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Report to the Chairman, Committee on Science, Space and Technology, House of Representatives

November 1990

SPACE OPERATIONS

NASA Is Not Archiving All Potentially Valuable Data

[redacted]

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Information Management and
Technology Division

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November 2, 1990

The Honorable Robert A. Roe
Chairman, Committee on Science, Space,
and Technology
House of Representatives

Dear Mr. Chairman:

On March 2, 1990, we reported on how well the National Aeronautics and Space Administration (NASA) managed, stored, and archived space science data from past missions. This present report, as agreed with your office, discusses other data management issues, including (1) whether NASA is archiving its most valuable data, and (2) the extent to which a mechanism exists for obtaining input from the scientific community on what types of space science data should be archived.

As arranged with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the date of this letter. We will then give copies to appropriate congressional committees, the Administrator of NASA, and other interested parties upon request.

This work was performed under the direction of Samuel W. Bowlin, Director for Defense and Security Information Systems, who can be reached at (202) 275-4649. Other major contributors are listed in appendix IX.

Sincerely yours,

for Ralph V. Carlone
Assistant Comptroller General

Executive Summary

Purpose

The National Aeronautics and Space Administration (NASA) is responsible for space exploration and for managing, archiving, and disseminating space science data. Since 1958, NASA has spent billions on its space science programs and successfully launched over 260 scientific missions. Through these efforts it has collected massive volumes of data for immediate and long-term scientific use stored on over 1.2 million reels of magnetic tape. During the next 5 years NASA plans to launch over 30 new missions, and expects that by the late 1990s the annual volume of its space science data will increase five thousandfold.

Given the nation's investment in space missions, and the need to preserve and safeguard the irreplaceable information they produce, the House Committee on Science, Space, and Technology asked GAO to determine if NASA (1) was archiving all of its valuable space science data, and (2) had a mechanism in place to allow scientists to provide input on what data should be archived.

Background

Space missions generate massive volumes of data. NASA's 1978 policy governing the management of space science data specifies the types of data to be archived. The policy requires missions to archive only data that has been analyzed by principal investigators. The end result of that analysis—archival data—is usually altered and may account for only a small portion of all the data collected. Typically, after analyzed data are archived, tapes containing original and more complete versions of data are erased and reused.

Scientists play a key role in space science research. Scientists that are closely affiliated with specific missions often define mission objectives, analyze spacecraft data, and disseminate the results of their work to the world. Even outside scientists, who are not directly affiliated with specific missions, use spacecraft data—sometimes for research never anticipated when the data were originally collected. Depending on their roles, involvement in the planning, development, and operation of computer systems processing mission data gives affiliated and outside scientists a voice in deciding what mission data should be archived.

Results in Brief

NASA is not archiving all potentially valuable space science data. It does not archive original data from past missions that may be needed for future research. Further, NASA's archives are largely incomplete for many important missions and contain no data for others. Valuable data are missing because (1) NASA's 1978 policy does not require original or certain research and scientific data to be archived, and (2) missions did not prepare requisite plans for data management, archiving, and disposition.

NASA's existing network of committees, advisory panels, and working groups gives scientists an opportunity to provide input on the planning, development, and operation of mission data processing systems. However, affiliated scientists have expressed longstanding concerns that they must be more involved in the actual development and operation of the systems because recommendations they make are often not implemented. Participation of outside scientists is important because they may have different perspectives on the value of data NASA plans to archive. Although NASA policy encourages their participation, it is not required and seldom done. NASA said it was taking steps to expand the role of outside scientists in the management and archiving of space science data.

Principal Findings

Data From Some Important Missions Not Archived

Data from past NASA missions now reside on over 1 million magnetic tapes, yet NASA's existing data archives are incomplete for many important missions and contain no data for others. For 23 out of 37 important scientific missions, less than 60 percent of the required data was archived. And of 263 major science missions NASA launched between 1958-1987, 18 had not sent any data to the archival facility. NASA officials attributed the archival shortfalls to many factors, including a lack of (1) formal agreements between NASA and the principal investigators as to what data to archive, and (2) requirements for archiving of data from certain classes of missions.

Policy Permits the Destruction of Valuable Data

NASA's 1978 data management policy does not require (1) original data to be archived and made available for new research initiatives, or (2) any data to be archived from such sources and disciplines as bioscience, microgravity, aircraft, balloon, sounding rocket missions, and NASA instruments flown on foreign spacecraft or the Shuttle. Many space scientists and NASA advisory groups believe NASA should permanently archive selected original data so that future investigators might have access to original, unmodified data suitable for future processing and analysis. Some scientists feel that where possible, all original data should be saved as a first priority. Although scientists recognize that such a changed policy may require the storage of data in a more voluminous state, they think future scientists must have access to the original, unmodified data for further research and analysis. NASA agrees that its policy needs more flexibility and plans to revise it during 1990.

Mission Archiving Plans Not Prepared

Until recently, NASA had not enforced its own policy that requires missions to prepare project data management plans which address essential aspects of mission data management and archiving. Between May 1978 and October 1985, only one mission prepared the required plan. As a result, these missions have not formally described or identified data that should be archived or marked for destruction.

Scientists' Involvement in a Key Data Management Area Is Ineffective

NASA's Space Science and Applications Advisory Committee, management operations working groups, and mission-level data management and science teams provide a framework through which NASA seeks input from scientists during various mission phases. Mission-level teams often have provisions to involve affiliated and outside scientists in a key data management activity—the planning, development, and operation of mission data processing systems. Although affiliated scientists have been increasingly involved in planning these systems, they still express concern about their limited involvement in the actual development and operation of these systems. As a result, they believe mission data processing systems often do not perform as expected. NASA's efforts to involve outside scientists in data archiving decisions could be strengthened by more actively enlisting outside scientists as members of mission-level advisory committees that guide the development and operation of mission data processing systems, as well as recommend specific data that should be archived for future research.

Recommendations

Although NASA is taking several steps to improve its management of space science data, GAO is making a series of recommendations to the Administrator of NASA to ensure the preservation of all valuable space science data from past and future missions. They include recommendations that NASA (1) take appropriate action to ensure that any valuable missing data from past missions is archived, (2) revise data management policy to ensure that all valuable data are archived, and (3) identify areas where the participation of scientists in data management and archiving activities should be strengthened. Details on these and other recommendations are in chapter 4.

Agency Comments

In commenting on a draft of this report, NASA said that it presents a useful assessment of some key issues in science data management. Further, NASA noted that it shares many of the concerns identified by GAO, and said it has programs underway or plans to address them. NASA's comments and GAO's evaluation are included in appendix IX.

Contents

Tables

Abbreviations

CODMAC	Committee on Data Management and Computation
GAO	General Accounting Office
IMTEC	Information Management and Technology Division
ISSPP	Information Systems Strategic Planning Project
JPL	Jet Propulsion Laboratory
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NSSDC	National Space Science Data Center
OSSA	Office of Space Science and Applications
PDMP	Project Data Management Plan
SSAAC	Space Science and Applications Advisory Committee
TSSF	Tape Staging and Storage Facility

Introduction

NASA has spent over $24 billion on space exploration and research during the last three decades. It has launched over 260 major space science missions and acquired massive volumes of data that are stored on more than 1.2 million magnetic tapes, as well as hundreds of thousands of charts, reports, microfilms, negatives, and photographs. Its spectacular successes in many aspects of space exploration have provided scientists with data that have greatly expanded our understanding of the universe, the solar system, and Earth.

Background

NASA's Office of Space Science and Applications (OSSA) is responsible for space exploration and for the overall management, archiving, and dissemination of these data. Individual missions are managed by program managers within OSSA's six science divisions[1] and by mission management teams located at the Goddard Spaceflight Center in Greenbelt, Maryland, the Jet Propulsion Laboratory (JPL) located in Pasadena, California, and other NASA field centers. Responsibility for agency-wide planning, oversight, and coordination of space science data management lies within OSSA's Communications and Information Systems division.

Goddard's National Space Science Data Center (NSSDC) serves as NASA's principal data archival and dissemination facility. In addition, NASA is archiving, or plans to archive, space science data in several discipline data systems[2] and university-based data analysis and archival facilities such as the Infrared Processing and Analysis Center at the California Institute of Technology in Pasadena, the Planetary Data Systems and the NASA Ocean Data System at JPL, and the Pilot Land Data System and the NASA Climate Data System at Goddard.

The National Archives and Records Administration (NARA) is responsible for periodic reviews of NASA's and other federal agencies' management, archiving, and disposal of data. NARA is also responsible for reviewing and approving NASA's records disposition regulations governing the disposal and retention of space science data.

[1] Life Sciences, Earth Sciences and Applications, Solar System Exploration, Microgravity Science and Applications, Space Physics, and Astrophysics.

[2] Designed to support multiple missions in planetary, space plasma, ocean, land, and climate sciences, these systems archive selected mission data, provide investigators with on-line access to the archived data, and, in some instances, distribute data of high interest on optical disks.

Scientists Play an Important Role in Space Science Research

Space exploration and research is a costly, complex, and often lengthy process requiring close cooperation of hundreds of highly skilled spacecraft and mission planners, designers, engineers, communications specialists, and scientists. Successful space exploration is driven, to a large extent, by scientists who define the mission's scientific focus, analyze the acquired data, and disseminate their findings. In general, scientists who are closely affiliated with NASA missions often serve as principal investigators or co-investigators.[3]

Secondary users of space science data, outside scientists who are not closely affiliated with NASA missions, represent the scientific community at large and substantially contribute to the nation's space exploration and research. Often having served as principal investigators on past missions, they can competently advise NASA on data management and archiving.

Space Missions as Complex Information Systems

The primary objective of NASA space exploration missions is to advance scientific knowledge through data analysis. The first steps in this process are (1) acquiring, (2) processing, and (3) distributing space science data throughout the scientific community. Thus, all major missions include complex information systems consisting of many spaceborne and ground subsystems supported by engineers, data processing specialists, and scientists. These systems may generate and process large volumes and many types of data for periods up to 10 years or more. Given the complexity and volume of data, major missions demand the application of sophisticated inventory, cataloguing, tracking, and data disposition policies and procedures.

Future Missions Pose Significant Data Management Challenges

Future missions will dramatically increase the volume of data that will have to be processed, analyzed, and archived. Between 1990 and 1996, NASA plans to launch over 30 new missions. These missions are expected to produce tremendous volumes of data, unparalleled in NASA's history. NASA estimates that by the late 1990s the annual volume of space science data acquired by its missions will increase five thousandfold.[4] Thus, by the late 1990s, NASA may annually be handling volumes of data about 29 times greater than the volume of text contained in all 15 million books

[3]Appendix II explains in more detail other roles that scientists may have on NASA missions.

[4]NASA estimates an increase from .06 terabytes in 1989 to 312 terabytes by the late 1990s.

held by the Library of Congress.[5] According to Goddard officials, NASA would annually need over 1.7 million standard reels of magnetic tape or about 48,000 optical disks.

Missions Generate Several Types of Data

In most instances, missions produce large volumes of data which go through several phases from their origination in space to their storage at a NASA archival facility. For ease of understanding, we placed the many types of space science data into two broad categories—original data and archival data.

Original data includes[6] raw data acquired by spacecraft instruments and sensors; master data records that contain the complete original experiment(s) data combined with supporting information such as orbital position, spacecraft attitude, and command and housekeeping data; and experiment data records which are usually extracted from master data records and contain information about a smaller subset of the spacecraft instruments.

Archival data records are usually created and provided to NASA by principal investigators[7] who have analyzed the original data and reported the results of their research through various publications. Often archived data have been irreversibly changed or transformed through calibration and processing, or reduced in volume by sampling. Appendix III shows the general flow of scientific data from spacecraft to data archival facility.

