Panel on International Data Exchange. This panel is to collect and classify the various formal and informal international arrangements used to exchange environmental data and information and to cooperate or coordinate on environmental research and data matters. The panel is then to evaluate the international arrangements in terms of their effectiveness, ease of access to data, cost of data exchange, and potential for furthering the objectives of global change research.

Conclusions

Foreign activities in the environmental satellite area have grown over the past few years and are expected to continue to grow significantly in the near future. At least 9 civilian foreign environmental satellites were launched between 1977 and 1987 and more than 30 are planned for the period from 1988 to 1997. Foreign satellite efforts are also expanding from weather satellites into earth observing satellites. At present Japan, France, and India have earth observing satellites, and a number of additional countries plan to launch them.

In addition to launching their own satellites, many foreign countries have been collecting and archiving satellite data from other countries' satellites that cover their areas. Because of the involvement with past satellites and their own recent efforts, these countries have had considerable experience in archiving satellite data. The officials told us that the data obtained are important in many research areas. In addition, foreign officials cited few major archiving problems. The Canadians and Japanese cited constraints to keeping all the data they had collected, and both countries had developed criteria as to what data should be retained over the long term.

Some level of international coordination is being accomplished through international organizations as well as on an individual project-by-project basis. However, many foreign officials thought that more could be done in the future to help ensure better coordination of archiving activities. In this regard, there are several opportunities at the international level to discuss international cooperation in the retention, maintenance, and dissemination of satellite data.

The U.S. experts said that foreign data are valuable for research purposes and their importance will increase in the future as additional foreign satellites are launched. Some concern was expressed that future foreign data may not be readily available to U.S. scientists for research purposes. NOAA and NASA officials said they were working to overcome the concerns identified and ensure that foreign data was as widely available as possible. They are participating with foreign countries in satellite missions, negotiating agreements to obtain certain foreign satellite data, and participating in international organizations to begin addressing such concerns and minimize their impact on data availability.

Selected Background Information on the U.S. Archiving Agencies

NOAA

As of March 1, 1988, NOAA reported it had about 145,000 magnetic tapes and about 6 million film products (primarily photographs) of environmental satellite data. During fiscal year 1988, NOAA expects to add about 18,000 magnetic tapes and about 165,000 film products. In fiscal year 1987, NOAA filled about 3,000 orders for copies of its environmental satellite data, generating over $1 million in sales. Most of the sales were to U.S. government agencies (52 percent), but many sales were also made to foreign, private, and academic sources.

In 1974, NOAA established the Satellite Data Services Division (SDSD),[1] to manage the archiving of the satellite data being produced. Its principal magnetic tape archive is located in Suitland, Maryland, and its film archive is located in Camp Springs, Maryland. Other facilities also contain certain satellite data, including the University of Wisconsin in Madison, Wisconsin, which has magnetic tape cassettes of weather data; and the National Snow and Ice Data Center in Boulder, Colorado, operated by the University of Colorado, which primarily holds photographic images produced by DOD's meteorological satellites.

Funding for operating NOAA's environmental satellite data archives has risen from about $1.0 million in fiscal year 1982 to about $1.8 million in fiscal year 1987. Funding for the archive operations comes from a number of sources. Operating expenses appropriations for SDSD over the last 6 years have been $423,000 annually.[2] Revenues from data sales are also used to help finance operational costs. During this 6-year period, sales ranged from about $570,000 to about $1.2 million. In addition, in the last 2 years, supplemental funding of $310,000 and $140,000, respectively, was transferred from other parts of NOAA to SDSD to cover the remaining costs of operations.

NASA

Various NASA organizations, such as the National Space Science Data Center and the Jet Propulsion Laboratory, have responsibilities for various types of data. The National Space Science Data Center,[3] located at the Goddard Space Flight Center in Greenbelt, Maryland, is the primary archive for NASA's environmental satellite data.

[1]The Satellite Data Services Division is part of the National Environmental Satellite, Data, and Information Service's National Climatic Data Center.

[2]During fiscal years 1986 and 1987, an additional $320,000 was allocated annually by the National Climatic Data Center. These funds were for the maintenance of computer equipment.

[3]The National Space Science Data Center is part of the Communications and Information Systems Division in the Office of Space Science and Applications.

As of March 1, 1988, NSSDC was responsible for over 110,000 magnetic tapes (80,000 unique tapes and 30,000 backup tapes) and numerous film products, including about 110,000 photographic images, 2 million feet of film, 40,000 microfilm reels, and 40,000 microfiche cards. Of this, NASA officials estimate that about 60 percent are environmental satellite data. NSSDC maintains about 35,000 magnetic tapes at the Goddard Space Flight Center in Greenbelt, Maryland, and about 75,000 magnetic tapes at the Federal Record Center in Suitland, Maryland.

NSSDC generally receives environmental satellite data for archiving after scientists perform the initial research on the data from the satellite mission. While the initial research is underway, the data are usually kept by the project office responsible for the research or by the scientist. NASA's Tape Storage and Staging facility, in Landover, Maryland, is available to provide data storage and handling assistance to the project offices and individual science teams. In this regard, at least an equivalent amount of environmental data to that archived by NSSDC are held by other NASA organizations.

