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Landsat is the National Aeronautics and Space Administration's (NASA's) experimental project to determine the usefulness of satellite-acquired data for the management of the Earth's environment and natural resources. Costs for the first three missions and a proposed fourth mission are estimated at up to $656 million. However, greater questions than cost must also be faced. Findings/Conclusions: Landsat already has provided information previously unavailable; future technology may provide even more valuable information. Continued Government support of research and development of remote-sensing technology is needed. However, committing the Government to support an operational Landsat system is premature. Such action should be taken only if further study reveals that the benefits to be gained justify the expense and resources required to establish the system. Recommendations: The Director of the Office of Science and Technology Policy, in conjunction with NASA and cognizant Federal agencies, should study the technical, political, economic, institutional, and international issues which are involved in an operational Landsat system and should recommend a Government policy role in satellite-based, remote-sensing technology. After reviewing the results of such a study, the Congress and the executive branch should have better information on which to reach a decision as to whether and to what extent the Government should support an operational, satellite-based Earth resources information system. (Author/SC)

REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Landsat's Role In An Earth Resources Information System

National Aeronautics and Space Administration
Office of Science and Technology Policy

Landsat is NASA's experimental project to determine the usefulness of satellite-acquired data for the management of the Earth's environment and natural resources. Costs for the first three missions and a proposed fourth mission are estimated at up to $656 million. But greater questions than cost must also be faced.

Possible evolution from an experimental project to an operational system raises many such questions which require study. The Director of the Office of Science and Technology Policy, Executive Office of the President, should undertake such a study with the objective of suggesting the Government's role in satellite-based, remote-sensing technology.

PSAD-77-58

JUNE 10, 1977

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 second report on the National Aeronautics and Space Administration's Landsat project. It discusses the need for a clear statement of Government policy regarding support of an operational Landsat system. 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.

Elmer B. Staats

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

LANDSAT'S ROLE IN AN EARTH RESOURCES INFORMATION SYSTEM

National Aeronautics and Space Administration
Office of Science and Technology Policy

D I G E S T

Landsat is a $326 million experimental project of the National Aeronautics and Space Administration (NASA) which has been in existence for 7 years to determine the usefulness of satellite-acquired data for the management of the Earth's environment and natural resources. Two Landsat spacecraft are in orbit, and a third will be launched in September 1977. A proposed subsequent program would add two more spacecraft to be operated from 1981 to 1986. The first has been requested in the fiscal year 1978 budget and will cost from $290 million to $330 million.

Issues greater than cost are involved in the future of Landsat. These issues--technical, political, economic, institutional, and international--should be considered now.

NASA RESPONSE TO EARLIER GAO RECOMMENDATION

In January 1976 GAO recommended that NASA lead other Federal agencies in developing a plan for evaluating progress being made toward the goal of deciding if, and when, there should be an operational Earth resources satellite system. NASA has begun to do this. However, there has been no agreement among the users on what performance objectives must be achieved during 1981-86 to justify an operational system. (See p. 8.)

LANDSAT BENEFITS

The technology of remote-sensing by satellite provides access to previously unobtainable information about natural resources and the environment. A broad community in and out of

Government throughout the world has used Landsat data--in agriculture, mineral exploration, water resources, land use, coastal zone monitoring, mapping, oceanography, meteorology, and environmental studies.

There is no assurance yet, however, as to the net benefits, if any, which would arise from an operational Landsat system. (See p. 11.)

HOW LANDSAT WORKS

Landsat orbits the Earth 14 times a day. Its instruments can scan a swath 185 kilometers wide along a continuous path from pole to pole. Because the Earth is continually rotating on its own axis, Landsat instruments, after 18 days, will have had the opportunity to look at nearly every place on Earth (cloud cover permitting). (Further explanation on p. 2.)

Data-receiving stations are in Goldstone, California; Fairbanks, Alaska; Greenbelt, Maryland; Canada; Brazil; and Italy. The foreign stations were built by their governments, which pay NASA $200,000 a year for the right to receive data directly from the satellite.

INTERNATIONAL IMPLICATIONS

Although financed, built, launched, and operated by the United States for national purposes, Landsat also provides natural resources and environmental information to the world community. The United States maintains an open data distribution system under which any nation, corporation, or individual may purchase Landsat data. (See p. 17.)

International sensitivities are involved in remote-sensing by satellites. Sovereignty questions have been raised by several countries concerning the acquisition of data over a country and the availability of that data to countries other than the United States

and the country observed. Other countries have argued for open dissemination of all data.

Although the current experimental Landsat project appears to be gaining international acceptance, problems could arise if Landsat becomes operational.

Users who obtain first rights or exclusive rights to Landsat data could realize economic advantages. Some countries may be sensitive to a system controlled by the United States, especially if private, profit making corporations handle the first receipt and processing of Landsat data. NASA has taken the position that at least the initial receipt, preliminary processing, and distribution of data in any operational system be handled by the U.S. Government to assure equal treatment to all Landsat users. (See p. 18.)

It can be argued that remote-sensing technology and information about Earth resources are valuable assets which should be closely controlled to protect the technological lead and economic power of the United States. It can also be argued that an international system would best serve the interests of the United States on grounds that benefits accruing to other countries would result in international goodwill, which would more than offset short-range U.S. technological and economic losses. (See p. 18.)

GAO POSITION ON AN OPERATIONAL SYSTEM

Legislation introduced in the 95th Congress would establish a Landsat-centered Earth Resources and Environmental Information System. It would be operated by NASA and the Department of the Interior. (See p. 9.)

Landsat already has provided information previously unavailable; future technology may provide even more valuable information. Continued Government support of research and development of remote-sensing technology is needed. (See p. 16.)

However, committing the Government to support an operational Landsat system is premature. Such action should be taken only if further study reveals that the benefits to be gained justify the expense and resources required to establish the system. Such a study might inquire into the

--validity of economic analyses of the benefits of a Landsat operational system,

--value of other than economic benefits that might result from an operational system,

--mechanisms for identifying and aggregating data requirements and training requirements of users and potential users,

--need for and composition of a user charge policy,

--mechanics of setting up cooperative arrangements among existing and planned information systems,

--respective roles of the Government and the private sector,

--feasibility of committing the Government to support a satellite-based system for a specified time and then terminating that support,

--impact of concerns of other nations and international laws and treaties on space and oceans on an operational satellite system, and

--potential military security problems.