Original Data May Hold Key to Future Research

Original data have greater long-term scientific value that archival data. Archival data records usually contain only a subset of the original data, or calculations based on the original data. Our March 1990 report[8] on NASA's archival practices noted that original data retain their scientific value indefinitely because they (1) are unique and may not be replicated

[5]This estimate assumes that an average book contains 300 pages of text, with 400 words per page and 6 characters (bytes) per word. One terabyte is over 1 trillion bytes.

[6]Although original data may include other types—some with no scientific value—we use the term "original" to refer primarily to master data records and experiment data records.

[7]In some instances, archival records may be also created by investigator teams and guest investigators.

[8]Space Operations: NASA Is Not Properly Safeguarding Its Valuable Space Science Data, (GAO/IMTEC-90-1, Mar. 2, 1990).

by future missions, (2) may be combined with data from future missions, (3) may be needed to plan future missions, (4) may be needed for long-term studies of environmental changes, (5) may not have been fully analyzed, (6) may be reprocessed using new computer technology and advanced analytical techniques to obtain new or more accurate information, or (7) are of significant historic interest.[9]

The Value of Original Data Has Been Established

Many space scientists and NASA advisory groups think that NASA should permanently archive selected original data so that future investigators might have access to original, unmodified data suitable for future processing and analysis. According to NASA's Chief Scientist for the global change research program, scientists need original data from early missions to develop longitudinal data bases. Even if these data have been analyzed before by one group of scientists for one set of purposes, their preservation is increasingly important to scientists in other disciplines.

A group of scientists recognized the long-term value of original data in a 1987 report[10] that focused on ocean data. This report recommended that, where possible, all original data be saved as a first priority before anything else is considered for storage and archiving. While recognizing this would require storing data in their most voluminous state, the report asserted this would allow scientists to reprocess the original, unmodified data sets—an essential condition for further research and analysis. Similarly, a 1989 report of NASA's Information Systems Strategic Planning Project (ISSPP) recommended that all mission data, defined as potentially valuable by the scientific community, must be archived.

The preservation of original data may be important to the global change research program. A 1988 NASA advisory council report[11] identified many data sets generated by past, active, and planned missions as needed for the long term measurements of global variables.

[9]NASA officials noted that data from some missions may be understood only by the original investigators.

[10]Issues and Recommendations in Satellite Data Management, report of the Satellite Ocean Data System Science Working Group Archive Panel, Scripps Institution of Oceanography, September 1987, p. 5.

[11]Earth System Science: A Close View, Report of the Earth System Science Committee, NASA Advisory Council, NASA, January 1988.

NASA Is Not Preserving All Valuable Space Science Data

NASA is not preserving all valuable space science data. Except in rare cases, it has not archived original data from past missions that may be needed for future research. Further, NASA's existing data archives are largely incomplete for many important missions and contain no data for others. These conditions can be attributed to a number of factors. NASA is not archiving original data because its 1978 policy covering archiving of space science data is obsolete. The policy requires that only analyzed data be archived. It permits the destruction of original data that may have significant long-term value for future research. Another reason is that until recently, NASA had not enforced its own policy that requires missions to prepare project data management plans (PDMP) which address essential aspects of mission data management and archiving. With one exception, none of NASA's space science missions launched between May 1978 and October 1985 prepared the required plans that should have described and identified data to be archived or marked for destruction.

NASA's management practices do not guarantee that original data from past missions is fully processed, analyzed, and archived by project scientists and principal investigators before being destroyed.

NSSDC officials cited numerous reasons why it had incomplete or missing data for some missions, including (1) no formal agreements between NASA and the principal investigators as to what data to archive, and (2) a policy that did not require the archiving of data from bioscience, microgravity, aircraft, balloon, sounding rocket missions, or data from NASA instruments flown on foreign spacecraft or on the Shuttle. They admitted that management controls covering the destruction of original data could be improved, but could not readily explain why missions did not submit required data plans—other than "until recently, no one in NASA took the PDMP requirement seriously."

No Data Were Archived From Some Important Missions

A number of NASA's past missions have not submitted data to NSSDC. For example, of the 263 major science missions NASA launched between 1958-1987 (see app. IV), 18 had not submitted any data—digital or otherwise—to NSSDC, while 19 had archived only non-digital data such as paper or film records (see app. V).

When asked, NSSDC officials could not readily determine the location and status of data for 28 of the 37 missions. Although unaware of the exact location, they said that it was likely that data for these missions were held by the principal investigators. OSSA officials told us that the program managers in OSSA's science divisions should know where these data are located. Because NASA lacks an agency-wide inventory of its tapes containing space science data, we could not readily verify these statements or determine whether these data were stored elsewhere.

NSSDC officials cited six reasons why the center has not archived any data for these missions. First, there was often no formal agreement between NASA and the principal investigators as to what data to archive. Second, NASA has not previously required the archiving of data from bioscience, microgravity, aircraft, balloon, sounding rocket missions, or NASA instruments flown on foreign spacecraft or the Shuttle. Third, other federal agencies, NASA centers, and universities may be archiving some of these data. Fourth, between 1978-1985, NASA missions did not prepare the required project data management plans identifying data to be archived. Fifth, NSSDC staffing and resources were not, during the last decade, adequate to handle the number, complexity, and volume of data to be archived; thus, missing data may not have been aggressively pursued. NASA recognized this problem in 1988 and is funding NSSDC's data acquisition function at a higher level. Sixth, missions did not accurately estimate the cost of archiving, resulting in insufficient resources to prepare and distribute archival data to NSSDC. In 1989, NSSDC developed a cost model[1] designed to help managers estimate archival costs for their missions. It will also help OSSA's science divisions select the appropriate level of archival service, estimate archival costs, and, one hopes, include adequate funding for archival services in the missions' budgets.

Noting inconsistencies in the kind of data archived from mission to mission or discipline to discipline, a recent report[2] underscored the need to develop a coherent and comprehensive data management policy to preserve all valuable data. Given the absence of uniform format and content requirements for principal investigators to archive their data, it recognized how difficult it is to find archived data and analyze them.

[1] A Cost Model for NASA Data Archiving, Version 2.0, National Space Science Data Center, June 1990.

[2] Report of the Information Systems Strategic Planning Project: A Recommended Information Systems Strategic Plan for NASA's Office of Space Science and Applications (OSSA) and Office of Space Operations (OSO), January 1990, p. 44.

NSSDC's Data Holdings for Many Important Missions Are Incomplete

In 1986, the National Research Council's Committee on Data Management and Computation (CODMAC) requested that NSSDC report on the status of its archival data holdings for 37 missions that CODMAC and NSSDC termed "currently important." NSSDC reviewed its data archives and in June 1987 contacted over 214 principal investigators associated with these missions to locate valuable data that need to be archived. By May 1988, NSSDC received 100 valid and 25 inappropriate responses, with 89 investigators failing to respond to follow-up letters and telephone calls.[3] In a briefing to CODMAC, NSSDC presented a "project report card." Of the 37[4] important missions, only 6 missions had archived more than 90 percent of their data, 7 missions archived between 60 to 90 percent, and 23 missions provided less than 60 percent of data due for archiving at NSSDC. After discussing the ratings with NSSDC staff, we summarized the status of data archival efforts for the 37 missions in Table 2.1.

Table 2.1: Status of Archival Data for Currently Important Missions

Mission (common abbreviation)	Date of launch	Percentage of data archived at NSSDC[a]	Current level of archival effort[b]
1. Atmosphere Explorer C (AE-C)	12/73	60–90	none
2. Atmosphere Explorer D (AE-D)	10/75	60–90	none
3. Atmosphere Explorer E (AE-E)	11/75	60–90	none
4. Active Magnetosphere Particle Tracer Explorer Charge Composition Explorer (AMPTE/CCE)	8/84	60–90	good
5. Active Magnetosphere Particle Tracer Explorer Ion Release Module (AMPTE/IRM)	8/84	> 90	completed[c]
6. Active Magnetosphere Particle Tracer Explorer United Kingdom Subsatellite (AMPTE/UKS)	8/84	0	none[d]
7. Dynamic Explorer 1 (DE-1)	8/81	< 10	very good
8. Dynamic Explorer 2 (DE-2)	8/81	< 10	very good
9. Interplanetary Monitoring Platform J (IMP-J)	10/73	60–90	fair
10. International Sun Earth Explorer 1 (ISEE 1)	10/77	10–29	good
11. International Sun Earth Explorer 2 (ISEE 2)	10/77	10–29	good
12. International Sun Earth Explorer C (ISEE C)	8/78	10–29	good
13. Orbiting Solar Observatory 8 (OSO 8)	6/75	10–29	poor
14. Solar Maximum Mission (SMM)	2/80	30–59	fair

(continued)

[3]In commenting on the poor response to NSSDC's letter to principal investigators, NSSDC's director noted that if NSSDC could not get information on NASA space science data held by individual investigators, the members of the scientific community may not fare any better.

[4]Data from one mission are archived in England and were therefore not included in our analysis of NSSDC's holdings.

Mission (common abbreviation)	Date of launch	Percentage of data archived at NSSDC[a]	Current level of archival effort[b]
15. Mariner 6	2/69	< 10	none
16. Mariner 7	3/69	< 10	none
17 Mariner 9	5/71	< 10	none
18. Mariner 10	11/73	30–59	none
19. Pioneer 10	3/72	30–59	good
20. Pioneer 11	4/73	30–59	good
21. Pioneer Venus A Orbiter	5/78	10–29	fair
22. Pioneer Venus 2	8/78	10–29	fair
23. Viking 1	8/75	30–59	none
24. Viking 2	9/75	30–59	none
25. Voyager 1	9/77	30–59	good
26. Voyager 2	8/77	30–59	good
27. High Energy Astronomy Observatory 1 (HEAO 1)	8/77	30–59	very poor
28. High Energy Astronomy Observatory B (HEAO B)	11/78	60–90	none
29. High Energy Astronomy Observatory 3 (HEAO 3)	9/79	10–29	very poor
30. Infrared Astronomical Satellite (IRAS)	1/83	> 90	complete[c]
31. International Ultraviolet Explorer (IUE)	1/79	> 90	complete[c]
32. Earth Radiation Budget Satellite (ERBS)	10/84	60–90	good
33. Heat Capacity Mapping Mission (HCMM)	4/78	100	complete
34. Nimbus 7	10/78	> 90	complete[c]
35. Ocean Dynamic Satellite A (SEASAT A)	6/78	30–59	unknown[e]
36. Solar Mesosphere Explorer (SME)	10/81	> 90	complete
37. Shuttle Imaging Radar B (SIR-B)	10/84	30–29	unknown[e]

[a]NSSDC estimate of data that should be archived by each mission.

[b]NSSDC's assessment of the level of effort by the principal investigators and projects to generate archival data for submission to NSSDC.

[c]OSSA officials told us that the archiving of data for these missions was successfully completed.

[d]NSSDC officials said that data from this mission are archived in the United Kingdom

[e]NSSDC was not aware of the current archival efforts because data from this mission are archived at JPL.

An NSSDC official expressed concern about the possible misinterpretation of Table 2.1, since its determination of the volume of data that ought to be archived by the NSSDC is subjective. He provided a listing of facilities storing "as yet not archived" data as well as an explanation of NSSDC's archival effort for these missions. This information is presented in appendix V.

The incompleteness of NSSDC's archives was addressed in a 1989 NASA report which noted that:

> A wealth of data has been acquired on NASA missions and some, but not all, of these data have been submitted to the NSSDC. Scientists involved in NASA programs require access to these data to solve outstanding scientific problems and to prepare for future missions in a situation in which present data are insufficient. These users need to know the extent and quality of the NSSDC data holdings, as does NSSDC, to assess what it has and what it has not, but should have. Thus, NSSDC should perform a complete review of its archive, determine what it needs to curate in its present archive, and what it needs to aggressively procure.[5]

An NSSDC official pointed out that in order to accomplish this objective, NSSDC would need the full cooperation of the scientific community.