During 1987, NSSDC reported that it had filled requests for about 3,000 magnetic tapes. Most of NSSDC's requests for data in 1987 came from foreign sources (29 percent), the U.S. government (24 percent), and universities (22 percent). NSSDC officials said they normally provide the data to users free of charge but do request that users provide blank magnetic tapes when requesting that data. NSSDC officials said that they charge a fee for labor and reproduction only when the order is particularly large or from commercial users. NSSDC officials said they provide the data free because part of their mission is to make data available for scientific purposes and charging a fee may reduce requests from some researchers. In fiscal year 1987, they received about $37,000 from data sales.

The Center was budgeted at $3.6 million in fiscal year 1987 for its operations, an increase of $1.2 million over fiscal year 1986. In addition, NSSDC received about $2.2 million in fiscal year 1987 (down from $3.1 million in fiscal year 1986) for research activities directed at such things as developing new archiving approaches, dissemination techniques, and storage media.

USGS

The EROS facility is located on about 300 acres near Sioux Falls, South Dakota. As of March 1, 1988, it contains over 500,000 worldwide Landsat scenes on about 47,000 magnetic tapes as well as over 750,000 photographic scenes. EROS also began receiving in May 1987 some data from

NOAA's polar orbiting weather satellite and reported having about 700 magnetic tapes of that satellite's data. In addition to its satellite data archive responsibilities, EROS personnel perform research and development using the satellite land images as well as train and assist users of these data. Further, EROS is the location of the National High Altitude Photography Archive.[4]

During fiscal year 1987, EROS received about 60,000 inquiries and orders which resulted in producing more than 150,000 photographic images and 10,000 magnetic tape products. EROS identified sources of these requests as U.S. government (50 percent), foreign (20 percent), and industry (20 percent), with academia, state and local governments, and private individuals making up the rest.

In fiscal year 1987, EROS received about $18.2 million to operate. NOAA provided about $6.7 million for handling the Landsat operations and USGS provided about $8.9 million for EROS operations. Other agencies provided about $1.1 million and $1.5 million was obtained through data sales (other than Landsat).

[4]The National High Altitude Photography Archive is a collection of photographs taken from airplanes. This collection is used to provide high resolution images of the surface features of the U.S.

Description of NASA's Discipline-Oriented Data Systems

Data system name	Goal of data system
Pilot Land Data System	To establish a prototype state-of-the-art data and information system to support research in the land-related sciences that will lead to a permanent research tool.
NASA Climate Data System	To provide an advanced scientific information system that supports researchers in the atmospheric, ocean, and earth sciences by allowing them to interactively identify, access, obtain, manipulate, and display climate-related data.
NASA Ocean Data System	To support the oceans research community by providing interactive access to data sets, catalogs, and documentation from space-borne ocean viewing sensors, and to fulfill the data management and distribution requirements of NASA oceanic flights of the 1990s.
Planetary Data System	To develop and implement a system that the planetary science community can use to easily access archived planetary data and information about those data.

Source: NASA.

Examples of Recent Interagency Cooperation

NOAA/NASA Data Management Working Group

In February 1985, the NOAA/NASA Data Management Working Group was established to provide a forum for reaching solutions to issues of mutual concern. Since then, NOAA and NASA have met to

- develop procedures for NOAA to obtain NASA Project Data Management Plans and the subsequent review by the group of those plans relevant to both agencies;
- examine the possibility of developing uniform archiving nomenclature, archive directories, and catalog formats and contents;
- work out agreements on duplicate data that both agencies maintain (for example, both agencies hold certain data from the Nimbus-7 satellite and the Defense Meteorological Satellite); and
- act as the implementing body for specific items concerning data management under the NOAA/NASA memorandum of understanding for the joint use of the Polar Platforms.

Officials of both agencies told us that they view this group as important in ensuring that their efforts are properly coordinated. They noted that coordination will become even more important in the future as the requirements for data archiving grow with the increases expected in data being generated. The group has asked USGS to attend the next meeting which is scheduled for September 1988.

NASA/USGS Coordinating Committee for Data Management

The NASA/USGS Coordinating Committee For Data Management was established in June 1987 to coordinate the activities of these two agencies. Since its first meeting the group has

- provided NASA and USGS personnel with information on the data each maintains that are of common interest to them;
- discussed the possibilities of establishing a computer link between the two agencies; and
- discussed the options for increasing the use of the EROS data center for archiving some of NASA's future data.

A NASA official said that although this group was recently formed, it has provided the means to better coordinate the activities of the two agencies. He said he expects future discussions will cover additional areas of common concern. NOAA officials also attend these meetings because the items discussed are of interest to NOAA.

Interagency Working Group on Data Management for Global Change

The Interagency Working Group on Data Management for Global Change was established in June 1987. It includes representatives from NOAA, NASA, USGS, the National Science Foundation, the Department of the Navy, and the Department of Energy. In addition, the Departments of State and Agriculture provide observers. It is chaired by NOAA's National Environmental Satellite, Data, and Information Service's Assistant Administrator. This working group is to make it as easy as possible for scientists and others to get data appropriate to the study of global change. In its quarterly meetings, the group has

- begun preparing an implementation plan for a data and information system for global change and
- initiated a test to demonstrate the ability to exchange directory information between the agencies through an on-line computer network.

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