NEED FOR CLEAR FEDERAL GOVERNMENT POLICY

A clear statement of Government policy regarding support of an operational Landsat system is needed. Development of such a policy involves consideration of technical, political, economic, institutional, and international issues which are interrelated

in a complex way. These issues transcend individual agency responsibilities. Recently, the Office of Science and Technology Policy was established in the Executive Office of the President. The responsibilities of that office make it a logical place to center a study of the issues.

RECOMMENDATION

The Director of the Office of Science and Technology Policy, in conjunction with NASA and cognizant Federal agencies, should study the issues involved and recommend a Government policy role in satellite-based, remote-sensing technology. (See p. 20.)

After reviewing the results of such a study, the Congress and the executive branch should have better information on which to reach a decision as to whether and to what extent the Government should support an operational, satellite-based Earth resources information system.

AGENCY COMMENTS

The Office of Science and Technology Policy concurred in the need to address the questions GAO raised, stating that its proposal for a policy study will be considered, and a decision will be made after further discussions within the executive branch. (See app. III.)

NASA offered clarification of specific sections of the report. Its comments have been incorporated as appropriate and included in their entirety in appendix II.

Contents

ABBREVIATIONS

HUD	Department of Housing and Urban Development
LACIE	Large Area Crop Inventory Experiment
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
System	Earth Resources and Environmental Information System
Team	Interagency Decision Team

CHAPTER 1

INTRODUCTION

ORIGIN AND PURPOSE OF LANDSAT

Landsat is an experimental Earth resources surveying satellite project managed by the National Aeronautics and Space Administration (NASA). Landsat's objective is to use remote-sensing technology to assist in achieving better management of our environment and natural resources. Two Landsats have been launched, and a third is planned for launch in September 1977.

The Landsat project is a part of the Earth Resources Detection and Monitoring program within NASA's Office of Applications. It was formerly known as the Earth Resources Technology Satellite, which was part of a program that included

--experimental satellites;

--experimental Earth resources aircraft;

--data acquisition, processing, analysis, distribution, and archiving facilities; and

--supporting research and development programs.

Remote-sensing has been used over the years by many Government agencies, academic institutions, and industrial concerns. Great strides were made in the 1940s and 1950s in military developments of airborne instruments for mapping and exploration of hard-to-reach regions. With the advent of the space program, it was logical to extend airborne techniques to space.

In 1966 the Department of the Interior established its Earth Resources Observation Systems program and specifically requested NASA to begin the design and development of a satellite system for surveying Earth resources. NASA's experimental Earth Resources Technology Satellite was approved for development in 1970, and the first spacecraft (renamed Landsat-1) was launched in July 1972. Landsat-2 was launched in January 1975, and Landsat-C is scheduled to be launched in September 1977.

By 1976 the orbit of Landsat-1 began to naturally degrade and, in October of that year, NASA decided to discontinue

data-gathering operations during orbit adjustments. The agency resumed limited Landsat-1 operations in February 1977; however, one of the instruments partially failed in March 1977.

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 Landsat orbits the earth 14 times a day at an altitude of 912 kilometers, its instruments can scan a swath 185 kilometers wide along a continuous path going from pole to pole. The instruments are normally turned on when there is a user for the data and the sky is relatively cloud free. Because the Earth is continually rotating about its own axis, Landsat instruments scan a different 185-kilometer-wide swath every orbit until, after 18 days, they will have had the opportunity to look at nearly every place on Earth (cloud cover permitting). The main instruments on Landsats 1 and 2 are a multispectral scanner, a return beam vidicon camera, and two tape recorders for storing data which is acquired out of a receiving station's range.

Landsat instruments measure the intensity of the sunlight reflected from the surface of the Earth. These measurements are then converted into electronic signals, transmitted to Earth, recorded on magnetic tape, and reconstructed into photographic images. Because different materials on the Earth's surface reflect sunlight differently, the reconstructed image visualizes the different substances on Earth viewed by the instruments, e.g., water, wheat, and forests. Resource managers are then able to use these images or magnetic tapes to monitor the Earth's resources.

Receiving stations are located in Goldstone, California; Fairbanks, Alaska; Greenbelt, Maryland; and in 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 satellite.

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.

SCOPE OF REVIEW

This report updates information on Landsat's uses and expected benefits; cost, schedule, and performance status; future uncertainties; and international implications discussed in our study entitled "Land Satellite Project" (PSAD-76-74, Jan. 30, 1976). This review was made at the request of the Chairman, Subcommittee on HUD-Independent Agencies, Committee on Appropriations, United States Senate. Our review work was performed primarily at the Goddard Space Flight Center, Greenbelt, Maryland, and at NASA headquarters. Information presented herein was obtained by (1) reviewing project plans, reports, correspondence, and other documents and (2) discussing aspects of the project with officials of the Departments of State, Agriculture, the Interior, and the Office of Management and Budget.

NASA and the Office of Science and Technology Policy reviewed this report and their comments appear in appendix II and appendix III, respectively.

CHAPTER 2

LANDSAT-C PROJECT STATUS

This chapter presents information on (1) the cost, schedule, and performance status of Landsat-C, (2) additional project costs, and (3) NASA's project status reporting system.

COST

NASA's March 1975 planning estimate of $35.7 million for Landsat-C project costs was in its fiscal year 1976 budget plan. Not included in that estimate was $7 million for the 5-band multispectral scanner--a major instrument in the spacecraft. This cost was included, however, in the fiscal year 1977 budget estimate, bringing the total cost estimate to $42.7 million. The following table compares elements of the March 1975 estimate (adjusted to include scanner costs) to the November 1976 estimate.

	NASA planning estimate, March 1975	Changes	Goddard Space Center Project Office estimate, November 1976
	(millions)		
Spacecraft	$19.15	$ 2.75	$21.90
Payload	6.75	.05	6.80
Multispectral scanner	7.00	(.50)	6.50
Ground operations	6.20	(.80)	5.40
Allowance for program adjustment (reserve)	3.00	(1.30)	1.70
Institutional management system	.60	(.20)	.40
Total	$42.70	$ 0.00	$42.70

The increase of $2.75 million in the spacecraft's cost was offset by a $1.30 million decrease in the project's reserve and minor decreases in the other cost elements.