Policy Permits the Destruction of Valuable Data

The overall management and archiving of NASA's space science data is governed by a 1978 policy.[6] Among other things, the policy defines the type of space science data records to be archived. It directs NSSDC to archive analyzed data prepared by principal investigators, specifically excludes original data records from permanent archiving, and does not require archiving data from life sciences, microgravity, aircraft, balloon, sounding rocket missions, or from instruments carried by foreign spacecraft and by the Shuttle.[7]

According to NASA officials, OSSA formulated its 1978 policy when most missions were flying instruments that were developed and sometimes built by principal investigators. Because it was believed in nearly all cases that only the principal investigators from these missions could understand and analyze the data, the agency deemed it appropriate to archive only analyzed data identified by the principal investigators as important to save. NASA officials told us they were planning to revise NASA's data management policy during 1990.

[5] Information Systems Strategic Planning Project, Science User Workshop, Panel Reports, Annapolis, Maryland, May 1-3, 1989, p. 7.

[6] Policy Concerning Data Obtained from Space Flight Investigations, NASA Management Instruction 8030.3A, May 2, 1978.

[7] NASA's sounding rocket and balloon program is managed by Goddard Space Flight Center's Wallops Flight Facility. Wallops launches about 90 balloons and sounding rockets per year. NASA is archiving data from some Shuttle missions, according to one official, "based on common sense rather than on specific rules."

NASA's Records Schedule 26[8] implements portions of the 1978 data management policy and provides day-to-day agencywide guidance on the disposal of space science data. It requires that original data be destroyed after analyzed data have been archived, unless a NASA field center director approves their retention. NASA must seek NARA approval to destroy any unprocessed original data.

Required Mission Data Management Plans Were Not Prepared

Under a key provision of NASA's 1978 data management policy, each mission must prepare a project data management plan. The plans should address all essential functions related to the mission's management and archiving of space science data, including

- plans for data analysis and dissemination,
- milestones for data processing and analysis,
- identification, and time limits for the transfer of valuable data to permanent archives, and
- plans for destroying original data.

NASA stresses the importance of developing this information because the submission of space science data to NSSDC often extends over a period of time much longer than the life of the spacecraft project office, thus making the PDMP a valuable post-project agreement. Because NSSDC is the sole NASA organization responsible for identifying and acquiring archival data in the post-mission phase, its ability to identify and acquire archival data depends on detailed project data management plans and cooperation from each project.

Only one of NASA's 25 space science missions launched between May 1978 and October 1985 prepared the required plans.[9] Hence, these missions, which are listed in appendix VI, have not formally identified data that should be archived or marked for destruction. Since 1988, three out of eight active missions have not prepared the plans. (Appendix VII details the submission of PDMPs for other active and future missions.)

[8] NASA Records Schedule 26: Computer Sensible—Scientific, Engineering, and Experimental, December 4, 1978.

[9] Although the Infrared Astronomical Satellite does not have a PDMP, the project did prepare an "interface control document" that described data to be archived at NSSDC.

Lax Enforcement Cited as Reason for Noncompliance

Acknowledging the missions' lack of compliance, NASA officials could not explain why NASA has not enforced this requirement. One official responsible for agency-wide coordination of science data management activities noted that until recently, "no one in NASA took the PDMP requirement seriously." The ISSPP task force partially explained the missions' lackluster performance in this area, noting that the development of a data management plan has been imposed on individual projects, but the project has been left to its own devices to prepare this document. No management structure or support approach exists to assist in the implementation of such a plan.[10]

Better Management Safeguards Needed to Prevent Premature Destruction of Original Data

Under NASA's 1978 record disposition policy,[11] tapes containing original data can be released after analyzed data has been archived. We noted, however, that NASA is routinely releasing tapes without adequately ensuring that archival data had been created. Between 1986 to 1989, Goddard released over 532,000 tapes, a large portion of which contained original data.[12]

Current Policies Permit the Disposal of Original Data

NASA's agencywide records management policy permits original data to be destroyed only after analyzed data have been archived. Before destroying any original data that was not analyzed and archived, NASA must obtain approval from NARA. Goddard's local policy, however, does not establish a system of sound management controls to ensure that the required data have been successfully archived before destroying original data. The policy also does not require projects to obtain NARA's approval for destroying data that was not analyzed or archived.

[10] Information System Strategic Planning (ISSP) Project, Science User Workshop, Annapolis, Maryland, May 1-3, 1989, p. 8.

[11] NASA Records Disposition Handbook (NHB 1441.1A), NASA Records Schedule 26: Computer-sensible—Scientific, Engineering, and Experimental, December 4, 1978; and Goddard Space Flight Center Management Instruction (GMI 8030.1A), Retention of Magnetic Data Tapes, March 7, 1979.

[12] The 532,000 tapes released by Goddard are not included in the count of the 1.2 million tapes in NASA's storage.

No Guarantee at Goddard That Analyzed Data Are Archived Before Original Data Are Destroyed

Original data from many missions are often stored at Goddard. Because of overcrowding at its tape storage facility, as well as the cost of storing magnetic tapes indefinitely, Goddard periodically purges its inventory. Essentially, Goddard gives users two options—release the tapes for reuse, or get special permission from the Director of Goddard and fund their retention. If users elect to release the tapes, they are not specifically required to determine or certify that archival data have been created.

One user explained that he had released thousands of tapes because he could not afford continued storage and was reluctant to raise the retention issue all the way up to the Goddard director. He told us that data on the tapes were valuable, and, in an attempt to salvage some of them, he authorized the destruction of every other carton of tapes, placing the tapes he saved in a basement at Goddard.

Because of concerns about Goddard's practices, we requested NARA to assess Goddard's tape release program and to determine if tapes have been released without proper authorization. On March 27, 1990, NARA representatives met with NASA and Goddard staff to discuss this issue. In a subsequent letter to NASA dated April 6, 1990, NARA noted it could not determine conclusively whether any unauthorized disposal had occurred. According to a NARA official, time constraints and inadequate documentation prevented it from determining whether original data were released without proper authorization. However, because NARA believed that original data may have been destroyed before the archival records were created, it recommended that NASA develop a mechanism to prevent the destruction of original records before analyzed data were archived at NSSDC. A NARA official stated that unless NASA implemented safeguards to protect original data from premature disposal, potentially valuable data may be destroyed.

Scientists' Participation in Data Management

An extensive network of committees, advisory panels, and working groups exists to involve closely affiliated and outside scientists in data management and archiving decisions and activities. Affiliated scientists are actively involved in broad aspects of planning future missions. However, they have expressed serious concerns about their limited involvement in the development and operation of mission data systems. Outside scientists are generally not involved in data management and archiving activities, even though their involvement is encouraged by NASA policy.

NASA recently sponsored a comprehensive effort known as the Information Systems Strategic Planning Project (ISSPP). The project was formed to develop strategic goals to meet the information systems challenges of the 1990s. It involved nearly 200 participants from the scientific community, NASA headquarters and field centers, and contractors. In general, scientists who were interviewed during the project stated that NASA's mission data systems will never be successful unless they can fully participate in the planning, design, development, operation, and evaluation of these systems. A recent project report[1] noted that scientists' participation on high-level advisory panels was important but not sufficient. The report stated that frequent involvement by scientists on the working level was more essential, allowing them to work closely with NASA centers and contract personnel in developing and operating mission data management systems.

Scientists Participate in Data Management Activities

According to an OSSA official, several mechanisms involve scientists in the management of space science data, including the Space Science and Applications Advisory Committee (SSAAC), management operations working groups, and mission-level data management and science teams.

Scientists Participate in SSAAC and Its Subcommittees to Advise OSSA

In November 1988, NASA established SSAAC to advise OSSA on space observations and the use of space technology in support of space exploration and research. The committee set up several discipline-oriented subcommittees to advise OSSA's science divisions. One of these, the Communications and Information Systems Subcommittee, was specifically chartered to provide advice to OSSA's Communication and Information Systems Division, which is primarily responsible for managing NASA's space science data.

[1] Information Systems Scenarios for Space Science and Applications, Information Systems Strategic Planning Project, Operations and Information Systems, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, December 1989, p. 6.

SSAAC has met three times since its formation in late 1988. The minutes of its meetings show that the committee and its subcommittees focused largely on funding priorities for proposed missions. It is too early to assess the impact of the new advisory structures on the overall direction of NASA's space exploration research. However, the committee and its subcommittees—particularly the Communication and Information Systems subcommittee—could furnish valuable input and guidance to NASA's management and archiving of space science data.

Scientists Participate in Management Operations Working Groups to Advise OSSA's Science Divisions

OSSA pursues scientist participation on the sub-discipline and project levels through management operations working groups. OSSA officials told us these groups played an important role in allowing scientists not affiliated with NASA missions to participate in the planning and management of various aspects of space science research. In 1989, OSSA's science divisions sponsored 24 groups in the microgravity, space physics, earth science, solar system exploration, flight systems, astronomy and astrophysics, and life sciences disciplines. Although these groups could influence future NASA missions, as well as guide the management and archiving of data collected by past missions, their activities have been largely focused on programmatic, rather than data management, issues.

OSSA is planning to expand the role of outside scientists in the management and archiving of space science data. An OSSA official told us the office has two data management working groups—one ongoing and one planned. The Astrophysics Data System working group operates under the aegis of the Astrophysics division's Science Operations Branch. A second group, the Space Science Data Systems Steering Committee, has been established by the Space Physics division. According to the ISSPP task force, both divisions have gotten user involvement. An NSSDC official also told us that the Life Science discipline has put a group of scientists together, in a committee, to review future data management issues. In addition, the NSSDC is hosting a microgravity data management and archiving workshop.

Mission-Level Teams Making Critical Data Management Decisions Seldom Include Scientists

Project and mission-level teams make detailed data management and archiving decisions. However, scientists, including potential users of data who were not affiliated with a specific mission, seldom participated in mission-level data management and archival decisions. NSSDC guidelines for developing project data management plans stress the importance of establishing mission-level data management advisory committees to guide the development of mission data management and archival plans. Their role is to determine which data should be archived, what ancillary information should be stored with the data, and when and where the archiving should be done. The guidelines recommend that the committee include, if possible, potential investigators--outside scientists—not associated with the mission.

JPL officials who manage the Mars Observer, Galileo, and Magellan missions told us that they were not aware of any NASA guidelines requiring them to seek input from outside scientists. However, they noted that each project published data-related information and seeks input in other forms. Examples they cited included the distribution of project newsletters and consultations with the NASA-funded Planetary Science Data Steering Group. They believed these activities ensured that the interests of the science community were adequately represented.

Scientists Believe Their Participation in a Key Data Management Area Is Ineffective

Despite NASA's efforts to foster scientists' participation in various aspects of space science exploration and research, scientists have expressed concern about their lack of involvement in planning, developing, and operating mission data management systems. This concern is not new. In 1982, CODMAC noted there was commonly a lack of scientific involvement in data-system planning during the early mission planning and system development phase.[2] The committee recommended that NASA involve scientists in all mission phases, noting this involvement should include an oversight of scientific data management activities carried out through a peer review process.

Returning to this problem in 1988, CODMAC reported[3] that NASA emphasized the collection of space science data while paying less attention to its handling, management, and dissemination. The report argued that scientists must help plan data collection activities to ensure high scientific return from the data. The committee recommended that future missions allow scientists to participate more actively in the data management process.

