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Landsat is a National Aeronautics and Space Administration (NASA) experimental project to determine the usefulness of satellite-acquired data for managing the Earth's environment and natural resources. Findings/Conclusions: Although the project has been going on since 1970 and will extend into the 1980s at costs which will exceed $650 million, there is no clear statement of Government policy regarding support of an operational system. Development of such a policy will require consideration of complex technical, political, economic, institutional, and international issues. The Office of Science and Technology Policy (OSTP) has considered some technical and funding issues relating to Landsat-D and is planning to form a Cabinet level policy group to study broader issues. Legislative proposals for operational systems include establishment of an Earth Resources and Environmental Information System which would broaden the Government's role in remote sensing technology. Before such a commitment is taken, studies of issues involved should be undertaken. Recommendations: The Director of OSTP should periodically inform the Congress of the goals and results of its studies relating to satellite-based, remote-sensing policy issues. (HTW)

6044

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Landsat Policy Issues Still Unresolved

Landsat is a NASA experimental project that determines the usefulness of satellite-acquired data for the management of the Earth's environment and natural resources.

Legislation establishing a Landsat-centered Earth Resources and Environmental Information System would broaden the Government's role in satellite-based, remote-sensing technology from support of research and development to support of an operational system.

Evolution from an experimental project to an operational system raises many complex issues. The Director of the Office of Science and Technology Policy has begun to study these issues. He should continue this effort and periodically report to the Congress on the status of his study.

PSAD-78-58
APRIL 17, 1978

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-183134

To the President of the Senate and the
Speaker of the House of Representatives

This is our third report on the National Aeronautics and Space Administration's Landsat project. It discusses the need to keep the Congress informed on the goals and results of studies relating to satellite-based, remote-sensing policy issues. This review was made as a part of our continuing effort to apprise the Congress of important issues involved in research and development projects.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of this report are being sent to the Director, Office of Science and Technology Policy; the Director, Office of Management and Budget; and the Administrator, National Aeronautics and Space Administration.

Comptroller General
of the United States

D I G E S T

Remote sensing by satellite--the Landsat project--provides access to previously unobtainable information about natural resources and the environment. The National Aeronautics and Space Administration (NASA) is developing this new technology in accordance with its legislative charter and should continue to support research and development in this field.

However, it is not certain as to whether, when, and how the Federal Government should establish or support an operational Landsat system. This lack of certainty exists because there is no clear statement of Government policy regarding support of an operational system. Development of such a policy will require consideration of complex technical, political, economic, institutional, and international issues. The project has been going on since 1970 and will extend into the 1980s. NASA's costs will exceed $650 million. With this level of investment and the time involved, these policy issues should be studied. (See p. 10.)

GAO recommended in June 1977 that the Director of the Office of Science and Technology Policy study the issues involved and report to the President and the Congress a suggested Government policy role in satellite-based, remote-sensing technology. (See p. 10.)

The Office of Science and Technology Policy has considered some technical and funding issues relating to Landsat-D, the fourth satellite in the project. It is viewed as a new generation spacecraft because it will carry a new sensing instrument to provide improved information for Earth resources management. NASA estimates the cost of Landsat-D and a backup spacecraft at $350 million. The Office of Science and Technology Policy is planning to form a Cabinet level policy group to study broader issues, such as the proper role of the Government in an operational Earth resources satellite system, the extent of private sector participation in this system, and international alternatives to a U.S. system. (See p. 11.)

RECOMMENDATION

Because the Congress has shown a keen interest in the Landsat program, it should be fully informed on the status of the policy issues involved in the possible evolution of the Landsat experimental project to an operational system. Therefore, the Director of the Office of Science and Technology Policy should periodically inform the Congress of the goals and results of its studies relating to satellite-based, remote-sensing policy issues. (See p. 15.)

AGENCY COMMENTS

The Office of Science and Technology Policy concurred with GAO's assessment of the Office's activities regarding Landsat. The Office is taking up the policy issues relating to forming a future remote-sensing policy. (See app. II.)

NASA clarified specific sections of the report. Its comments have been incorporated as appropriate. (See app. III.)

Contents

ABBREVIATIONS

EROS	Earth Resources Observation Systems
GAO	General Accounting Office
LACIE	Large Area Crop Inventory Experiment
MSS	multispectral scanner
NASA	National Aeronautics and Space Administration
OSTP	Office of Science and Technology Policy

CHAPTER 1

INTRODUCTION

Landsat is a National Aeronautics and Space Administration (NASA) experimental project to determine the usefulness of satellite-acquired data for managing the Earth's environment and natural resources. It is a part of the Earth Resources Detection and Monitoring Program within NASA's Office of Space and Terrestrial Applications.