SCHEDULE

Although delivery of the multispectral scanner was delayed, project officials told us that they saw no problems in meeting the scheduled September 1977 launch date. All other major system components are on or ahead of schedule. NASA, however, is considering delaying the launch of Landsat-C to minimize any gap in data between Landsat-C and the proposed follow-on system.

PERFORMANCE GOALS

The basic Landsat-C spacecraft will be identical to the two previous Landsats, and therefore, the performance expected should be comparable. There are certain differences, though, in the instruments aboard the Landsat-C spacecraft. One of these includes the addition of a fifth band on the multispectral scanner to measure temperatures on the surface of the Earth. Plans also call for improving the spatial resolution of the return beam vidicon camera system from 80 to 40 meters. Data from this instrument should supplement the lower resolution scanner data, thereby increasing its utility.

Another performance goal of Landsat-C is to improve the capability and reliability of the wideband video tape recorders. In each of the first two Landsats, one of the tape recorders malfunctioned early in the mission. Without full tape recorder capability, the amount of data which can be acquired over foreign countries is limited because all data acquired by Landsat, while out of range of a receiving station, must be recorded until Landsat regains contact with a receiving station. NASA is making improvements to increase tape recorder reliability.

ADDITIONAL PROJECT COSTS

The $42.7 million cost figure discussed above does not include all costs associated with Landsat-C. Other costs incurred to support the project include those for (1) the launch vehicle, (2) tracking and data acquisition, (3) Government salaries, and (4) prorated shares of NASA's general support cost. We did not attempt to measure these other costs because NASA, at the specific request of the Subcommittee on HUD-Independent Agencies, Senate Committee on Appropriations, put together total program cost figures for Landsat as follows.

Landsat Total Program Costs

	Landsats 1&2	Landsat-C	Total
	---------(millions)----------		
Research and development	$188	$43	$231
Launch vehicle	9	5	14
Facilities	2	-	2
Cost proration (note a)	58	21	79
Total	$257	$69	$326

a/Represents a proration of basic engineering, technical, scientific, and research efforts.

NASA's PROJECT STATUS REPORTS

Landsat-C is one of the projects included in NASA's project status report system. NASA, at the request of the Chairman, Subcommittee on HUD-Independent Agencies, Senate Committee on Appropriations, is developing the system to provide the Congress with a report in January and July of each year on the cost, schedule, and technical aspects of its major projects. The chairman requested that we work with NASA and the subcommittee staff in developing a project-reporting system that will serve the needs of the Congress. A copy of the July 1976 Landsat-C project status report is shown in appendix I.

Our report, "Improved Reporting Needed on National Aeronautics and Space Administration Projects," (PSAD-77-54, Jan. 27, 1977) contained recommendations for broadening the project status reports to provide the Congress with increased visibility on NASA's projects.

To the extent that NASA accepts and implements our recommendations, future Landsat-C project status reports will give the Congress more meaningful information. Such information is needed particularly at this stage of the Landsat program, when decisions will be made on the nature of follow-on programs.

CHAPTER 3

SHOULD LANDSAT BECOME OPERATIONAL?

The Landsat experimental project, which began in 1970, is costing an estimated $326 million for its first three missions. NASA has proposed, in its fiscal year 1978 budget, a fourth mission--Landsat-D. Budget estimates for Landsat-D range from $290 million to $330 million and include the cost of the launch vehicle, development costs of an experimental multispectral scanner called the thematic mapper, and 3 years of operation. If Landsat-D is approved by the Congress, total NASA Landsat costs will be well over a half-billion dollars. The question arises: Should the experimental project evolve into an operational system? There are a number of complex issues which should be studied before the question is answered.

In January 1976 we reported that none of the involved agencies had developed a long-range plan including operational requirements to assist in deciding whether Landsat should become an operational system. We recommended that NASA take the initiative in leading the other participating agencies to develop a plan which included requirements, milestones, and dates for evaluating progress being made toward the goal of deciding if there should be an operational system. We recognized that such a plan must postulate a Government policy role in satellite-based, remote-sensing technology.

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 (System) centered on Landsat. The bill, if enacted, will promulgate a policy of Government support of an operational Earth resources satellite system.

We welcome NASA's action taken in response to our recommendation, and the legislative effort to establish Government policy in satellite-based, Earth resources systems. However, we believe that there should be a thorough study of the issues involved prior to committing the Government to support an operational system.

The rest of this chapter discusses actions taken on our recommendation, our observations on proposed legislation to establish a Landsat-centered operational system, and our observations on steps to be taken to develop a clear statement of Government policy regarding support of an operational Landsat system.

NASA ACTIONS

NASA agreed with our earlier recommendation and formed an ad hoc group to study future Landsat-type systems. The group, designated the Interagency Decision Team (Team), consisted of representatives of NASA and the major Federal users of Landsat data--the Departments of Agriculture, Commerce, the Interior, and State; and the U.S. Army Corps of Engineers.

The Team first met in July 1976 to help the NASA Administrator focus on and resolve issues relating to proposed Earth resources satellites beyond Landsat-C and determine what to recommend to the Office of Management and Budget, the President, and the Congress.

The Team examined several different types of Landsat follow-on systems to reach a consensus on the satellite system best capable of meeting most of the user agency data requirements. The Team's discussions focused on the technical characteristics and capabilities of a series of experimental Landsat follow-on satellites to be launched in the 1980s. It did not, however, discuss specific requirements of users that must be met before Landsat can become operational. The system agreed upon and endorsed by NASA is the result of a series of compromises due to the multimission characteristics of the Landsat project and cost considerations.

The Team recommended a validation period of approximately 5 years, to begin with the launch of Landsat-D in 1981 followed by the launch of Landsat-E at the end of Landsat-D's useful life. The Team believed 5 years of continuous satellite data (1) would be sufficient to encourage active user participation, investment in equipment, and development of systems and (2) would allow time to determine the costs and benefits to users of Earth resources data. Landsat-D and Landsat-E each would be equipped with a 5-band multispectral scanner (as on Landsat-C) as well as an experimental second-generation, 6-band multispectral scanner called the thematic mapper. However, NASA's fiscal year 1978 request to the Congress for Landsat-D funding did not provide for the 5-band multispectral scanner. NASA is working with Federal agencies, foreign users, and the commercial sector to see if it is possible to arrange for funding to buy a scanner for Landsat-D.