[2] Data Management and Computation, Volume 1: Issues and Recommendations, Committee on Data Management and Computation, Space Science Board, Assembly of Mathematical and Physical Sciences, National Research Council, National Academy Press, Washington, D.C., 1982, p. 2.

[3] Selected Issues in Space Science Data Management and Computation, Committee on Data Management and Computation, Space Science Board, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, National Academy Press, Washington, D.C., 1988, p. 6.

In December 1989, 7 years after CODMAC's report, NASA's ISSPP repeated the earlier concerns. Its report[4] noted that the number one concern (and frequent complaint) of scientists was the lack of adequate arrangements for user involvement in the planning, design, building, operation, and evaluation of experiment control and information handling systems. Scientists were tired of information systems that did not work well, promises that were never kept, and studies with no follow-through. Underscoring the need for user input on both the advisory and working levels, the report recommended that NASA reverse the recent trend under which the role of university scientists in system planning and development was shrinking in favor of NASA engineers and investigators.

[4] Information Systems Scenarios for Space Science and Applications, Information Systems Strategic Planning Project, Operations and Information Systems, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, December 1989, p. 5.

Conclusions and Recommendations

During the last three decades NASA has achieved spectacular success in many aspects of space exploration and has provided scientists with data that have greatly expanded our understanding of the universe, the solar system, and Earth. Through hundreds of missions it has collected massive volumes of data and expects the annual volume to increase five thousandfold by the late 1990s. NASA's data archives, however, are incomplete for many important missions and contain no data for others. For example, 23 of 37 important scientific missions had archived less than 60 percent of the required data, and 18 of the 263 missions launched between 1958 to 1987 sent no data to NSSDC.

NASA officials attributed the archival shortfalls to several factors, including a lack of (1) formal agreements between NASA and the principal investigators as to what data to archive, and (2) requirements to archive data from such sources and disciplines as bioscience, microgravity, aircraft, balloon, sounding rocket missions, and NASA instruments flown on foreign spacecraft or the Shuttle. Considering the onslaught of data expected by the late 1990s, now is a good time to determine if missing archival data from these missions are worth pursuing. If so, NASA should take aggressive steps to obtain outstanding archival data from past missions.

Although many data have been collected over the past 30 years, NASA is not archiving all potentially valuable data. NASA's 1978 data management policy was written when NASA believed that only analyzed data should be saved because scientists may not understand original data. However, analyzed data have often been irreversibly changed or transformed through calibration and processing, or were reduced in volume by sampling. Many space scientists and NASA advisory groups now believe NASA should permanently archive selected original data as a first priority. Although scientists recognize that such a changed policy may require the storage of data in a more voluminous state, they think future scientists must be able to access the original, unmodified data for further research and analysis. NASA agrees that its policy needs more flexibility and plans to revise it during 1990.

NASA's archives are incomplete because it failed for 10 years to enforce its own policy requiring missions to prepare PDMPs, which address essential aspects of mission data management and archiving. With 1 exception, none of NASA's 25 space science missions launched between May

1978 and October 1985[1] prepared them. Because these missions have not formally described or identified data that should be archived or marked for destruction, NSSDC has been hard-pressed to ensure the proper archiving of data from some missions. Recognizing the importance of the plans, NASA now appears headed in the right direction—five of the eight missions launched from February 1988 to July 1990 have submitted the required plans. However, NASA must remain vigilant to ensure that every mission prepares a PDMP well before launch.

NASA must also establish better management controls to ensure that original data are not destroyed until archival data have been provided to the archival facility. Although policy permits original data to be destroyed after analyzed data are archived, it does not require that project offices attest to their creation. We found that NASA had routinely released thousands of tapes—many containing original data—without guaranteeing that analyzed data had been archived. A NARA official echoed our concerns, stating that unless NASA implemented safeguards to protect original data from premature disposal, potentially valuable data may be destroyed.

NASA's extensive network of committees, advisory panels, and working groups provides the basic framework within which scientists can participate in the planning, development, and operation of mission data systems. Groups such as (1) SSAAC and its discipline-oriented subcommittees, (2) the management operations working groups, and (3) mission-level data management and science teams could offer substantial advice and guidance to NASA in all areas of mission planning, development, and operations, if specifically tasked to do so. However, early efforts by several of these groups have apparently focused on budget and programmatic problems, with less attention to data management issues. In addition, groups of scientists have persistently complained about their lack of involvement in the development and operation of mission data management systems. This was cited as a continuing problem by CODMAC in 1982 and 1988, and again by NASA's own ISSPP task force in 1989.

NASA could increase the involvement of scientists in data management and archiving activities by requiring, rather than encouraging, projects to enlist outside scientists as members of the mission-level data management advisory committees. These teams make important decisions on

[1]This covers the time period between the date the PDMP requirement went into effect and the last mission launched prior to the Challenger accident.

which data should be archived, what additional information should be stored with the data to make it more usable, and when and where the archiving should be done.

Recommendations

We recommend that the Administrator:

- require NSSDC to identify and, if warranted and cost effective, obtain all outstanding archival data from past missions not yet delivered to its archives;
- revise data management policy to (1) recognize the need to archive selected original data of potential long-term scientific value, and (2) specify archiving requirements for data produced by life science, microgravity, aircraft, balloon, and sounding rocket missions, and data from NASA instruments flown on Shuttle missions and foreign spacecraft;
- ensure that all missions develop and submit approved PDMPS;
- establish and enforce an internal controls system to ensure that original data are not destroyed until NSSDC has received all appropriate archival data; and
- determine what additional actions could be taken to (1) involve scientists more in the development and operation of mission data management systems, and (2) more strongly encourage missions to include participation of outside scientists on mission-level data management committees.

Agency Comments

In commenting on a draft of this report, NASA said that it presents a useful assessment of some key issues in science data management. Further, NASA noted that it shares many of the concerns we identified, and said it has programs underway or plans to address them. NASA's comments and our evaluation are included in appendix IX.

Objectives, Scope, and Methodology

On November 9, 1988, the House Committee on Science, Space, and Technology asked us to report on several aspects of NASA's management and archiving of space science data. Our first report on this subject was issued on March 2, 1990.[1] Our current objectives were to determine (1) whether NASA is archiving its most valuable data, and (2) the extent to which a mechanism exists for obtaining input from the scientific community on what types of space science data should be archived.

To meet these objectives, we:

- reviewed NASA's policies and guidelines governing the management, archiving, and destruction of space science data;
- reviewed reports and documents related to the management of space science data, including reports prepared by NASA and various scientific groups and committees;
- interviewed NASA and JPL officials responsible for the overall management of NASA's space science data;
- interviewed NSSDC representatives and analyzed NSSDC's archival data holdings;
- interviewed NARA officials responsible for overseeing NASA's record management activities; and
- interviewed JPL project managers and staff responsible for the design, development, and operations of the Galileo mission to Jupiter, Magellan mission to Venus, and the Mars Observer mission.

Our audit work was performed in accordance with generally accepted government auditing standards, between December 1989 and May 1990. We obtained written comments on a draft of this report from NASA officials and have incorporated these comments where appropriate.

[1] Space Operations: NASA Is Not Properly Safeguarding Valuable Data From Past Missions (GAO/IMTEC-90-1, Mar. 2, 1990).

Scientists' Involvement

Principal Investigators

Virtually all of NASA's past missions and some future missions used or will use the principal investigator model. Under this approach or model, the principal investigators, frequently working with co-investigators, are responsible for the planning, development, and integration of experiments and instruments, data analysis, and the selection and preparation of the analyzed data for archiving.

Guest Investigators

Although guest investigators seldom participate in the initial mission planning or instrument design, they have access to space science data to conduct independent investigations. This approach was used in several missions, and NASA plans to use this approach in future missions, most notably the Hubble Space Telescope, which will have a major guest investigator component.

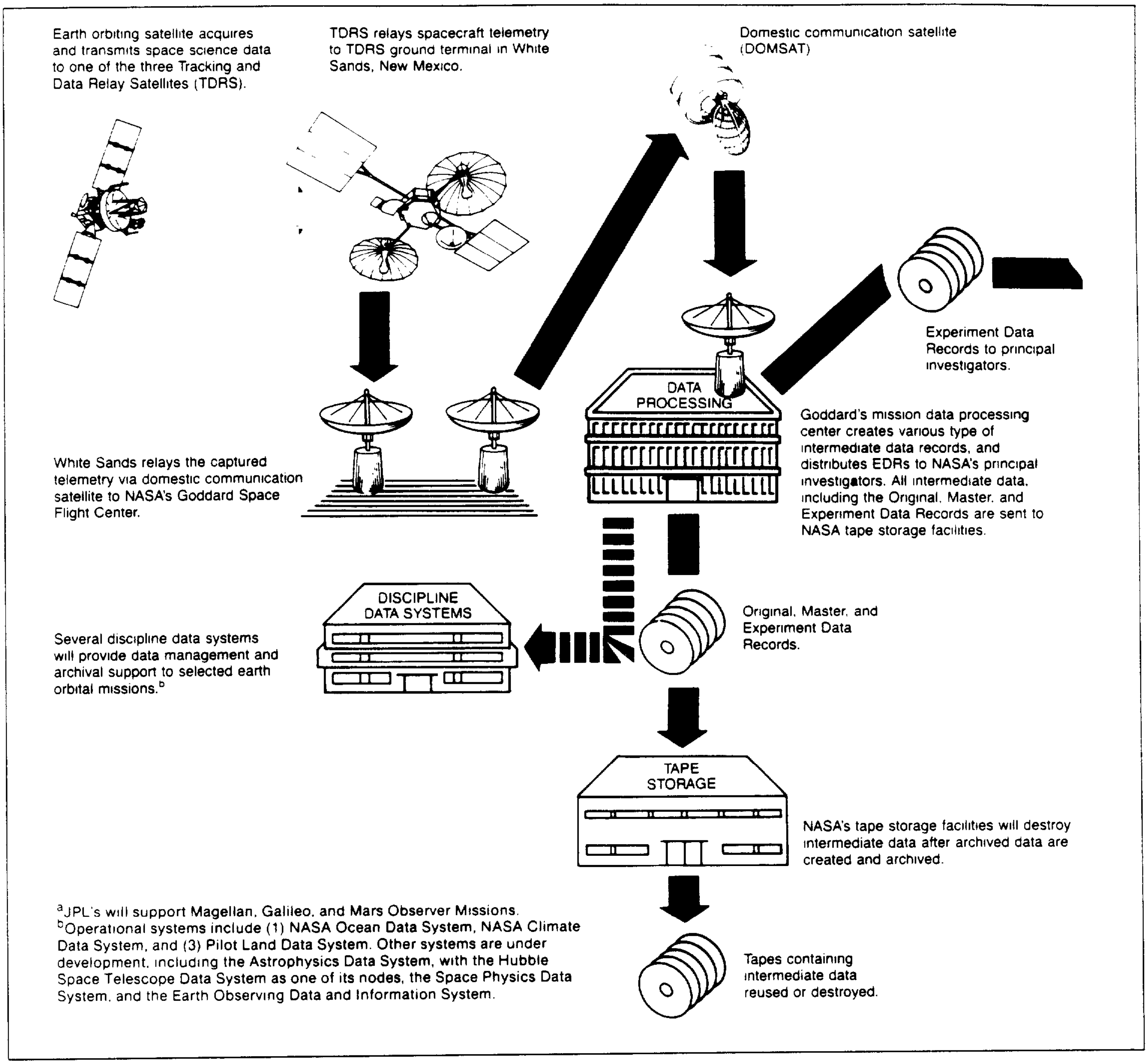
Investigator Team Member

The members of an investigator team usually share data acquired by their instruments. This approach helps collaborative research and allows them to share intermediate results and data processing techniques. For example, this approach worked in the Atmospheric Explorer program, where a common mission data base was accessible to all investigators.