In 1966 the Department of the Interior established its Earth Resources Observation Systems (EROS) Program and requested that NASA design and develop a satellite system for surveying Earth resources. Landsat was approved for development in 1970.

In July 1972 the first Landsat satellite was launched. A second was placed in orbit in January 1975 and a third was launched in March 1978. The first was turned off in January 1978, but NASA is still acquiring data from the second and third satellites. A fourth satellite--viewed as a new generation Earth resources satellite because it will carry an advanced sensing instrument--is scheduled for launch in 1981.

Federal agencies participating in the Landsat project include the Departments of Agriculture, Commerce, the Interior, and State; the Army Corps of Engineers; the Coast Guard; the Environmental Protection Agency; and the Agency for International Development.

HOW LANDSAT WORKS

As a Landsat spacecraft orbits the Earth, its instruments --a multispectral scanner (MSS) and a return beam vidicon camera system--view the Earth and measure the intensity of the sunlight reflecting from the surface. These measurements are then converted into electronic signals, transmitted to Earth, and recorded on magnetic tapes which can be reconstructed into photographic images. Different materials on the Earth's surface--water, crops, and forests--reflect light differently; therefore, the reconstructed image is different and the substance can be identified. Resource managers then use the images and tapes to monitor the Earth's resources.

Receiving stations are located in Goldstone, California; Fairbanks, Alaska; Greenbelt, Maryland; and Canada, Brazil,

and Italy. The foreign stations were built by the respective governments, which pay NASA $200,000 a year for the right to receive data directly from the satellites.

Landsat data is used in research investigations and quasi-operational demonstrations to obtain knowledge and experience needed to decide whether the United States should proceed with the design and development of an operational Earth resources satellite system.

REASON FOR OUR REVIEW OF LANDSAT

Counting Landsat-D (the fourth satellite) and its back-up satellite, NASA's investment in the project will exceed $650 million. If the experimental project is to evolve into an operational system, benefits to be gained should justify the costs to be incurred.

Legislation was introduced in the 95th Congress that would establish a Landsat-centered Earth Resources and Environmental Information System. Enactment of such legislation would broaden the Government's role from support of research and development to support of an operational system.

In our June 10, 1977, report, "Landsat's Role in an Earth Resources Information System" (PSAD-77-58), we stated that a Federal Government commitment to support an operational Landsat system was premature and that such action should be taken only if further study reveals that the benefits to be gained justify the resources required to establish the system. We recommended that the Director of the Office of Science and Technology Policy (OSTP), in conjunction with NASA and cognizant Federal agencies, study the complex issues involved and recommend a Government policy role in satellite-based, remote-sensing technology.

This is our third report on the Landsat project made at the request of the Chairman, Senate Subcommittee on HUD-Independent Agencies, Committee on Appropriations. It provides the Congress with information on actions taken in response to our June 1977 recommendation and information on the status of Landsat-3 1/ and Landsat-D, the third and fourth satellites in the series.

1/ Landsat-3 was called Landsat-C before launch.

Our report "Crop Forecasting by Satellite: Progress and Problems" (PSAD-78-52), April 7, 1978, involves the Large Area Crop Inventory Experiment (LACIE). The LACIE project is the most significant single effort under way to demonstrate a useful and cost-effective application for Landsat data. To date, LACIE has had mixed success in achieving its performance goals.

SCOPE OF REVIEW

Our review work was performed at OSTP, the Goddard Space Flight Center, and NASA Headquarters. We reviewed project plans, status reports, correspondence, professional papers, and other documents, and held discussions with responsible officials.

CHAPTER 2

LANDSAT PROJECT STATUS

NASA, at the request of the Chairman, Senate Subcommittee on HUD-Independent Agencies, Committee on Appropriations, prepares reports in January and July of each year on the cost, schedule, and technical aspects of selected projects. These reports permit the Congress to track the progress of and changes in NASA projects.

LANDSAT-3 PROJECT STATUS

A copy of the January 1978 Landsat-3 project status report is shown in appendix I. It shows an estimated total project cost of $49.6 million. There have been increases to some project cost elements; however, the reserve funds have been adequate to cover the increases. One reason for the increases was the change in launch schedule from September 1977 to March 1978. This change resulted in the need for additional contractor support during this period. Had the satellite been launched as originally scheduled, this support would not be required and the reserve funds would not have been needed.

The schedule change was desirable and was made possible due to the continued operation of Landsat-2. By delaying the launch of Landsat-3, the possibility of a data gap before the launch of Landsat-D is reduced. If Landsat-3 can operate for 3 years and the development of Landsat-D remains on schedule, the data gap will be minimal. Landsat-1 operated for 5-1/2 years, while Landsat-2 has been in orbit more than 3 years.