The Team's recommendation to have one satellite in orbit during the validation period was a compromise due to the additional costs necessary to launch and operate more satellites. One orbiting satellite would permit 16-day coverage of the Earth as compared to 8-day coverage possible with two satel-

lites in orbit. Although the Team felt that 8-day coverage was desirable, it decided that the associated costs could not be justified during the validation period. The change from an 18-day cycle on existing Landsats to the 16-day cycle will be made possible by reducing the satellite's altitude from 912 kilometers to 705 kilometers. The Team believed a decision for more satellites could be made as late as 1979 if further experience justified 8-day coverage.

Sending data out from Goddard after receipt has been averaging 15 days. Another characteristic of the proposed Landsat follow-on system is the delivery of processed data to all user agencies within 2 to 5 days. This improved delivery time would be accomplished by relaying Landsat's data via other satellites to the user agencies.

The concept of a validation period as set forth above does not make clear what must be achieved and when it must be achieved before deciding on an operational system. During such a period, large numbers of users might make substantial investments and come to rely heavily on the Landsat system. Such users would have problems if the Government decided to withdraw support of the system because benefits did not justify costs. This raises the issue of whether it would be feasible to commit the Government to support a satellite-based system for a specified time and then terminate that support.

PROPOSED LEGISLATION TO ESTABLISH AN OPERATIONAL 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 commitment by the Government 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 prior to committing the Government to an operational system, a study of the technical, political, economic, institutional, and international questions should be undertaken. We also suggested that the study might be undertaken by the Office of Science and Technology Policy, Executive Office of the President.

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 calls 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 is 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 is 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 envisions (1) a validation phase in which the design and performance of the space and data-handling equipment are finalized and (2) the establishment of an operational space segment within 7 years after the bill becomes law.

S.657 also provides that the Director of the Office of Science and Technology Policy shall provide oversight and coordination for the System. Specific duties of the Director would be

--aiding in planning, developing, and fostering the execution of national policies for the establishment and operation of the System;

--providing for continuous review of the System;

--coordinating the activities of Government agencies having responsibilities in the field of Earth resources, environmental information, and Earth resource use;

--supervising relationships of Government agencies with foreign governments or entities or with international bodies as is appropriate;

--ensuring the availability of System products for local, State, or national needs; and

--determining the benefits of participation or management by the private sector in the System and recommending to the President the transfer of part or all of the System to the private sector at the earliest practicable date if such transfer will improve the System.

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.

We welcome such an effort to establish Government policy in satellite-based Earth resources systems. However, we believe that prior to committing the Government to an operational system, a study of the many questions involved should be undertaken. Our observations on these questions and suggestions for addressing them are discussed in the following section.

QUESTIONS FOR STUDY

A clear statement of Government policy regarding support of an operational Landsat system is needed. Development of such a policy involves consideration of technical, political, economic, institutional, and international questions which are interrelated in a complex way. A brief discussion of some of these questions points out the need to plan and develop a policy before establishing an operational Landsat system.

What are the benefits of an operational system?

The technology of remote-sensing by satellite provides access to previously unobtainable information about our natural resources and environment. A broad community of users in and out of Government throughout the world has used Landsat data in the areas of agriculture, mineral exploration, water resources, land use, coastal zone monitoring, mapping, oceanography, meteorology, and environmental studies.

There is no assurance, however, as to the net benefits, if any, which would arise from an operational Landsat system. A NASA-funded study, completed in October 1974, estimated that a benefit to cost ratio of 12 to 1 could be achieved with an operational system over a period of some 16 years. Well over one-half of the projected benefits would come from improved agricultural forecasting based on assumed improvements in technology.

As pointed out in our January 1976 Landsat report, the NASA-funded study results should be used only with a complete understanding of the effects the assumptions and methodologies used had on the costs and benefits reported. Because of uncertainties associated with projecting future economic benefits, some assumptions are necessary; however, a user of the study should be aware of them. For example, the benefits identified in agricultural forecasting are dependent upon the assumption

that improvements in Landsat technology will be realized. NASA officials believe that significant improvements are possible.

An internal NASA memorandum, in discussing a critique of the NASA-funded study by a Department of the Interior consultant, stated that crop acreage forecasting was the most important area of disagreement. The memorandum stated

> "Simply stated [the study] contends that if crop production errors can be reduced by 25% the benefits would be about 250 million dollars per year. [The consultant] contends that there is no way that NASA technology can achieve such a reduction. He allows a * * * chance of * * * improvement which reduces the 250 million dollars to 2.5 million.
>
> "However, we do not believe that these issues will be finally resolved by statistical studies. We believe that LANDSAT capabilities will be demonstrated by the achievements of the LACIE [Large Area Crop Inventory Experiment] program. Not until these results are available will we be in a position to state conclusively that Landsat can provide this sort of information."

More realistic and reliable assessments of improved crop-forecasting benefits possible from an operational Landsat system may come from the LACIE project as well as from improvements developed outside the project. NASA, the Department of Agriculture, and the Department of Commerce are involved in the project to determine the feasibility of improving foreign crop production estimating, using Landsat data and weather information. Wheat was chosen as the experimental crop, and the U.S. Great Plains was the initial test area. LACIE is designed to proceed through 3 wheat crop years (1974-77) and is scheduled to end with a final evaluation report in June 1978. Officials of NASA and the Department of Agriculture consider the results encouraging to date. Top Agriculture officials are not yet convinced of operational payoffs; however, there are plans to begin, in fiscal year 1978, a transition from the experimental LACIE to an operational foreign wheat-forecasting system.

Based on available evidence, a decision at this stage of the Landsat experimental project to go operational would be based on (1) the expectation that the system would, in time, become cost beneficial, (2) the assumption that social and political benefits justify the costs, or (3) a combination thereof.

Are users' needs being met?

As a part of NASA's Space Applications program, Landsat is intended to demonstrate the use of space-related technolog for down-to-earth, practical benefits. Concerns of Landsat data users are: technical problems, uncertainty regarding program continuity, and the need for training.

As can be expected with an experimental project, the usefulness of Landsat data varies depending on the specific needs of Earth resource managers. Frequently mentioned technical improvements needed to increase the usefulness of currently available Landsat data are

--higher spatial resolution (the smallest sized area on the ground for which the sensor data can be analyzed for content),

--an Earth surface, temperature-measuring sensor,

--more frequent cycle of coverage, and

--faster data product delivery times.