Retrospective Investigator

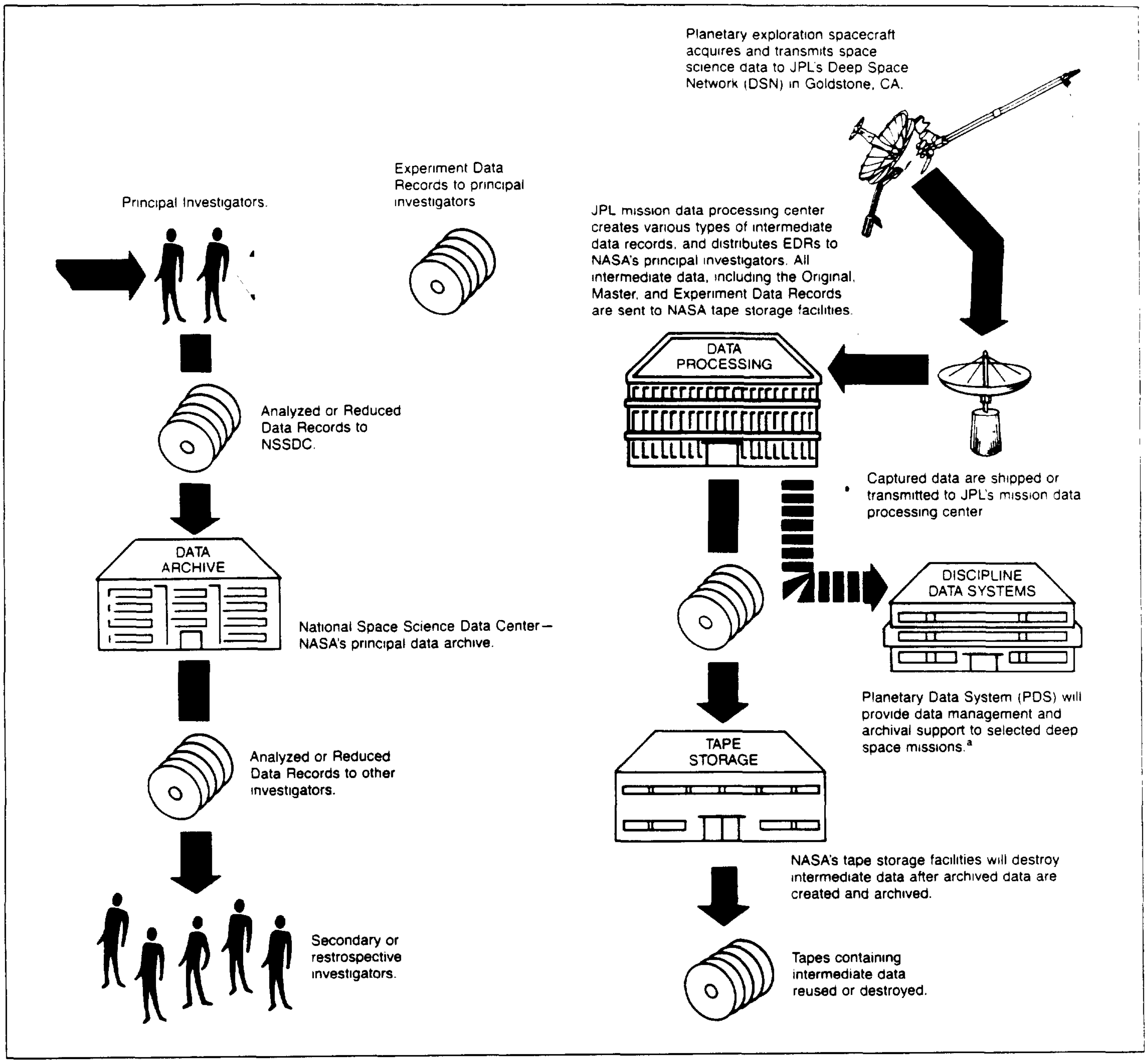
To a great extent, retrospective investigators represent the scientific community. They are usually not associated with NASA missions and play no part in the instrument development, the initial data analysis, or in archiving analyzed or reduced data. By and large, they conduct research using data archived by the NSSDC or by other NASA data storage facilities and projects, as well as data provided informally by the principal investigators.

Typical Data Flow From Past Earth-Orbiting or Deep Space Missions



[a]JPL's will support Magellan, Galileo, and Mars Observer Missions.

[b]Operational systems include (1) NASA Ocean Data System, NASA Climate Data System, and (3) Pilot Land Data System. Other systems are under development, including the Astrophysics Data System, with the Hubble Space Telescope Data System as one of its nodes, the Space Physics Data System, and the Earth Observing Data and Information System.


Planetary exploration spacecraft acquires and transmits space science data to JPL's Deep Space Network (DSN) in Goldstone, CA.
Principal Investigators.
Experiment Data Records to principal investigators
JPL mission data processing center creates various types of intermediate data records, and distributes EDRs to NASA's principal investigators. All intermediate data, including the Original, Master, and Experiment Data Records are sent to NASA tape storage facilities.
DATA PROCESSING
Analyzed or Reduced Data Records to NSSDC.
Captured data are shipped or transmitted to JPL's mission data processing center
DATA ARCHIVE
DISCIPLINE DATA SYSTEMS
National Space Science Data Center—NASA's principal data archive.
Planetary Data System (PDS) will provide data management and archival support to selected deep space missions.[a]
TAPE STORAGE
Analyzed or Reduced Data Records to other investigators.
NASA's tape storage facilities will destroy intermediate data after archived data are created and archived.
Secondary or restrospective investigators.
Tapes containing intermediate data reused or destroyed.

Holdings From Major Missions Archived by the NSSDC

Mission name	Alternate name(s)	Launch date	Quantity of holdings by storage medium[a]		
			Tapes	Paper	Film
Pioneer 1	Able 1	10/11/58	0	4	6
Pioneer 3	1958 THETA 1	12/6/58	0	0	0
Vanguard 2	Vanguard SLV 4	2/17/59	0	0	13
Pioneer 4	1959 NU 1	3/3/59	0	0	0
Explorer 6	Able 6	8/7/59	3	14	109
Vanguard 3	Vanguard TV4 Backup	9/18/59	1	0	11
Explorer 7	1959 Iota 1	10/13/59	18	0	10
Pioneer 5	1960 ALPHA 1	3/11/60	0	2,000	39
TIROS 1	Television Infrared Observation Satellite 1 (TIROS A)	4/1/60	0	0	4
ECHO 1	1960 IOTA 1	8/12/60	1	0	38
Explorer 8	1960 XI 1	11/3/60	0	0	6
TIROS 2	Television Infrared Observation Satellite 2 (TIROS B)	11/23/60	126	0	14
Explorer 9	1960 DELTA 1	2/16/61	0	0	4
P 14	1960 KAPPA 1, Explorer 10	3/25/61	0	0	3
S 15	1960 NU 1, Explorer 11	4/27/61	3	0	7
TIROS 3	Television Infrared Observation Satellite 3 (TIROS C)	7/12/61	79	0	17
EPE-A	1961 UPSILON 1, Explorer 12	8/16/61	37	0	18
S 55A	1961 CHI 1, Explorer 12 (Meteoroid Satellite)	8/25/61	0	0	4
TIROS 4	Television Infrared Observation Satellite 4 (TIROS D)	2/8/62	144	0	22
OSO 1	Orbiting Solar Observatory 1 (OSO A)	3/7/62	27	0	119
ARIEL 1	1962 OMICRON 1, UK 1	4/26/62	2	0	21
TIROS 5	Television Infrared Observation Satellite 5 (TIROS E)	6/19/62	0	0	17
Mariner 2	1962 ALPHA RHO 1	8/27/62	6	0	11
TIROS 6	Television Infrared Observation Satellite 6 (TIROS F)	9/18/62	0	0	23
Alouette 1	1962 BETA ALPHA 1	9/29/62	108	14	10,872
EPE-B	1962 BETA GAMMA 1, Explorer 14	10/2/62	122	0	43
EPE-C	1962 BETA LAMBDA 1, Explorer 15	10/27/62	26	0	9
Relay 1	1962 BETA UPSILON 1	12/13/62	11	3,000	16
S 55B	1962 BETA CH 1, Explorer 16	12/16/62	0	4	15
AE-A	Atmosphere Explorer A (Explorer 17)	4/3/63	0	0	7
TIROS 7	Television Infrared Observation Satellite 7 (TIROS G)	6/19/63	701	0	52
IMP-A	Interplanetary Monitoring Platform A (IMP 1, Explorer 18)	11/27/63	44	0	20
AD-A	Air Density Explorer A (Explorer 19)	12/19/63	0	0	7
TIROS 8	Television Infrared Observation Satellite 8 (TIROS H)	12/21/63	0	0	29
Relay 2	Relay B	1/21/64	6	0	26
Echo 2	Echo C	1/25/64	1	0	39
Ariel 2	Ariel 2	3/27/64	0	0	14
Ranger 7	RA B	7/28/64	0	0	4,325

(continued)

Mission name	Alternate name(s)	Launch date	Quantity of holdings by storage medium[a] Tapes	Paper	Film
IE-A	Ionosphere Explorer A (Explorer 20)	8/25/64	1	0	1,176
NIMBUS 1	Nimbus A	8/28/64	238	0	195
OGO 1	Orbiting Geophysical Observatory 1 (OGO A)	9/5/64	410	39	146
IMP-B	Interplanetary Monitoring Platform B (IMP 2, Explorer 21)	10/4/64	40	0	11
BE-B	Beacon Explorer B (Explorer 22)	10/10/64	3	27	39
S 55C	Explorer 23	11/6/64	0	1	17
AD-B	Air Density Explorer B (Explorer 24)	11/21/64	0	0	28
Injun 4	Explorer 25	11/21/64	282	0	24
Mariner 4	Mariner 4	11/28/64	12	0	192
San Marco 1	San Marco A	12/15/64	0	0	2
EPE-D	Energetic Particle Explorer D (Explorer 26)	12/21/64	256	0	17
TIROS 9	Television Infrared Observation Satellite 9 (TIROS I)	1/22/65	0	0	18
OSO 2	Orbiting Solar Observatory 2 (OSO B)	2/3/65	0	0	10
Pegasus 1	Pegasus 1	2/16/65	1	0	17
Ranger 8	Ranger 8	2/17/65	0	0	7,142
Ranger 9	Ranger 9	3/21/65	0	0	5,819
BE-C	Beacon Explorer C (Explorer 27)	4/29/65	140	0	55
Pegasus 2	Pegasus 2	5/25/65	1	0	17
IMP-C	Interplanetary Monitoring Platform C (IMP 3, Explorer 28)	5/29/65	118	0	15
Gemini 4	Gemini 4	6/3/65	0	0	0
TIROS 10	Television Infrared Observation Satellite 10	7/2/65	0	0	12
Pegasus 3	Pegasus 3	7/30/65	1	0	16
Gemini 5	Gemini 5	8/21/65	0	0	1
OGO 2	Orbiting Geophysical Observatory 2 (OGO C)	10/14/65	43	227	35
GEOS 1	Geodetic Explorer 1 (GEOS A, Explorer 29)	11/6/65	274	0	7
Pioneer 6	Pioneer A	12/16/65	47	122	39
Solar Explorer	Explorer 30	11/19/65	22	0	13
DME-A	Explorer 31	11/29/65	100	0	2,539
Alouette 2	Alouette B	11/29/65	118	1,626	7,348
Gemini 7	Gemini 7	12/4/65	0	0	1
ESSA 1	OT 3	2/3/66	0	0	10
ESSA 2	OT 2	2/28/66	0	0	22
NIMBUS 2	Nimbus C	5/15/66	1,858	5	3,031
AE-B	Atmosphere Explorer B (Explorer 32)	5/25/66	1	1	9
Surveyor 1	Surveyor 1	5/30/66	0	0	11,540
OGO 3	Orbiting Geophysical Observatory 3 (OGO B)	6/7/66	254	0	782
PAGEOS 1	Pageos A	6/24/66	55	0	24
IMP-D	Interplanetary Monitoring Platform D (AIMP 1)	7/1/66	436	0	60
Gemini 10	Gemini 10	7/18/66	0	0	1