The cost estimate of $49.6 million does not include all costs associated with Landsat-3. Other costs are launch support, tracking and data acquisition support, civil service salaries, and a share of NASA's general support costs. NASA does not include these costs in the project budget on the grounds that they would be incurred even if the project didn't exist. We did not attempt to measure these costs; however, NASA estimated that the total project budget would be $69 million if the additional cost categories were included.

The Landsat-3 spacecraft is identical to the first two satellites; however, there are some differences in

its instrument systems. The MSS has the added capability of measuring temperatures on the surface of the Earth. Further, a second system, called the return beam vidicon camera, has its spatial resolution 1/ improved from 80 meters to 40 meters. It is anticipated by NASA and Landsat data users that the better resolution data will supplement the MSS data, thereby increasing its utility.

LANDSAT-D PROJECT STATUS

In fiscal year 1978 NASA received congressional approval to undertake the development of two additional Earth resources technology satellites. The first is called Landsat-D and the second, requested primarily to provide a backup capability, is called Landsat-D backup. The project is experimental and is designed to extend the flow of satellite-acquired Earth resources data into the mid-1980s. Landsat-D is viewed as a new generation in Earth resources technology satellites and will carry a new sensing instrument called the thematic mapper which is under development within the project. (See p. 8.)

The objective of the project is to continue the exploration of advanced research and development techniques for satellite-based Earth resources remote sensing systems. Specifically, the project will

--assess the capability of the thematic mapper to provide improved information for earth resources management,

--provide for system level feasibility demonstration in concert with user agencies to define the need for and characteristics of an operational system,

--encourage continued foreign participation in the program, and

--provide a transition for both domestic and foreign users from the MSS data to the higher resolution and data rate of the thematic mapper.

1/ The smallest size of an object that can be recorded by a sensor.

Cost

As noted earlier, fiscal year 1978 was the first year of project funding although funds were approved in fiscal year 1977 to start development of the thematic mapper. Several Landsat-D contracts have not been awarded; therefore, the figures provided here are considered preliminary or planning estimates by NASA.

Each cost element shown in the following table includes the cost of the components for Landsat-D and D backup. A description for each of the project elements is provided on pages 8 and 9.

Landsat-D and D Backup Cost Estimate
Goddard Space Flight Center Project Office
November 1977

	(millions)
Spacecraft	$ 42.5
Instruments	94.9
Instrument module	85.8
Ground data handling system	72.5
Landsat-D assessment system	7.9
Management reserve and administrative support	36.0
Total	329.6
Launch vehicle	18.5
Facilities	3.1
Tracking and data acquisition	1.5
Total	a/23.1
Total	$352.7

a/ The Landsat-D project office is not responsible for managing these funds.

The cost figures presented above include $39.8 million for two first generation MSS. However, the Administration recently decided to include MSS on the initial Landsat-D mission only. NASA is currently reviewing the cost and schedule impact of this decision and plans to report to the Congress the results of its assessment.

The $3.1 million for facilities is for the construction of a new satellite control center and the ground data management system at Goddard. The total amount shown above does

not include funds for civil service salaries or launch support services.

Schedule

The planning date for the launch of the Landsat-D spacecraft is March 1981. No launch date has been set for the second satellite as this will depend on how well the first spacecraft operates. The earliest date the second mission could be launched would be 6 months after the first launch. Major milestones for the project are as follows.

Landsat-D Milestones

Event	Date
Mission system contract award	June 1978
Construction of facilities completed	Dec. 1979
Delivery of first spacecraft	Jan. 1980
Delivery of MSS	Mar. 1980
Delivery of first thematic mapper	July 1980
Delivery of ground data handling system	Oct. 1980
Launch first spacecraft	Mar. 1981

Procurement plans

The project involves four major contracts. The thematic mapper and the MSS are each being developed under a separate contract. The spacecraft contractor is responsible for delivering two complete spacecraft units with support systems installed. The mission system contractor will develop the instrument module and have overall responsibility for integrating and testing all elements of the satellite system. This includes also the procurement, installation, and testing of the entire ground data handling system being installed in the new facility at Goddard.

Performance goals

Landsat-D will orbit the Earth 15 times each day at an altitude of about 700 kilometers compared to Landsat-3's 912-kilometer orbit. The altitude was changed to achieve 30-meter resolution for the thematic mapper and make the spacecraft shuttle retrievable. This will permit total coverage of the Earth every 16 days. The satellite will transmit data back to Earth via the Tracking and Data Relay Satellite System which is due to begin operations in mid-1980. The Landsat-D project consists of a space segment with inorbit support systems and a ground segment as discussed below.

Space segment

The space segment is comprised of the spacecraft, the instrument module, and the instruments. This segment is designed for 3 years of orbital operations which may be extended as Landsat-D is designed to be compatible with the space shuttle. As a result, it can be refurbished in orbit, or retrieved with the shuttle, refurbished on Earth, and returned to orbit.