Landsat-C will include some of these improvements, and Landsat-D, if developed as planned, will make further technical improvements.

Many current and potential users of Landsat data consider the uncertainty regarding continuous data availability as a major deterrent to more extensive use. It seems certain that a decision to go operational would provide the user community the assurance it needs. However, it is not clear what must be achieved and when it must be achieved before a decision can be made. As discussed earlier, Interagency Decision Team discussions focused on improved technical characteristics and not on specific operational requirements of users that must be met before Landsat can become operational.

Ideally, a comprehensive inventory of Landsat user data requirements and an estimate of the costs to meet these requirements, should be developed and then a judgment made on the value of meeting them. Such information would assist in deciding the extent to which the Government should support an operational Landsat system.

There should at least be clear statements of information needs from the major Government agencies which use or plan to use Landsat data or which serve users of the data. The agencies should also state their views on the need for and composition of user charges. Such statements should assist in deciding whether or not an operational system is justified.

During our prior review, we found strong indications that current and potential users of Landsat data lack sufficient knowledge of how to use the data. We recommended that NASA take the lead, in conjunction with potential users, in developing a plan to provide formal training to Landsat data users to realize a maximum return from the large investments already made in the Landsat project. NASA's response to this recommendation was that it considered training a current and continuing issue which would be addressed in planning with other agencies for a Landsat follow-on system.

We believe the Interagency Decision Team would have provided an excellent forum for discussing the Government's Landsat training responsibilities. This issue was not discussed and remains unresolved.

How would an operational system interact with existing or planned systems?

A decision to establish an operational Landsat system would have to take into account its interaction with existing or planned Earth resources information systems. The broadness of the term "earth resources and environment" is indicated by the previously discussed bill--S.657, which defines the term as including but not limited to food and fiber crops, forests, water, air, minerals, and materials. Merely identifying and understanding the multitude of information systems pertaining to these resources is a formidable task. The following illustrations provide some idea of the complexity involved in interrelationships among Earth resources information systems.

Our report, "U.S. Actions Needed to Cope with Commodity Shortages" (B-114824, April 29, 1974), pointed out that commodity policy formulation involves numerous Government departments, agencies, offices, administrations, and policy councils as well as additional international program agencies, energy agencies, advisory councils, and regulatory agencies.

In discussing the need for a focal point for commodity policy, the report pointed out that there are 60 or more agencies dealing with foreign economic affairs and 64 groups which have dealt with energy activities. Determining whether and how Landsat should supplement or replace any of the information systems of the above organizations would require considerable analysis and evaluation.

A second illustration concerns the mission of the National Oceanic and Atmospheric Administration (NOAA) in the

Department of Commerce. The agency conducts remote-sensing activities in carrying out the responsibility for improving man's comprehension of oceanic life and the weather. NOAA is involved in both the space and data-handling segments of systems which provide data to assist Earth resources managers. NOAA's National Environmental Satellite Service manages the space segment and operates two systems. The first is the polar-orbiting series of spacecraft which provides global daytime and nighttime images of the Earth's cloud cover and other weather phenomena. The second is the Geostationary Observational Satellite which provides continuous observations of weather systems, oceans, space environment, and other Earth characteristics.

NOAA's Environmental Data Service manages the data handling segment through the

--National Climatic Center,

--National Oceanographic Data Center,

--National Geophysical and Solar Terrestrial Data Center,

--Center for Climatic and Environmental Assessment,

--Environmental Science Information Center, and

--Center for Experimental Design and Data Analysis.

These centers support NOAA's concern with fluctuations in climate and environment and their probable socio-economic impact. They support large-scale field research projects and explore and predict the effects of long-term changes in the world on global food production, energy use, and resource management. In addition, NOAA arranges the exchange of information through world data centers, for which NOAA has the United States' responsibility in most environmental disciplines. NOAA's holdings in its data centers are extensive and are found in a variety of useful forms, including satellite and radar photographs, physical oceanographic measurements, solar data, and a host of other types of material.

NOAA is also using and disseminating Landsat data. It uses the data in studies of sea-ice distribution; snow runoff potential; circulation and surface characteristics of oceans, lakes, and bays; air and water pollutants; fishery resources;

and severe storm detail. The possibility exists that it would be more feasible to merge the Landsat system into NOAA's existing operational satellite systems than to establish a new operational system.

A third illustration involves the relationships among Landsat and other NASA experimental projects, such as

--Seasat for ocean dynamics research;

--Magnetic field satellite for location of natural resources such as coal, oil, and minerals;

--Nimbus-G for pollution monitoring;

--TIROS for weather; and

--the Heat Capacity Mapping Mission for mineral potential assessments, soil moisture studies, and mapping snow coverage.

All of the above involve satellite-based remote-sensing of Earth resources for practical applications. Any established operational Landsat system should be designed to take advantage of technological gains from these and future experimental projects.

The above illustrations demonstrate the need for a thorough study of the interrelationships of existing or planned Earth resources information systems. Such a study would provide information to assist in making a determination as to whether and how the various systems would fit together in an operational system.

What is the Government's role in supporting satellite-based, remote-sensing technology?

The Government's role in fostering the development and use of 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. At one extreme, one could argue that Landsat information on Earth resources should be made available to all as a Government service. At the

other extreme, one could argue that the users of the information should pay the costs of obtaining it.

The private sector alone would 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 opinion, continued Government support of research and development is needed for remote-sensing technology. Landsat has provided unique information previously unavailable, and future technology may provide even more valuable information. However, we believe that it is premature to commit the Government to support an operational Landsat system. In our opinion, such action should be taken only if further study reveals that the benefits to be gained justify the allocation of resources required to establish the system.

Will a national system best serve the interests of the United States?

Landsat, although financed, built, launched, and operated by the United States for national purposes, also provides natural resources and environmental information to the world community. The United States maintains an open data distribution system under which any nation, corporation, or individual may purchase Landsat data products.

International sensitivities are involved in remote-sensing by satellites. Sovereignty questions have been raised by several countries concerning the acquisition of data over a country and the availability of the data to countries besides the United States and the country observed. Other countries have argued for open dissemination of all data.