(continued)

Mission name	Alternate name(s)	Launch date	Quantity of holdings by storage medium[a] Tapes	Paper	Film
Lunar Orbiter 1	Lunar Orbiter A	8/10/66	17	0	1,315
Pioneer 7	Pioneer B	8/17/66	28	94	29
Gemini 11	Gemini 11	9/12/66	0	0	0
Lunar Orbiter 2	Lunar Orbiter B	11/6/66	22	0	35,011
Gemini 12	Gemini 12	11/11/66	0	0	0
ATS 1	Application Technology Satellite 1 (ATS B)	12/7/66	142	36	99
Biosatellite 1	Biosatellite 1	12/14/66	0	0	0
ESSA 4	TOS B	1/26/67	0	1	6
Lunar Orbiter 3	Lunar Orbiter C	2/5/67	22	0	20,960
OSO 3	Orbiting Solar Observatory 3 (OSO E)	3/8/67	293	0	24
ATS 2	Application Technology Satellite 2 (ATS A)	4/6/67	65	0	15
Surveyor 3	Surveyor 3	4/17/67	1	0	12,997
ESSA 5	TOS C	4/20/67	0	0	13
San Marco 2	San Marco B	4/26/67	0	0	3
Lunar Orbiter 4	Lunar Orbiter D	5/4/67	18	0	19,281
Ariel 3	UK 3	5/5/67	138	0	70
IMP-F	Interplanetary Monitoring Platform F (IMP 4, Expl. 34)	5/24/67	388	17	521
Mariner 5	Mariner Venus 67	6/14/67	10	0	4
IMP-E	Interplanetary Monitoring Platform E (AIMP 2, Expl. 35)	7/19/67	402	0	170
OGO 4	Orbiting Geophysical Observatory 4 (OGO D)	7/28/67	580	0	219
Lunar Orbiter 5	Lunar Orbiter E	8/1/67	21	0	35,045
Biosatellite 2	Biosatellite 2	9/7/67	0	0	12
Surveyor 5	Surveyor E	9/8/67	4	0	36,487
OSO 4	Orbiting Solar Observatory 4 (OSO D)	10/18/67	29	0	26
ATS 3	Application Technology Satellite 3 (ATS C)	11/5/67	0	5	86
Surveyor 6	Surveyor F	11/7/67	2	0	60,512
ESSA 6	TOS D	11/10/67	0	5	11
Pioneer 8	Pioneer C	12/13/67	19	52	65
TETR 1	Test and Training Satellite 1 (TETR A)	12/13/67	0	0	2
Surveyor 7	Surveyor G	1/7/68	3	0	42,241
GEOS 2	Geodetic Explorer 2 (GEOS B, Explorer 36)	1/11/68	81	0	31
OGO 5	Orbiting Geophysical Observatory 5 (OGO E)	3/4/68	918	0	599
SOLRAD 9	Explorer 37	3/5/68	0	0	0
ESRO 2	International Radiation Satellite 1 (ESRO 2B, IRIS)	5/17/68	0	0	2
RAE-A	Radio Astronomy Explorer A (RAE 1, Explorer 38)	7/4/68	0	0	2,499
AD-C	Air Density Explorer C (Explorer 39)	8/8/68	0	0	18
Injun 5	Injun C (Explorer 40)	8/8/68	11,829	0	21,829
ATS 4	Application Technology Satellite 4 (ATS D)	8/10/68	0	0	2
ESSA 7	TOS E	8/16/68	0	0	7

(continued)

Mission name	Alternate name(s)	Launch date	Quantity of holdings by storage medium[a] Tapes	Paper	Film
Aurora	ESRO 1A	10/3/68	0	0	1
TETR 2	Test and Training Satellite 2 (TETR B)	11/8/68	0	0	14
Pioneer 9	Pioneer D	11/8/68	14	53	37
HEOS 1	HEOS A	12/5/68	12	3	6
OAO 2	Orbiting Astronomical Observatory 2 (OAO A2)	12/7/68	427	0	125
ESSA 8	TOS F	12/15/68	0	0	22
OSO 5	Orbiting Solar Observatory 5 (OSO F)	1/22/69	499	0	731
ISIS 1	ISIS A	1/30/69	150	14	6,274
Mariner 6	Mariner 6	2/25/69	16	0	572
ESSA 9	TOS G	2/26/69	0	0	14
Apollo 9	Apollo 9	3/3/69	0	0	0
Mariner 7	Mariner Mars 69B	3/27/69	21	0	894
NIMBUS 3	Nimbus B2	4/14/69	1,545	12	10,413
OGO 6	Orbiting Geophysical Observatory 6 (OGO F)	6/5/69	516	0	186
IMP-G	Interplanetary Monitoring Platform G (IMP 5, Explorer 41)	6/21/69	648	28	30
Biosatellite 3	Biosatellite D	6/29/69	0	0	2
Apollo 11	Apollo 11	7/16/69	25	1	6,515
PAC-A	Package Attitude Control	8/9/69	0	0	9
OSO 6	Orbiting Solar Observatory 6	8/9/69	84	0	28
ATS 5	Application Technology Satellite 5	8/12/69	320	0	55
Boreas	ESRO 1B	10/1/69	0	0	1
GRS-A	German Research Satellite A (AZUR)	11/8/69	60	0	5
Apollo 12	Apollo 12	11/14/69	1,970	1	21,671
ITOS 1	TIROS M	1/23/70	0	0	4
SERT 2	Space Electric Rocket Test 2	2/4/70	0	0	12
TOPO 1	TOPO 1	4/8/70	0	0	1
NIMBUS 4	Nimbus 4	4/8/70	3,278	0	12,667
Apollo 13	Apollo 13	4/11/70	2	1	2,241
OFO 1	Orbiting Frog Otolith	11/9/70	0	0	0
RMS	Radiation Meteoroid Satellite	11/9/70	0	0	1
NOAA 1	ITOS A	12/11/70	0	0	2
SAS-A	Small Astronomy Satellite A	12/12/70	352	0	15
Apollo 14	Apollo 14	1/31/71	6	1	28,285
IMP-I	Interplanetary Monitoring Platform I (Explorer 43)	3/13/71	286	11	1,881
San Marco 3	San Marco 3	4/24/71	0	0	7
ISIS 2	ISIS 2	4/31/71	273	54	6,028
Mariner 9	Mariner 9	5/30/71	50	85	44,531
SOLRAD 10	Explorer 44	7/8/71	0	0	21
Apollo 15	Apollo 15	7/26/71	2,072	4	80,436

(continued)

			Quantity of holdings by storage medium[a]		
Mission name	**Alternate name(s)**	**Launch date**	**Tapes**	**Paper**	**Film**
Apollo 15 SUBST	Apollo 15 Subsatellite	8/4/71	737	0	74
EOLE 1	CAS A	8/16/71	1	0	4
TETR 4	Test and Training Satellite 4	9/29/71	0	0	2
OSO 7	Orbiting Solar Observatory 7	9/29/71	134	1	193
S-Cubed A	Small Scientific Satellite A (Explorer 45)	11/15/71	25,072	0	1,391
Ariel 4	Ariel 4	12/11/71	1,904	0	6
HEOS 2	HEOS 2	1/31/72	15	0	3
Pioneer 10	Pioneer F	3/3/72	317	5	517
TD 1A	TD 1	3/12/72	3	0	7
Apollo 16	Apollo 16	4/16/72	2,110	1	90,121
Apollo 16 SUBST	Apollo 16 Subsatellite	4/24/72	95	0	8
LANDSAT 1	Earth Resources Technology Satellite A	7/23/72	0	0	20
Explorer 46	Meteoroid Technology Satellite	8/13/72	0	0	6
OAO 3	Orbiting Astronomical Observatory 3 (Copernicus)	8/21/72	50	145	198
IMP-H	Interplanetary Monitoring Platform H (Explorer 47)	9/22/72	886	26	1,559
NOAA 2	ITOS D	10/15/72	0	0	7
SAS-B	Small Astronomy Satellite B (Explorer 48)	11/16/72	1	1	1,743
ESRO 4	ESRO 4	11/21/72	3	0	4
Apollo 17	Apollo 17	12/7/72	8	0	86,242
NIMBUS 5	Nimbus E	12/11/72	3,151	0	47,279
Aeros	Aeros	12/16/72	2	0	18
Pioneer 11	Pioneer G	4/6/73	333	8	791
Skylab	Skylab	5/14/73	1,197	48	41,085
Skylab CSM 1	Skylab Command and Service Module 1	5/25/73	0	0	0
RAE-B	Radio Astronomy Explorer B (Explorer 49)	6/10/73	13	0	82
Skylab CSM 2	Skylab Command and Service Module 2	7/28/73	0	0	1,600
IMP-J	Interplanetary Monitoring Platform J (Explorer 50)	10/25/73	1,677	90	5,556
Mariner 10	Mariner 73	11/3/73	590	1	15,186
NOAA 3	ITOS F	11/6/73	0	0	8
Skylab CSM 3	Skylab Command and Service Module 3	11/16/73	0	0	4,800
AE-C	Atmosphere Explorer C (Explorer 51)	12/16/73	869	0	127
San Marco 4	San Marco C2	2/18/74	0	0	14
SMS 1	Synchronous Meteorological Satellite 1	5/17/74	6,561	0	4,343
ATS 6	Application Technology Satellite 6	5/30/74	1,186	1	1,693
Hawkeye	Injun F (Explorer 52)	6/3/74	0	0	14
Aeros 2	Aeros B	7/16/74	8	0	7
ANS	Astronomical Netherlands Satellite	8/30/74	2	0	8
UK 5	United Kingdom 5	10/15/74	2	0	18

(continued)