The Landsat-D mission will use a standardized spacecraft to provide the basic functions, such as power, propulsion, control, and communications and data handling. Attached to the spacecraft unit will be the instrument module which houses the sensors and other subsystems needed to carry out the mission.

The primary instrument aboard will be an advanced MSS device called the thematic mapper. This instrument will view the Earth in seven spectral bands, with a spatial resolution of 30 meters for six of these bands and 120 meters for the band in the thermal infrared region of the spectrum. The initial design of the thematic mapper provided for a seven-band capability, although only six channels were authorized for development. The need for data in an additional band was reviewed by NASA with the data users. As a result the 2.2-micrometer band was approved by NASA to obtain improved geological data. The other spectral bands which the thematic mapper will detect were selected principally to optimize the capabilities for observing vegetation.

A first generation MSS, identical to that being flown on Landsat-3, will also be aboard the first Landsat-D mission. (See ch. 3.) This sensor has five spectral bands; four have spatial resolution of 80 meters, whereas the thermal band has spatial resolution of 240 meters. The advantages of

including this instrument on the "D" mission are to provide (1) a reliable, space-proven backup sensor, (2) continuity of data similar to that currently being acquired, and (3) transitional data to aid users in converting to the new thematic mapper data.

Ground segment

The ground segment will consist of an operations control center, a data management system, and a Landsat assessment system. The ground equipment and personnel involved in these operations will be at the Goddard Space Flight Center in new facilities being constructed for Landsat-D operations.

The spacecraft and instruments will be operated and controlled from the operations control center, and data from the satellite will be received at the control center. The data will be transmitted from Landsat to the Tracking and Data Relay Satellite which will relay the data to a receiving station located in White Sands, New Mexico. The data will then be sent to Goddard via a Domestic Communications Satellite. Landsat-D also will be equipped to transmit data directly to ground stations throughout the world. The stations which are currently receiving Landsat data will be required, however, to make equipment modifications to receive the new thematic mapper data.

The data management system portion of the ground segment will perform the initial data processing steps required before distribution to the user agencies. Data products required by the general public will continue to be obtained through the Department of the Interior's EROS Data Center located in Sioux Falls, South Dakota.

The purpose of the assessment system is to ascertain whether the mission is meeting its objectives. The activities in this program will include an analysis of the data products to (1) verify that they are meeting specifications and (2) develop improved processing methods which can be transferred to the data users. Another activity will be to determine the improvements provided by the thematic mapper data over the first generation MSS. A number of application demonstrations will be carried out to evaluate the ability of the total Landsat system to support an ongoing activity on a continuing basis.

CHAPTER 3

THE GOVERNMENT'S ROLE IN EARTH RESOURCES SATELLITE SYSTEMS

The Government's role in fostering the development and use of satellite technology for the public benefit varies. In the case of weather satellites, the Government provides meteorological information as a public service. In the case of communications satellites, the Government contributed to their development, but they are now being operated primarily with private capital.

A clear cut Federal Government role in the establishment or support of an operational Landsat system has not yet been developed. At one extreme, Landsat information on Earth resources could be made available to all as a Government service. At the other extreme, the users of the information would have to pay the costs of obtaining it.

The private sector alone will not be likely to establish an operational Landsat system given the magnitude of investment, the long period of time before there would be a return on the investment, and the risks involved. Government support of such a system would broaden its role in satellite-based remote sensing from support of research and development to support of an operational system.

In our June 10, 1977, report "Landsat's Role In An Earth Resources Information System," we concluded that a clear statement of Government policy regarding support of an operational Landsat system was needed. We recognized that development of such a policy would be a complex task requiring coordination of many Federal agencies due to the technical, political, economic, institutional, and international questions to be addressed, all of which are interrelated. We pointed out, however, that Landsat had been an ongoing project for more than 7 years and would involve a total NASA investment of more than $650 million for spacecraft development and operation into the 1980s. With this level of investment and the extended time period involved, we concluded that it was now time to address these questions and proceed with the development of a Government policy.

As a result, we recommended that the Director, OSTP, in conjunction with NASA and other Federal agencies, study

the issues involved and suggest to the President and the Congress a Government policy role in satellite-based, remote-sensing technology. Both OSTP and NASA agreed with our recommendation, and OSTP agreed to take the leadership role in studying the issues involved in developing further satellite remote-sensing information systems.

ACTIONS TAKEN BY OSTP

In assuming the leadership role, OSTP established an ad hoc committee of the Federal Coordinating Council for Science, Engineering, and Technology to examine such issues as those raised in our June 10 report. The committee is comprised of representatives from NASA, the Departments of Agriculture, the Interior, Commerce, and State; the Environmental Protection Agency; the Corps of Engineers; and the National Science Foundation.