Although the current experimental Landsat project appears to be gaining international acceptance, certain problems could arise if Landsat becomes operational. One potential problem involves the spatial resolution of Landsat sensors. Spatial resolution is defined as the smallest sized area on the ground for which the sensor's data can be analyzed for content. Many Landsat users desire high spatial resolution for more detailed analysis of Earth resources

data; however, as spatial resolution becomes higher, the military security issues become obvious. Current planning for the proposed thematic mapper includes a 30-meter spatial resolution capability compared to 80 meters on Landsats 1 and 2. NASA officials said they do not believe that the 30-meter resolution will raise any new concerns since (1) 10-meter-resolution Skylab data has been published without adverse reaction, (2) the United Nations Outer Space Affairs Division has produced reports recommending use of 10-meter-resolution data for most remote-sensing applications, and (3) European plans for remote-sensing satellites contemplate higher resolutions than 30 meters. NASA officials said there are no current plans to increase the Landsat's resolution beyond 30 meters. A Department of Defense official has testified that, in the future, resolution limits may have to be established on instruments used in unclassified programs.

Users who obtain first rights or exclusive rights to Landsat data could realize economic advantages. Some countries may be sensitive to a system controlled by the United States, especially if private profit-making corporations handle the initial receipt and processing of Landsat data. NASA has taken the position that at least the initial receipt, preliminary processing, and distribution of data in any operational system be handled by the U.S. Government to assure equal treatment of all Landsat users.

It can be argued that remote-sensing technology and information about Earth resources are valuable assets which should be closely controlled to protect the technological lead and economic power of the United States. It can also be argued that an international system would best serve the interests of the United States on grounds that benefits accruing to other countries would result in international goodwill which would more than offset the short-range U.S. technological and economic losses.

We believe that the advantages and disadvantages of a national system as opposed to an international system require thorough study to assist in shaping Federal Government policy regarding support of an operational Landsat system.

Where should policy development be centered?

The previous questions indicate the need for a clear statement of how the Government intends to proceed

in the possible evolution of Landsat from an experimental project to an operational system. Policy planning and development clearly should precede establishment of such a system.

The focal point for establishing policy and plans regarding an operational system might be in a number of places. To date, it has centered in NASA because of its heavy involvement in the current experimental phase. Accordingly, we directed our previous Landsat recommendations to NASA. The Departments of Agriculture, Commerce, Defense, State, and the Interior also should be heavily involved in planning for a possible operational system. As user agencies, these departments should establish their requirements. It could be expected, however, that the differing needs of the Departments could not be fully satisfied because of cost and technical limitations. The problem then would be to reach a compromise which would best serve national needs. Thus, there is a need for a policy-development focal point that would not be unduly influenced by any particular set of agency needs.

Since our last report on Landsat, an office has been established which would be a logical place to center policy development. The Office of Science and Technology Policy was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 (Public Law 94-282). The act sets forth a comprehensive statement of national policy for science and technology linked to enumerated priority goals.

The Director of the Office of Science and Technology Policy is responsible for defining coherent approaches for applying science and technology to critical and emerging national and international problems and for promoting coordination of the scientific and technological responsibilities and programs of the Federal departments and agencies. He is also responsible for initiating studies and analyses of alternatives available for the resolution of national and international problems and, insofar as possible, determining and comparing probable costs, benefits, and impacts of such alternatives. The Director serves as a member of the Domestic Council and is directed to work in close consultation and cooperation with the Domestic Council, the National Security Council, the Council on Environmental Quality, the Council of Economic Advisers, the Office of Management and Budget, the National Science Board, and the Federal departments and agencies.

As discussed above, bill S.657 provides that the Director of the Office of Science and Technology Policy would be responsible for aiding in planning, development, and fostering the execution of national policies for the establishment and operation of the proposed Earth Resources and Environmental Information system.

Officials of the Office of Science and Technology Policy reviewed this report and agreed with our findings. (See app. III.) They stated

> "* * * the resolution of the set of issues related to development of an operational system presents a formidable task which may be impossible to accomplish before considerable additional experience with early Landsat satellites has been accumulated. The need to address the questions raised in your report is, in the longer term, very clear and this office would support a review at a suitable future date. At the present time, however, the proposal will be considered very carefully and the decision on a study of this nature will be made after further consultations within the Executive Branch."

CONCLUSIONS AND RECOMMENDATION

The Government has invested $326 million in the Landsat experimental project, and NASA is requesting authority in the fiscal year 1978 budget for another mission which will cost up to $330 million. There is a need for a clear statement of Government policy regarding support of an operational Landsat system. Without such a statement, it is possible to continue indefinitely with experimental satellites, avoid an operational system decision, and leave users in a continuous state of uncertainty regarding the future, if any, of the program.

Development of such a policy involves consideration of technical, political, economic, institutional, and international questions which are interrelated in a complex way and which transcend individual agency responsibilities. We recognize the complexity involved in resolving these questions and appreciate the fact that more experience will make the task easier. However, the Landsat experimental project has been in existence for 7 years, and we believe the time to address these questions is now.

Therefore, we recommend that the Director of the Office of Science and Technology Policy, in conjunction with NASA and cognizant Federal agencies, study the issues involved and report to the President and the Congress a suggested Government policy role in satellite-based, remote-sensing technology. The study might inquire into the

--validity of economic analyses of the benefits of a Landsat operational system,

--value of other than economic benefits that might result from an operational system,

--mechanisms for identifying and aggregating data requirements and training requirements of users and potential users,

--need for and composition of a user charge policy,

--mechanics of setting up cooperative arrangements among existing and planned information systems,

--respective roles of the Government and the private sector,

--feasibility of committing the Government to support a satellite-based system for a specified time and then terminating that support,

--impact of concerns of other nations and international laws and treaties on space and oceans on an operational satellite system, and

--potential military security problems.

After reviewing the results of such a study, the Congress and the executive branch should have better information upon which to reach a decision as to whether and to what extent the Government should support an operational satellite-based Earth resources information system.

National Aeronautics and Space Administration

LANDSAT-C
PROJECT STATUS REPORT

A. 1. Dates
   a. As of date: December 31, 1976
   b. Submission date: January 31, 1977

2. Designation: Landsat-C

3. Nomenclature: Earth Re[illegible]ces Technology Satellite

4. Popular Name: Lands[illegible]

5. Mission & Description:

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 platforms via the satellite through a central processing facility to users for monitoring and managing selected earth resources.