Mission name	Alternate name(s)	Launch date	Quantity of holdings by storage medium[a] Tapes	Paper	Film
NOAA 4	ITOS G	11/15/74	0	0	14
Helios-A	Helios 1	12/10/74	177	1	85
LANDSAT 2	Earth Resources Technology Satellite B	1/22/75	0	0	15
SMS 2	Synchronous Meteorological Satellite 2	2/6/75	6,392	0	3,823
GEOS 3	Geodetic Explorer 3	4/9/75	160	0	15
SAS-C	Small Astronomy Satellite C (Explorer 53)	5/7/75	0	24	3,019
NIMBUS 6	Nimbus F	6/12/75	1,058	0	48,538
OSO 8	Orbiting Solar Observatory 8	6/21/75	660	1	213
ASTP-Apollo	Apollo Soyuz Test Project	7/15/75	4	0	3,633
COS-B	Cosmic Ray Satellite B	8/9/75	0	0	0
Viking 1	Viking B	8/20/75	668	7	56,785
Viking 2	Viking A	9/9/75	520	1	37,486
AE-D	Atmosphere Explorer D (Explorer 54)	10/6/75	44	0	3
GOES 1	Geostationary Environmental Satellite A	10/16/75	5,289	0	2,934
AE-E	Atmosphere Explorer E (Explorer 55)	11/20/75	886	0	29
Helios-B	Helios 2	1/15/76	98	1	65
LAGEOS	Laser Geodetic Satellite	5/4/76	115	0	0
NOAA 5	ITOS H	7/29/76	0	0	12
GEOS/ESA	GEOS 1	4/20/77	22	0	14
GOES 2	Geostationary Environmental Satellite B	6/16/77	2,957	0	103
GMS	Geostationary Meteorological Satellite	7/14/77	0	0	1
HEAO 1	High Energy Astronomy Observatory 1 (HEAO A)	8/12/77	186	0	113
Voyager 2	Mariner Jupiter/Saturn B	8/20/77	385	1	68,466
Voyager 1	Mariner Jupiter/Saturn A	9/5/77	409	1	83,660
ISEE 1	International Sun Earth Explorer 1 (ISEE A)	10/22/77	629	2	9,435
ISEE 2	International Sun Earth Explorer 2 (ISEE B)	10/22/77	267	0	2,120
METEOSAT 1	Meteorological Satellite A	11/23/77	0	0	0
IUE	International Ultraviolet Explorer	1/26/78	1,460	0	55,501
LANDSAT 3	Earth Resources Technology Satellite C	3/5/78	0	0	6
HCMM	Heat Capacity Mapping Mission	4/26/78	2,678	0	158,830
Pioneer Venus 1	Pioneer Venus Orbiter	5/20/78	411	4	5,580
GOES 3	Geostationary Environmental Satellite C	6/16/78	619	0	841
SEASAT 1	Ocean Dynamics Satellite A (SEASAT A)	6/26/78	19	0	3
GEOS-B/ESA	GEOS 2	7/14/78	15	0	28
Pioneer Venus 2	Pioneer Venus 78	8/8/78	31	2	8
ISEE 3	International Sun Earth Explorer 3 (ISEE C)	8/12/78	181	0	6,685
CAMEO	Chemically Active Materials Ejected in Orbit	10/24/78	0	0	0
TIROS-N	Television Infrared Observation Satellite N	10/13/78	1	0	3
NIMBUS 7	Nimbus G	10/24/78	13,595	0	88,796

(continued)

Mission name	Alternate name(s)	Launch date	Quantity of holdings by storage medium[a] Tapes	Paper	Film
HEAO 2	High Energy Astronomy Observatory 2 (HEAO B, Einstein)	11/13/78	23	0	22
SAGE	Stratospheric Aerosol and Gas Experiment (AEM B)	2/18/79	235	0	2
UK 6	Ariel 6	6/2/79	0	1	3
NOAA 6	NOAA A	6/27/79	0	0	0
HEAO 3	High Energy Astronomy Observatory 3 (HEAO C)	9/20/79	33	0	1
MAGSAT	Global Magnetic Survey Mission (AEM C)	10/30/79	228	0	65
SMM	Solar Maximum Mission	2/14/80	7	0	232
GOES 4	Geostationary Environmental Satellite D	9/9/80	0	0	0
GOES 5	Geostationary Environmental Satellite E	5/22/81	17	0	0
DE 2	Dynamics Explorer 2 (DE B)	8/3/81	4	0	41
DE 1	Dynamics Explorer 1 (DE A)	8/3/81	8	0	50
SME	Solar Mesosphere Explorer	10/6/81	131	0	0
STS 2/OSTA-1	Office of Space and Terrestrial Application 1	11/12/81	11	0	2,200
STS 3/OSS-1	Shuttle OFT 3	3/22/82	0	0	2,582
IRAS	Infrared Astronomical Satellite	1/25/83	165	0	1,178
NOAA 8	NOAA E	3/28/83	0	0	0
GOES 6	Geostationary Environmental Satellite F	4/28/83	81	0	0
EXOSAT	European X-Ray Observatory Satellite	5/26/83	1	0	0
Spacelab 1	Spacelab 1 (STS-9)	11/28/83	0	0	0
AMPTE/CCE[b]	Active Magnetospheric Particle Tracer Explorer	8/16/84	78	0	63,597
AMPTE/IRM	AMPTE/Ion Release Module	8/16/84	194	0	4
AMPTE/UKS	AMPTE/United Kingdom Subsatellite	8/16/84	0	0	1
ERBS	Earth Radiation Budget Satellite	10/5/84	277	5	0
STS-41G	Shuttle Imaging Radar B (SIR B)	10/5/84	173	0	36,298
NOAA 9	NOAA F	12/12/84	120	2	0
Spacelab 3	STS-51B	4/29/85	23	0	0
PDP	Plasma Diagnostic Package	7/29/85	0	0	0
Spacelab 2	STS-51F	7/29/85	13	50	2,924
Spacelab D-1	STS-61A	10/30/85	0	0	0
NOAA 10	NOAA G	9/17/86	0	0	0
GOES 7	Geostationary Environmental Satellite H	2/26/87	0	0	0

[a]The numbers in these columns represent identifiable record holdings on three storage media—tape, paper, and film. Units for tape and paper usually represent individual magnetic tapes or paper documents. Film units may be different, depending on the type of film used. For example, missions using 100-ft reels of microfilm are measured in number of reels. Those using other types of strip film, of various widths, are measured in linear feet of film. Slides or other individually held film frames, are measured in number of slides or frames. Microfiche are measured in number of microfiche cards. The holdings shown do not include ERBS and NOAA 9 data stored on 19 optical disks.

[b]Charge Composition Explorer.

NASA Missions With No Data Archived by the NSSDC

Table V.1: Missions Without Any Data

Mission	Launch date	Possible location of any data[a]
Apollo 9	3/3/69	Unknown
Application Technology Satellite 4 (ATS 4)	8/10/68	Unknown
Biosatellite 1	12/14/66	University of New Mexico
Biosatellite 2	9/7/67	Unknown
Biosatellite 3	6/29/69	Unknown
Gemini 4	6/3/65	EROS Data Center
Gemini 11	9/12/66	EROS Data Center
Gemini 12	11/11/66	EROS Data Center
Hawkeye	6/3/74	University of Iowa
Orbiting Frog Otolith 1 (OFO 1)	11/9/70	Unknown
Plasma Diagnostic Package (PDP)	7/29/85	University of Iowa
Pioneer 4	3/3/59	Unknown
Pioneer 3	12/6/58	Unknown
Skylab Command and Service Module 1 (CSM 1)	5/25/73	Unknown
Skylab Command and Service Module 2 (CSM 2)	7/28/73	Unknown
Skylab Command and Service Module 3 (CSM 3)	11/16/73	Unknown
Space Transportation Systems 9/Spacelab 1	11/28/83	Unknown
Space Transportation System 61A/Spacelab D-1	10/30/85	Unknown

[a]According to an NSSDC official, for locations showing "unknown", it is likely that these data are being held by the principal investigator or co-investigator. However, NSSDC is unaware of the exact location of these data.

Table V.2: Missions Without Digital Data

Mission	Launch date	Storage media: Paper	Storage media: Film	Possible location of digital data
Air Density Explorer A (AD-A)	12/19/63	0	7	Unknown
Air Density Explorer B (AD-B)	11/21/64	0	28	Unknown
Air Density Explorer C (AD-C)	8/8/68	0	18	Unknown
Atmosphere Explorer A (AE-A)	4/3/63	0	7	Unknown
Application Technology Satellite 3 (ATS 3)	11/5/67	5	86	Unknown
Explorer 9	2/16/61	0	4	Unknown
Explorer 8	11/3/60	0	6	Unknown
Gemini 10	7/18/66	0	1	EROS Data Center
Gemini 7	12/4/65	0	1	EROS Data Center
Gemini 5	8/21/65	0	1	EROS Data Center
ITOS 1	1/23/70	0	4	NOAA
Orbiting Solar Observatory 2 (OSO 2)	2/3/65	0	10	Unknown
Explorer 10	3/25/61	0	3	Unknown
Pioneer 1	10/11/58	0	6	Unknown
Pioneer 5	3/11/60	2,000	39	Unknown
Radio Astronomy Explorer A (RAE-A)	7/4/68	0	2,499	Unknown
Small Astronomy Satellite C (SAS-C)	5/7/75	24	3,019	Unknown
Space Transportation System 3/Office of Space Science 1 (STS-3/OSS-1)	3/22/82	0	2,582	Unknown
Surveyor 1	5/30/66	0	11,540	Unknown

Location and Status of Data for Currently Important Missions

Atmospheric Explorers (AE)—higher resolution data held by principal investigators.

Active Magnetospheric Particle Tracer Explorers (AMPTE)—some AMPTE/Charge Composition Explorer (CCE) higher resolution data held by AMPTE Science Data Center at John Hopkins University. OSSA and NSSDC officials told us that although CODMAC has identified AMPTE/Ion Release Module (IRM) and AMPTE United Kingdom Subsatellite (UKS) as "currently important scientific missions," NASA and NSSDC are not responsible for archiving data from these missions. However, NSSDC is archiving many AMPTE/IRM data.

Dynamic Explorers (DE)—most data held by principal investigators, being processed before submission to NSSDC.

Interplanetary Monitoring Platform (IMP)—limited unique IMP data held by principal investigators, key data in processing for submission to NSSDC.

International Sun Earth Explorers (ISEE)—most data held by principal investigators, being processed for submission to NSSDC.

Orbiting Solar Observatory (OSO)—all data held by principal investigators.

Solar Maximum Mission (SMM)—most data at Goddard's SMM Data Analysis Center (DAC) for public access; other data readied for submission to DAC; copies of SMM/DAC data will be archived by the NSSDC.

Mariner—data held by principal investigators, some data at JPL.

Pioneer—data held by principal investigators; NASA's Ames Research Center is working with investigators on data archival plans.

Pioneer Venus—data held by principal investigators; NASA's Ames Space Center is working with investigators on data archival plans.

Viking—data held by principal investigators, some data at JPL. Infrared data copied on CD-ROM optical disks (Compact Disk Read Only Memory).

Voyager—data held by principal investigators, JPL's Planetary Data System. Most imaging data on CD-ROMs.

High Energy Astronomy Observatory (HEAO)—most data from HEAO 1 and 3 held by principal investigators. Most data from HEAO B held by the Smithsonian Astronomical Observatory.

Infrared Astronomical Satellite (IRAS)—most data at NSSDC. According to the Infrared Processing and Analysis Center (IPAC) officials, the full set of IRAS data—including original and archival data, is also stored at IPAC at the California Institute of Technology in Pasadena, California, in the Netherlands at University of Groningen and Sterrewach Huygens Laboratorium at the University of Leiden, and in the United Kingdom by the IRAS Post Mission Analysis Facility at Rutherford Appleton Laboratory.

International Ultraviolet Explorer (IUE)—most data at NSSDC.

Earth Radiation Budget Satellite (ERBS)—most data at Langley Research Center; data are routinely submitted to NSSDC archive.

Heat Capacity Mapping Mission (HCMM)—all digitized data at NSSDC. Many raw data still unprocessed.

Nimbus-7—most data at NSSDC, selected data held by Goddard for distribution to investigators in coordination with NSSDC.

Seasat—all data at JPL.

Solar Mesosphere Explorer (SME)—most data at NSSDC, balance held by the University of Colorado.

Shuttle Imaging Radar B (SIR-B)—in compliance with NASA instructions, NSSDC is not distributing SIR-B data to users. In a form letter to scientists requesting SIR-B data, NSSDC notes that in compliance with the congressional decision after a reassessment of the Land Remote Sensing Commercialization Act of 1984, "SIR-B data will be distributed by a private firm yet to be identified."