The initial task of the committee was to review technical and policy issues relating to Landsat-D program planning. Specifically, the committee addressed the technical and funding implications of including the first generation MSS on the Landsat-D spacecraft, as well as alternative arrangements for processing and distributing Landsat-D data and data products.

MSS recommendation

NASA's fiscal year 1978 budget request to the Congress did not include funding for MSS on Landsat-D on the basis that the stated requirements for MSS were not for further research and development activities, but for operational or quasi-operational uses. Accordingly, it was felt that user agencies should pay for MSS.

The committee gave its recommendations to the Director, OSTP, in November 1977. Regarding MSS, the committee recommended that a five-band MSS, similar to the sensor on Landsat-3, be included on each of the two Landsat-D spacecraft. There were several reasons for making this recommendation:

--MSS has proved to be a reliable instrument which can serve as backup in the event the thematic mapper fails.

--Flying the MSS will provide data continuity in that the data will be similar to the data acquired by the first three Landsats.

--Including both instruments will allow comparisons of the usefulness of MSS and thematic mapper data

so that the advantages and disadvantages of each can be determined. The committee estimated the cost of two MSSs to be $39.8 million for fiscal years 1978 to 1984.

Data processing and distribution recommendation

Several alternatives for processing and distributing Landsat-D data and data products were considered by the committee. The principal difference between the various alternatives involved the amount of data processing NASA would perform before sending the data to the Department of the Interior's EROS Data Center. The final recommendation of the committee was that NASA should receive the data and perform only the initial processing steps. The data would then be transmitted via a communications satellite to the EROS Data Center, where all further processing and distribution would be carried out.

Several advantages are envisioned from this procedure:

--All film products would be produced in one location and available at an earlier date.

--NASA would not have to maintain a large photographic laboratory.

--The total data transmission system would be satellite-compatible because all data would be in a digital format when sent from Goddard. This alternative requires that some of the ground processing equipment planned for installation at Goddard be installed at the EROS Data Center.

Funding recommendation

The committee recognized the experimental nature of the project and recommended that NASA fund the entire project, including the MSS instruments and the ground data processing equipment to be located at the EROS Data Center. The $39.8 million for the MSS instruments and the ground data processing equipment costs are reflected in the Landsat-D cost estimate presented on page 6.

Subsequent to the committee's recommendation, NASA decided to request funds for only one MSS to be included on the first Landsat-D spacecraft. The funds required in fiscal years 1978 and 1979 will be provided by NASA. It is anticipated that the user agencies will share the cost burden in

later years. Further, the Administration's position is that if the users desire MSS on the Landsat-D backup spacecraft, they must provide the funds.

NASA and the Department of the Interior are in the process of deciding which elements of the Landsat-D ground data processing system can be located at the EROS Data Center. The budgetary implications associated with locating equipment at the Data Center rather than Goddard are also under review.

ACTIONS PLANNED BY OSTP

The OSTP committee did not address the broader, long-range policy questions regarding the Government's role in satellite-based, remote-sensing technology that were raised in our June 1977 report. OSTP is planning, however, to form a Cabinet level policy group to study issues, such as the proper role of the Government in an operational Earth resources satellite system, the extent of private sector participation in this system, and international alternatives to a U.S. system.

CONGRESSIONAL INTEREST IN MAKING LANDSAT OPERATIONAL

There have been a number of legislative proposals since 1974 to establish operational Landsat-type systems. The latest proposal was a bill introduced in the first session of the 95th Congress to establish an Earth Resources and Environmental Information System centered on Landsat. The bill, if enacted, will promulgate Government support of an operational Earth resources satellite system.

In August 1976 the Chairman and a member of the Senate Committee on Aeronautical and Space Sciences introduced a bill--S.3759, the Earth Resources Information Satellite System Act of 1976. The bill called for a firm Government commitment to establish and support an Earth Resources Information System centered on the Landsat project. The committee requested and received comments on the bill from companies, universities, and Government agencies interested in Landsat.

In commenting on the bill, we took the position that before committing the Government to an operational system, a study of the technical, political, economic, institutional, and international questions should be undertaken. We suggested that the study might be undertaken by OSTP.

The various comments received by the committee were incorporated into a new bill--S.657, 95th Congress--which was introduced in February 1977. The bill called for the development and establishment of an Earth Resources and Environmental Information System made up of a space segment and a data-handling segment. NASA was designated the manager of the space segment, which would include satellites or other observation sources and the associated ground equipment for command and control of the satellites. The Secretary of the Interior was designated as the manager of the data-handling segment, which would be the portion of the system receiving data from the space segment and then archiving, retrieving, processing, and disseminating it. The bill also provided that the Director, OSTP, would provide oversight and coordination for the system.