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

APPENDIX I

7. NASA Components:

Overall Program Management
Office of Applications
Earth Observations Programs

Project Management
Goddard Space Flight Center

Launch Vehicle Management
Goddard Space Flight Center

B. Current Summary

1. Progress, Problems and Pending Decisions

Fabrication of Landsat-C spacecraft elements is on schedule for a September 1977 launch readiness date. This includes prime contractor fabricated parts and long-lead purchased items like the Data Collection System, Telemetry Processor, Solar Arrays, Command Clock and the Wide Band Video Tape Recorder.

The RBV development is also on schedule. The qualification model has been completed and qualification testing is underway. Flight hardware fabrication is on schedule for January 1977 delivery to the Prime contractor.

The Multispectral Scanner will complete its development, assembly and test, and will be delivered in February 1977. The change from the previously reported September 1976 delivery is due to various problems during the integration and test cycle. The delayed delivery will not impact the overall schedule since MSS integration into the spacecraft is not scheduled until February 1977. In addition, the necessary modifications to the ground data processing facilities to accommodate the sensor changes will be inititated along with the detailed ground operations planning and the software.

Previous plans for a September 1977 launch date have been revised to provide for as much as a six-month launch delay. This action, which is dependent upon the operating condition of Landsat-2, 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.

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C. Mission/Technical Characteristic	1 Development Estimate	2 Last PSR	3 Current Estimate
Mission Estimate	Sept. 1977	Same	Sept. 1977 (earliest)
1. Launch Date			
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. Each succeding 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.

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	1 Development Estimate	2 Last PSR	3 Current Estimate
5. Technical			
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.	Same	Same

APPENDIX I

8. Science Payload (cont'd)	1 Development Estimate	2 Last PSR	3 Current Estimate
	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 length 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
3. Landsat-C Contract Definitization	Jan. 1976	June 1976	Same
4. Deliver Landsat-C MSS	July 1976	Sept. 1976	Feb. 1977
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	Same	Sept. 1977 (Earliest)

Variance Analysis: (Item 4) Delivery of the MSS was delayed due to problems encountered and solved during development tests. This does not have either a program schedule or cost impact due to need dates now established for this instrument.

(Item 7) Provision has been made to delay the launch of Landsat-C up to six months following September 1977, dependent upon continued successful operation of Landsat-2.

E. Program Acquisition Cost

(Dollars in Millions)

	1 Development Estimate (1/76)	2 Last PSR	3 Change	4 Current Estimate
Spacecraft, Experiments and Ground Operations	35.7	36.2	+1.2	37.4
Multi-Spectral Scanner (5th Band Devel.)	7.0	6.5	—	6.5
Total Landsat-C	42.7	42.7	+1.2	43.9
Launch Vehicle (Delta)	5.0	5.2	-.5	4.7

APPENDIX I

Assumptions:

Estimate in real-year dollars.

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

Variance Analysis:

Variance from previous report (Col. 2-Col. 4)

Spacecraft, Experiments, and Ground Operations +1.2

Provision for option to delay launch by six months

Launch Vehicle

Adjustment to reflect currently projected allocation of costs -0.5

Funding (Dollars in Millions)

	Prior Years	FY 1978	To Complete	Total
Spacecraft, RBV's and Ground Operations	33.5	3.2	.7	37.4
Multi-Spectral Scanner	6.5	--	--	6.5
Total Landsat-C	40.0	3.2	.7	43.9
Launch Vehicle (Delta)	4.7	--	--	4.7

F. Support Costs

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

Grand total of current project and support estimates: $49.0M

APPENDIX I

G. Other Agencies Involved

- As is the case with Landsat 1 and 2, many federal agencies are involved in the Landsat program. The principal agencies involved are:
  - Department of Interior
  - Department of Agriculture
  - Department of Defense
  - Department of State
  - Department of Commerce
- Landsat-C data products will continue to be provided to the public through three federal data dissemination centers:
  - 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
  - The U.S. Department of Agriculture Data Center in Salt Lake City, Utah
  - The National Oceanic and Atmospheric Administration Data Center in Suitland, Maryland; NOAA is a part of the Department of Commerce

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

APPENDIX I

APPENDIX II

National Aeronautics and
Space Administration

Washington D C
20546

W

16 MAR 1977

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 review your draft report entitled "Landsat's Role in an Earth Resources Information System" which was forwarded with your letter, dated February 18, 1977.

NASA's comments on the draft report are enclosed. Also, we are enclosing a copy of the most recent Landsat-C project status report in order to make Appendix I more current.

Sincerely,

John M. Coulter
Acting Assistant Administrator for
DOD and Interagency Affairs

Enclosure

GAO Note: Page numbers in enclosure refer to a preliminary draft of this report.

APPENDIX II

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
COMMENTS ON THE GAO DRAFT REPORT
ENTITLED "LANDSAT'S ROLE IN AN EARTH
RESOURCES INFORMATION SYSTEM"

General Comments:

In order to help make the report more current, we are enclosing a copy of the most recent Landsat-C project status report which is stated as of December 31, 1976. It is suggested that this be substituted for the proposed Appendix I.

We recommend that the following changes be made in the segments of the digest and text of the report to which they pertain.

Detailed Comments:

1. Page iii. Replace the sixth point ("--current concerns of other nations...") with the following three points:

--the establishment of patterns of practice and usage through existing U.S. cooperative remote sensing agreements with other countries,

--the implications of impending foreign remote sensing programs including planned satellite systems on U.S. leadership, influence, and freedom of action in this field,

--the relevancy of international laws and treaties such as the Outer Space Treaty.

2. Page 2 (last paragraph) and page 3 (first paragraph). Replace with the following paragraph:

"As Landsat orbits the earth 14 times a day at an altitude of about 570 miles, its instruments can look at a swath 100 nautical miles wide along a continuous path going from pole to pole. (The instruments are normally commanded on when there is a user for the data and the sky is relatively cloud free.) Because the earth is continually rotating about its own axis, Landsat instruments look at a different 100 nautical mile wide swath every orbit until, after 18 days, they will have had the opportunity to look at nearly every place on earth, cloud cover permitting. The main instruments on Landsats 1 and 2 are a multispectral

scanner, a return beam vidicon camera, and two tape recorders to store data which is acquired out of a receiving station's range."