NASA Missions Without Project Data Management Plans, 1978-85

Mission name	Date of launch
Pioneer Venus Orbiter	5/20/78
Ocean Dynamics Satellite A (SEASAT 1)	6/26/78
Pioneer Venus 78	8/8/78
International Sun Earth Explorer 3 (ISEE 3)	8/12/78
Chemically Active Materials Ejected in Orbit (CAMEO)	10/24/78
Nimbus 7	10/24/78
High Energy Astronomy Observatory (HEAO 2)	11/13/78
Stratospheric Aerosol and Gas Experiment (SAGE)	2/18/79
High Energy Astronomy Observatory (HEAO 3)	9/20/79
Global Magnetic Survey Mission (MAGSAT)	10/30/79
Solar Maximum Mission (SMM)	2/14/80
Dynamics Explorer 1 (DE 1)	8/3/81
Dynamics Explorer 2 (DE 2)	8/3/81
Solar Mesosphere Explorer (SME)	10/6/81
Office of Space and Terrestrial Application (STS 2)	11/12/81
Shuttle OFT 3 (STS3/OSS-1)	3/22/82
Infrared Astronomical Satellite (IRAS)[a]	1/25/83
Spacelab 1	11/28/83
Active Magnetospheric Particle Tracer Explorer (AMPTE/CCE)	8/16/84
Earth Radiation Budget Satellite (ERBS)	10/5/84
Shuttle Imaging Radar B (SIR-B)	10/5/84
Spacelab 3	4/29/85
Plasma Diagnostic Package (PDP)	7/29/85
Spacelab 2	7/29/85
Spacelab D-1	10/30/85

[a]The IRAS mission prepared, in lieu of an PDMP, an agreement for archiving its data at the NSSDC.

Status of Project Data Management Plans for Active and Planned Missions, 1988-91[a]

Missions	Actual Planned Launch	Date PDMP approved
Operational		
San Marco-D	3/1988	2/1988
Magellan	4/1989	5/1989
Galileo	10/1989	3/1990
Shuttle Solar Backscatter Ultraviolet Instrument 1 (SBUV-1)	10/1989	———[c]
Cosmic Background Explorer (COBE)	11/1989	6/1988
Hubble Space Telescope (HST)	4/1990	7/1982
Roentgen Satellite (ROSAT)	6/1990	———[d]
Combined Release and Radiation Effect Satellite (CRRES)	7/1990	———[e]
Planned		
Astronomy Laboratory 1/Broad Band X-Ray Telescope (Astro-1/BBXRT)	1990	2/1990
Space Life Sciences-1 (SLS-1)	1990	———
Ulysses	1990	———
Gamma Ray Observatory (GRO)	1990	———
Shuttle Solar Backscatter Ultraviolet Instrument 2 (SBUV-2)	1990	———
International Microgravity Laboratory 1 (IML-1)	1990	———
Atmospheric Laboratory for Applications and Science 1 (ATLAS-1)	1991	———
Spacelab-J	1991	———
Extreme Ultraviolet Explorer (EUVE)	1991	———
Upper Atmosphere Research satellite (UARS)	1991	———
Laser Geodynamics Satellite II (LAGEOS II)	1991	———

[a] Includes joint missions with foreign governments.

[b] Goddard News, Mixed Fleet Manifest, Vol. 36, No.3, March 1990.

[c] OSSA has no plans to prepare an PDMP for the SSBUV.

[d] ROSAT's PDMP is in the signature cycle. This German mission, with NASA instruments, will not be generating data for NASA until March 1991.

[e] Data from this mission will largely consist of photographs.

Comments From the National Aeronautics and Space Administration

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

NASA

National Aeronautics and Space Administration

Washington, D.C
20546

Office of the Administrator

SEP 17 1990

Mr. Ralph V. Carlone
Assistant Comptroller General
Information Management and
Technology Division
United States General Accounting Office
Washington, DC 20548

Dear Mr. Carlone:

This is the National Aeronautics and Space Administration's (NASA) response to the General Accounting Office (GAO) Draft Report GAO/IMTEC-90-73, entitled "Space Operations: NASA Is Not Archiving All Potentially Valuable Data," dated August 28, 1990.

Overall, the draft report presents a useful assessment of some key issues in science data management. NASA shares many of the concerns identified by GAO, has programs underway to address the majority of them, and plans to address the remainder. GAO acknowledges these plans and recognizes them in the body of the report. NASA finds the recommendations in the report to be reasonable and appropriate.

The enclosure provides more specific comments and suggestions that we believe will strengthen the report and reduce possible misinterpretations. We have also provided additional information and corrections directly to the members of your staff. We appreciate the efforts of your staff to solicit and consider NASA's views through the process of the review.

Sincerely,

John E. O'Brien
Assistant Deputy Administrator

Enclosure

NASA Response To GAO Draft Report

GAO/IMTEC-90-73

I. Executive Summary

NASA agrees in general with the conclusions and recommendations, but does, however, have some concern with respect to the perspective or emphasis that is presented. For instance, the emphasis on having no data archived for 18 of the 263 major science missions launched between 1958-1987 neglects the fact that data is archived for 245 or 93% of the missions.

Another concern is the potentially misleading title chosen to highlight the principal finding concerning scientist involvement in data archiving. "Lack of Scientists' Involvement in a Key Data Management Area" is not a completely accurate assessment. As stated, it is not consistent with the narrative supporting the assertion, nor with the facts and conclusions presented in the body of the report.

Significant parts of the science user community are, in fact, vitally concerned with, and playing key roles in archiving and data management systems. In addition to the investigator working groups that play a key role in flight mission planning, steering groups have been established by the various science discipline offices to oversee and provide advice and guidance in all aspects of data management across the respective discipline programs and projects. Examples include the Planetary Science Data Steering Committee, the Science Operations Working Group for Astrophysics, the Space Physics Data Systems Steering Committee, and the Life Sciences Data Systems Steering Committee. All groups include participants from the outside research community.

While there is no standing committee for Microgravity Science and Applications, a data management workshop involving members of the research community was conducted in July, 1990 and follow-on plans are being developed for an appropriate data management approach.

Furthermore, the Science Advisory Panel for the Earth Observing System Data and Information System (EOSDIS) includes representatives from the broad spectrum of Earth science users; they have been very active in EOSDIS planning to date, and will continue their active role during the course of the program.

NASA recognizes user involvement as a vital element for success; we will continue to build on past experience to strengthen that involvement in all elements of data management. With the context altered above, we certainly agree with the recommendation to continue to do so. We also accept the other recommendations which we consider to be constructive and appropriate.

See comment 1.

II. Chapter 2 "NASA Is Not Preserving All Valuable Space Science Data"

1. In spite of the clarifications provided through footnotes to Table 2.1 on page 18 the table is still potentially misleading. The rightmost column is especially confusing with respect to terminology, perspective, and intended message. For example, Viking, which is presented as having no archival effort, has an active project to restore data under the auspices of the Planetary Data System.

2. The statement on page 22, paragraph 2, "Between 1986 to 1989, Goddard released 532,000 tapes, a large portion of which contained original data", needs to be clarified to avoid misinterpretation. The statement is partially correct, but care should be taken to not surmise that almost half of the 1.2 million data tapes containing all of NASA's science data from 260 missions (described on page 1 of the document) were "released."

In fact, 532,000 tapes were sent to the Information Processing Division's (IPD) Magnetic Tape Certification Facility for degaussing, cleaning, and recertification for reuse. However, these were comprised of a variety of production-oriented tapes, many of which would never be considered for either short-term retention or long-term archiving.

Another 100,000 of these tapes were from missions such as Nimbus-7 and the Dynamics Explorers, which converted their Level 0 (raw) data to optical disks before releasing their data tapes for recertification.

Many of the other tapes released are from various processing steps in the IPD data processing cycle, including data capture tapes, pre-edit tapes, edit tapes, etc., all of which contain raw data. However, the science community associated with these missions received the required Level 0 products (e.g., decommutated data tapes).

The point is that of the 532,000 tapes that were released, only a small portion were for user data tapes and no tape was degaussed without the user's written permission.

See comment 2.

III. Appendix V - "NASA Missions With No Data Archived by the NSSDC"

It is important to note that the University of Iowa is preparing the Master Science files of the entire 4 year HAWKEYE mission to be archived under special arrangements made with the NSSDC. These arrangements were initiated in 1989 with the agreement that the University of Iowa would send the complete data set for archiving all at one time. The NSSDC expects to receive this important data set by the end of this calendar year.

See comment 3.

In addition, Plasma Diagnostic Package (PDP) data is at the University of Iowa and not at an UNKNOWN location as specified in this appendix.

IV. Appendix VII - "NASA Missions Without Project Data Management Plans"

See comment 4.

Although these missions did not have formal PDMPs, there are extensive documented arrangements fon data archiving and data access for many of these missions. For example, DE, IMP, and ISEE do have formal archiving plans and multi-year funding to carry out the completion of the data archiving. The NSSDC has nearly all levels (over 25,000 data tapes and several hundred optical disks) of NIMBUS-7 data. The Smithsonian Astrophysical Observatory is currently creating an extensive library of HEAO data on CD-ROMS.

The following are GAO's comments on the National Aeronautics and Space Administration letter dated September 17, 1990.

GAO Comments

1. "Executive Summary"

NASA agrees in general with the report's conclusions and recommendations, but mentions concern about our emphasis on its having no archival data for 18 of the 263 missions launched between 1958-87, believing it neglects the fact that data for 245, or 93 percent of these missions are archived. We acknowledge that some data are archived for most of NASA's missions and worded the executive summary accordingly. However, we consider the total absence of data for 18 missions as a major loss.

NASA also believes that the title we chose to highlight the scientists' involvement in a key data management area is potentially misleading. We modified the title to more accurately reflect our finding.

2. "NASA Is Not Preserving All Valuable Space Science Data"

NASA comments that table 2.1, which shows the status of archival data for currently important missions, is potentially misleading, and in the case of the Viking mission, inaccurate. The information presented in the far right column (which shows the current level of archival effort) was verified by NSSDC, and we believe it to be accurate. NSSDC has also provided more information clarifying the status of archival activities presented in appendix VI.

NASA says that our statement on the release (destruction or reuse) of 532,000 tape should be clarified to show that these tapes are not included in the 1.2 million data tapes kept in data storage facilities. We have clarified our statement in a footnote explaining that the 532,000 tapes are not part of the 1.2 million tapes in NASA's storage facilities.

According to NASA, (1) only a small portion of the 532,000 tapes released by TSSF contained original space science data, and (2) no tapes were released without the user's written permission. We disagree. Even if we exclude the 100,000 tapes from the Nimbus-7 and the Dynamics Explorer missions and an additional 180,000 tapes containing intermediate data not identified with a specific mission, between 1986-89 Goddard released over 200,000 tapes containing original data.

Further, the TSSF tape inventory data base does not provide enough information on the type of data. Second, there is a discrepancy in Goddard's tape release statistics. According to Goddard's initial estimates, between 1986-89 NASA released over 590,000 tapes. However, in June 1990, in response to our request to identify these tapes by spacecraft and type of data, Goddard's estimate of tapes released during this period was 67,000 less than the initial count. Regardless of the exact number of tapes involved, we believe Goddard released at least 200,000 tapes containing original data, and these tapes were released without ensuring that NSSDC had archived the analyzed data.

NASA states that no tape was released without the user's written permission. While we agree that TSSF obtained the signatures of Goddard officials responsible for these tapes, this does not ensure that these data were analyzed and archived at NSSDC.

3. "NASA Missions With No Data Archived by the NSSDC"

NASA pointed out that the University of Iowa is archiving data from the Hawkeye mission and from the Plasma Diagnostic package instruments. We modified appendix V to reflect these efforts.

4. "NASA Missions Without Project Data Management Plans"

NASA comments that while many pre-1985 missions did not prepare formal PDMPs, several had extensive documented arrangements for data archiving and access. We are aware that each NASA mission prepares voluminous reports and plans for the acquisition, processing, analysis, and distribution of mission data. However, we reaffirm our conviction that the lack of formal PDMPs is one reason why data from many missions were not archived. Without the PDMP, there is no single mission document that outlines plans for data analysis, dissemination, archiving, and the destruction of original data.

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