If enacted, S.657 would broaden the Government's role in satellite-based, remote-sensing technology from support of research and development to support of an operational system. This, in effect, would promulgate a policy of Government support of operational Earth resources satellite systems similar to the policy of supporting weather satellites.

However, as noted previously, prior to committing the Government to an operational system, a study of the many questions involved should be completed. In testifying on S.657, we concluded that the Director, OSTP, should study the issues involved and report to the President and the Congress a suggested Federal Government policy role in satellite-based, remote-sensing technology.

In June 1977 the House Subcommittee on Space Science and Applications of the Committee on Science and Technology, conducted hearings on Earth resources information systems. Specifically, the hearings addressed the definition and scope of an operational system and the institutional arrangements required for a transition from an experimental to an operational system. The results of these hearings were presented in a November 1977 report "Earth Resources Information Systems." The report recognized the existence of technical, economic, institutional, and international questions which need to be addressed. The report further recognized the need to define the role of the Government in an Earth resources information system. The committee report recommended that these questions and issues be resolved during a 5-year validation program at the end of which an operational Earth resources information system would be established.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

The Landsat project is developing the technology of remote sensing by satellite which provides access to previously unobtainable information about natural resources and the environment. NASA, in accordance with its legislative charter, should continue to support research and development in this field.

However, it is not certain as to whether, when, and how the Federal Government should establish or support an operational Landsat system. This lack of certainty exists because there is no clear statement of Government policy regarding support of an operational system. Development of such a policy will require consideration of complex technical, political, economic, institutional, and international issues. The project has been going on since 1970 and will extend into the 1980s, and NASA's costs will exceed $650 million. With this level of investment and the time involved, these policy issues should be studied.

OSTP has addressed some technical and funding issues relating to Landsat-D and is planning to form a Cabinet level policy group to study broader issues, such as the proper role of the Government in an operational Earth resources satellite system, the extent of private sector participation in this system, and international alternatives to a U.S. system.

The Congress has shown a keen interest in the experimental Landsat program, and legislation has been introduced to make Landsat operational. Accordingly, the Congress should be fully informed on the status of OSTP-sponsored studies of the policy issues involved in the possible evolution of the Landsat experimental project to an operational system.

OSTP examined this report and concurred in our assessment of its activities regarding Landsat. It is taking up the policy issues which relate to the formulation of a future remote-sensing policy.

RECOMMENDATION

We recommend that the Director, OSTP, periodically inform the Congress of the goals and results of its studies relating to satellite-based, remote-sensing policy issues.

National Aeronautics and Space Administration
OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS
LANDSAT-C
PROJECT STATUS REPORT

A. 1. Dates
   a. As of date: December 31, 1977
   b. Submission date: January 31, 1978

2. Designation: Landsat-C

3. Nomenclature: Earth Resources Technology Satellite

4. Popular Name: Landsat-C

5. Mission & Description:

One of the goals of the space program is to utilize space-developed or derived technology for research and development to better understand the nature and status of terrestrial problems. The Earth Resources program is structured to improve the acquisition, management, and availability of data related to the Earth's resources. Landsat-C is a key part of the Eartn Resources Program.

The objectives of Landsat-C are to provide the capability to experiment with improved remote sensors over those available on Landsat-1 and -2 and to provide continuity of data for experimentation and verification testing necessary to more precisely determine the full range of practical applications that can be achieved with remote sensing systems. Landsat-C augments and extends accomplishment of objectives defined for Landsat-1 and Landsat-2 which include the acquisition of multispectral repetitive high-resolution images from which data can be obtained for investigations in the agriculture, forestry, geology, land use, cartography, hydrology, ecology, and oceanography disciplines.

The secondary objective of the Landsat missions is the relay of in-situ data acquired by ground based plaftorms via the satellite through a central processing facility to users for monitoring and managing selected earth resources.

APPENDIX I

6. Prime Contractor: General Electric Co.

General Electric Company was competitively selected as the contractor to conduct the hardware design, development, fabrication, test, and initial operation for the Landsat-1 and -2 spacecraft and the Ground Data Handling System. Landsat-C is a follow-on noncompetitive procurement with GE.

Five-band Multispectral Scanner (MSS): Hughes Aircraft Corporation

Improved Return Beam Vidicon Camera System (RBV): RCA

7. NASA Components:

Overall Program Management
Office of Space and Terrestrial Applications

Project Management
Goddard Space Flight Center

Launch Vehicle Management
Goddard Space Flight Center

B. Current Summary

1. Progress, Problems and Pending Decisions

Spacecraft checkout is complete with shipment to WTR scheduled for mid January 1978.