3. Page 3, second paragraph, fourth and fifth lines. Delete "...in some cases..."

4. Page 10, first paragraph, third sentence. Replace with the following sentence:

"Budget estimates for Landsat-D range from $250 to $280 million, including the cost of the launch vehicle, an experimental multispectral scanner called the thematic mapper, and three years of operation. These estimates do not include the cost of developing the thematic mapper, which is estimated at $40 to $50 million."

5. Page 13, first paragraph. Add the following as the last sentence:

In the FY 1978 budget submissions to the Congress, however, the five-band multispectral scanner was not included.

6. Page 13, second paragraph, fourth line. Replace with the following:

"One orbiting satellite permits 16-day coverage of the earth as compared to 8-day coverage possible with two satellites in orbit. Although the Team felt that 8-day coverage was desirable, it decided that the associated costs could not be justified during the validation period. The Team believed a decision for more satellites could be made as late as 1979 if further experience justified 8-day coverage."

7. Page 17, third paragraph, last sentence. Replace with the following two sentences:

"For example, the benefits identified in agricultural forecasting are dependent on Landsat technology providing a more accurate system. Analysis indicates that significant improvement is possible.

8. Page 18, last paragraph, fourth line. Add the following sentence:

"...(LACIE) project. Furtnermore, improvements in the techniques for interpreting Landsat data may result in improvements in crop forecasting capability not achieved strictly within the LACIE. NASA, the ..."

9. Page 18, last paragraph, last sentence. Replace with the following sentence:

"Officials of NASA and the Departments of Agriculture and Commerce consider the results to date encouraging."

10. Page 19, first two lines. Replace with the following paragraph:

The Department of Agriculture is in the process of procuring elements of an operational system. However, they are proceeding carefully until they have the results of technical performance, evaluations of such performance, and a better understanding of the benefits to be derived.

11. Page 27, second paragraph. Add the following as the last sentence in that paragraph:

Other countries have argued for open dissemination of all data.

12. Page 27, third paragraph, seventh line. Replace rest of paragraph with the following:

"...analyzed for content. Some Landsat users desire high spatial resolution for more detailed analysis of earth resources data. However, if spatial resolution were to become progressively higher, the sensitivity/security issues might, at some point, become more acute. Current planning for the proposed thematic mapper includes a 30-meter spatial resolution capability compared to 80 meters on Landsats 1 and 2. NASA does not consider that the availability of 30-meter resolution Landsat data will raise any new concerns, however, since:

--NASA has gathered and widely published, without adverse reaction, 10-meter resolution data during the 1973-74 Skylab missions.

APPENDIX II

--The UN Outer Space Affairs Division has produced reports during 1975 and 1976 which recommend the use of 10-meter spatial resolution data for most remote sensing applications. This has also caused no adverse reaction.

--European plans for remote sensing satellites contemplate higher resolutions than 30 meters.

NASA has no current plans to increase the Landsat resolution beyond 30 meters."

13. Page 28, first paragraph. Replace with the following paragraph:

"In the Landsat program, the U.S. is committed to a policy of open data dissemination, without favor or discrimination of any kind. There is, therefore, no provision for first rights or exclusive rights to data and no issue on this point in the Landsat program. Nevertheless, some countries may be sensitive to a future system controlled by the U.S. if private profit-making corporations were to handle the initial receipt and processing of Landsat data. NASA has taken the position that at least the initial receipt, preliminary processing, and distribution of data in any operational system should be controlled by a governmental agency to assure equal treatment of all Landsat users."

14. Page 28, second paragraph, last line. Replace "...the short-range U.S..." with "...any short-range U.S..."

15. Page 32. Replace the eighth point ("--current concerns of other nations...") with the following three points:

--the establishment of patterns of practice and usage through existing U.S. cooperative remote sensing agreements with other countries,

--the implication of impending foreign remote sensing programs including planned satellite systems on U.S. leadership, influence, and freedom of action in this field,

--the relevancy of international laws and treaties such as the Outer Space Treaty.

3/15
Date

Bradford Johnston
Associate Administrator
for Applications

Enclosure

APPENDIX III

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

29 April 1977

Mr. R. W. Gutmann, Director
Procurement & Systems Acquisition Division
US General Accounting Office
Washington, DC 20548

Dear Mr. Gutmann:

This is in response to your letter directed to this office regarding a draft report "Landsat's Role in an Earth Resources Information System." At your request this office has reviewed your report focusing specifically upon the major findings and the recommendation that the OSTP play a key role in carrying out a study of the issues involved regarding the development of an operational Landsat system.

In general this office has no basic disagreement with the major GAO findings, i.e.:

o There is a need for continued Federal government support of R&D pertaining to remote sensing technology.

o It is premature to commit the Federal government to supporting operational Landsat systems.

o There has been no agreement on performance objectives that must be achieved during the validation period (1981-86) to justify an operational system.

Of these major findings it is the view of this office that the third point is an appropriate issue for the Office of Science and Technology Policy and it would be appropriate for the OSTP to consider playing a lead role in drawing together interagency views on this question. This would clearly require the participation and cooperation of a number of agencies, particularly NASA, Department of Interior, and the Department of Agriculture. Such a review could be carried out under the auspices of the Federal Coordinating Council for Science, Engineering and Technology of which the Director, OSTP is the chairman. The broader policy review suggested in your draft report, and particularly the resolution of the set of issues related to development of an operational system presents a formidable task which may be impossible to accomplish before considerable additional experience with early Landsat satellites has been accumulated. The need to address the questions raised in your report is, in the longer term, very clear and this office would support a review at a suitable future date. At the present time, however, the proposal will be considered very carefully and the decision on a study of this nature will be made after further consultations within the Executive Branch.

APPENDIX III

We appreciate the opportunity to comment on your draft report and commend your staff for an excellent analysis of this question. If you have any further inquiries regarding the OSTP view we will be pleased to respond to them.

Sincerely,

Russell C. Drew
Assistant Director

APPENDIX IV

PRINCIPAL OFFICIALS OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION RESPONSIBLE FOR ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
ADMINISTRATOR:		
Alan M. Lovelace (acting)	May 1977	Present
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 APPLICATIONS:		
Bradford Johnston	June 1976	Present
Leonard Jaffe (acting)	Apr. 1976	June 1976
Charles W. Mathews	Dec. 1971	Apr. 1976
COMPTROLLER:		
William E. Lilly (note a)	Feb. 1967	Present

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.