Previous plans for a September 1977 launch date have been revised to provide for as much as a six-month launch delay. This action is intended to minimize the potential for a gap in Landsat data availability during the period prior to the launch of the proposed Landsat-D in 1981.

In view of the above, the Landsat-C launch is scheduled for March 1978, from the WTR.

APPENDIX I

C. Mission/Technical Characteristic Mission Estimate	1 Development Estimate	2 Last PSR	3 Current Estimate
1. Launch Date	Sept. 1977	Sept. 1977 (earliest)	Mar. 1978
2. Orbital Parameters	A circular, near polar (99.09°) sun synchronous orbit or about 912 km with a north to south equatorial crossing time of about 9:30 am, local standard time. On successive days, each corresponding southbound pass progressively shifts westward about 159 km providing repetitive coverage every 18 days.	Same	Same
3. Design Life	1 year	Same	Same
4. Science Objectives		Same	Same

Provide multispectral photographic and digital data to users;
Provide land and coastal observation on a repetitive basis and at the same local time;
Provide satellite relay coverage of remote land-based Data Collection Platforms (DCP);
Provide and operate facilities for processing, temporal registration and distribution of data to users.

Various Analysis from last Report (Col. 3 - Col. 2)

Launch Date change - see Current Summary

APPENDIX I

Project Plan	Technical	1 Development Estimate	2 Last PSR	3 Current Estimate
	5. Weight			
	Basic Spacecraft	1516 lb/688 kg	Same	Same
	Payload	505 lb/229 kg	Same	Same
	Launch Vehicle Adapter	95 lb/43 kg	Same	Same
	Total	2116 lb/960 kg	Same	Same
	6. Stabilization	3 axis; horizon scanners; rate gyros; reaction jets and flywheels	Same	Same
	7. Launch Vehicle	Delta	Same	Same
	8. Science Payload	Multispectral scanner (MSS): A 5-channel scanning radiometer. Four of these channels will have spectral sensing capabilities for the following bands (in micrometers): .5 to .6(green); .6 to .7(red); .7 to .8 (near IR); and .8 to 1.1 (near IR). Imagery in the visible bands is about 185 km (100 mi) square with a resolution of 80 to 100 meters (270' to 330') depending upon geometry and contrast of features. A thermal infrared band (10.5 - 12.5 micrometers) will be incorporated which will provide capability to observe phenomena characterized by temperature changes.	Same	Same

APPENDIX I

8. Science Payload (cont'd.)	1 Development Estimate	2 Last PSR	3 Current Estimate
Project Plan	Return Beam vidicon camera (RBV): The spatial resolution will be improved over that of Landsat-1 and -2 by a factor of two, thus providing greater accuracy in locating and measuring the area of surface features.	Same	Same
	Wideband Video Tape Recorder Subsystem: Two Wideband Video Tape Recorders (WBVTR) record, store, and reproduce the data outputs from the MSS and/or RBV during remote sensing operations. Each recorder can record 30 minutes of 15-MHz analog data from the RBV. Data are recorded by four heads (on one wheel) rotating across the 2-inch wide tape. Recording and playback are each at 30cm/sec(12 in/sec) and in the same direction. The total usable tape lenth is 548m(1,800ft) for each recorder. In playback, the signal is read out sequentially by the same four rotating heads, with switching and demodulation producing a continuous 15 Mbps data stream.	Same	Same

APPENDIX I

D. Scheduled Milestones

	1 Development Estimate	2 Last PSR	3 Current Estimate
1. Initiate Landsat-C Long Lead Item Procurement	May 1975	Same	Same
2. Landsat-C Letter Contracts Authorized	May 1975	Same	Same
PAD 3. Landsat-C Contract Definitization	Jan. 1976	June 1976	Same
4. Deliver Landsat-C MSS	July 1976	Feb. 1977	Same
5. Deliver Landsat-C RBV	Jan. 1977	Same	Same
6. Complete Landsat-C Integration and Test	Sept. 1977	Same	Same
7. Launch Landsat-C	Sept. 1977	Sept. 1977 (Earliest)	Mar. 1978

E. Program Acquisition Cost

(Dollars in Millions)

	1 Development Estimate* (1/76)	2 Change	3 Last PSR 1/	4 Change	5 Current Estimate**
Spacecraft, Experiments and Ground Operations	35.7	+1.7	37.4	--	Same
Multi-Spectral Scanner (5th Band Devel.)	7.0	-0.5	6.5	--	Same
Total Landsat-C	42.7	+1.2	43.9	--	Same
Launch Vehicle (Delta)***	5.0	-0.3	4.7	+.6	5.3

*Then Pending PAD

**FY 1979 Budget to Congress

***Launch Vehicle Price-out

Assumptions:

Multi-spectral scanner 5th band development was begun earlier as long lead time procurement and is now considered integral with the Landsat-C project.

APPENDIX I

E. (Continued)

Variance Analysis from Development Estimate (Col. 2)

Spacecraft, Experiments and Ground Ops: Increase related primarily to provision for option to delay launch up to six months.

Multispectral Scanner: Decrease reflects revised estimate from the contractor for manufacture and integration of the sensor.

Launch Vehicle: Decrease reflects minor adjustment associated with allocation of costs among users.

Variance Analysis from Last Report (Col. 4)

Launch Vehicle -- Increase of $0.6M reflects higher unit cost for vehicle hardware resulting primarily from a production rate lower than originally planned.

Funding		(Dollars in Millions) Prior Years	FY 1979	To Complete	Total
PAD	Spacecraft, RBV's and Ground Operations	36.7	.7	--	37.4
	Multi-Spectral Scanner	6.5	--	--	6.5
	Total Landsat-C	43.2	.7	--	43.9
	Launch Vehicle (Delta)	5.3	--	--	5.3

F. Support Costs

		1 Development Estimate*	2 Last PSR **	3 Current Estimate***
	Tracking & Data Acquisition	.4	.4	.4

*PAD Approval 3/75

**Then Pend'g PAD

***FY 79 Budget to Congress

Grand total of current project and support estimates: $49.6M

APPENDIX I

G. Other Agencies Involved

c The following Government Agencies are involved in analyzing data from the Landsat-C predecessors (Landsat 1&2). Each of these agencies provides resources for operational use of Landsat data in support of their primary Agency mission.

- o Department of Interior
- o Department of Agriculture
- o Department of Defense
- o Department of State
- o Department of Commerce

o Landsat-C data products will be provided to the public through the Earth Resources Observation Satellite (EROS) Data Center, Sioux Falls, South Dakota, which is operated by the U.S. Geological Survey of the Department of the Interior.

o Foreign countries are involved in both data analysis and data acquisition activities. Three foreign countries--Canada, Brazil, and Italy--are currently operating ground stations which directly receive Landsat data. A number of other countries are either planning or constructing their own ground stations.

Note: Marginal line indicates new information not in prior PSR.

APPENDIX I

APPENDIX II

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20500

January 27, 1978

Mr. R. W. Gutmann
Director
Procurement and Systems Acquisition
Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Gutmann:

This letter is in response to your letter of January 13 to Dr. Frank Press which forwarded for review and comment the GAO draft report "Landsat Policy Issues Still Unresolved." We have examined the GAO report and find it to be a clear assessment of the current activities of the Office of Science and Technology Policy with regard to Landsat and the policy considerations which are associated with remote sensing.

As you know, the FY 1979 budget submitted by the President to the Congress contains funding for a multi-spectral scanner to be included on Landsat D. This office and NASA are taking up the other issues identified in the Federal Coordinating Council for Science, Engineering, and Technology ad hoc committee report and the policy issues which relate to the formulation of a future remote sensing policy.

Sincerely,

Philip M. Smith
Assistant Director
Natural Resources and
Commercial Services

APPENDIX III

National Aer[illegible] and
Space Administra[illegible] n

Washington, D C
20546

FEB [illegible] 1978

Reply to Attn of L-1

Mr. R. W. Gutmann
Director
Procurement and Systems
Acquisition Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Gutmann:

Thank you for the opportunity to comment on GAO's proposed report entitled "Landsat Policy Issues Still Unresolved" (Code 952199), which was furnished with your letter, dated January 13, 1978.

The enclosure includes information that will update the current status of the Landsat D project, as well as editorial changes to help improve the accuracy of the report.

Sincerely,

Kenneth R. Chapman
Associate Administrator for
External Relations

Enclosure *

* Enclosure not included as NASA comments have been incorporated as appropriate.

PRINCIPAL NASA OFFICIALS

RESPONSIBLE FOR ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
ADMINISTRATOR:		
Robert A. Frosch	June 1977	Present
Alan M. Lovelace (acting)	May 1977	June 1977
James C. Fletcher	Apr. 1971	May 1977
DEPUTY ADMINISTRATOR:		
Alan M. Lovelace	June 1976	Present
George M. Low	Dec. 1969	June 1976
ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS:		
Anthony J. Calio	Oct. 1977	Present
Bradford Johnston	June 1976	Sept. 1977
Leonard Jaffe (acting)	Apr. 1976	June 1976
Charles W. Mathews	Dec. 1971	Apr. 1976
COMPTROLLER:		
William E. Lilly (note a)	Feb. 1967	Present

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a/Position established in December 1972. Before that date, the comptroller function was part of the Office of the Associate Administrator for Organization and Management.

(952199)