

Originally Processed With FOIA(s):
2005-0336-F

FOIA Number:
2005-0336-F

FOIA MARKER

**This is not a textual record. This is used as an
administrative marker by the George Bush Presidential
Library Staff.**

Record Group/Collection: George H.W. Bush Presidential Records
Collection/Office of Origin: Science and Technology Policy, Office of (OSTP)
Series: O'Neil, John F., Files
Subseries: Government Organization Files

OA/ID Number: 62098
Folder ID Number: 62098-004

Folder Title:
NASA – Earth Observing System [2 of 3]

Stack:	Row:	Section:	Shelf:	Position:
	0	0	0	0

NASA EOSDIS

NATIONAL RESEARCH COUNCIL

2101 CONSTITUTION AVENUE WASHINGTON, D. C. 20418

OFFICE OF THE CHAIRMAN

April 9, 1992

Mr. Daniel S. Goldin
Administrator
National Aeronautics and
Space Administration
400 Maryland Avenue SW, Room 7137
Washington DC 20546

Dear Administrator Goldin:

Enclosed is an interim report by the National Research Council on NASA's plans for EOSDIS as well as a transmittal letter from the Chair of the Panel that prepared this report. As you know, EOSDIS is a very complex program, and the demands on the Panel that prepared this interim report were extraordinary—in understanding the program, in coping with a demanding schedule, and in reaching judgements. At the same time, my colleagues and I appreciate the importance of EOSDIS. To quote from the attached report: "If EOSDIS fails, so will EOS, and so may the U.S. Global Change Research Program."

It was against such an understanding that the National Research Council accepted this task, believing that we are obliged to assist the government, even when the time is short, the amount of information to be marshalled great, and the imperative to provide judgements urgent.

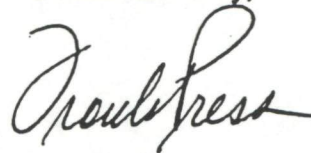
I believe the Panel that prepared this report has done an exceptional job, ably assisted by the people of NASA. At the same time, the judgements as well as the limits of this interim report should be clear. While the Panel supports the *schedule* for procuring a contractor for the EOSDIS Core System, it finds major shortcomings in the actual plans for EOSDIS, and provides substantial recommendations for implementing the program that the Panel believes will help ensure its success. Therefore, this report cannot be construed as an endorsement of NASA's current plans for EOSDIS, but rather a substantial critique of flaws, which, if addressed, will in the Panel's judgement help ensure a strong and responsive program over the long term. The Panel believes that the terms of the contract as stated in the Request for Proposal are sufficiently flexible to accommodate its recommendations.

The limits of the report should also be plain. It is an *interim* report, provided in response to requests from NASA and other interested parties for an early alert as to the

Panel's views of EOSDIS plans. The Panel's final report this August will offer detailed analyses for these interim judgements, and will also respond directly to the specific issues as posed in the Terms of Reference for this task.

I look forward to your comments on this interim report. And the Panel looks forward to a discussion with NASA officials involved in EOSDIS planning on this report and any further issues to be considered in preparing the final report. We are arranging for your colleagues at NASA with responsibility for the EOSDIS Project to be briefed by the Panel next week, and intend to release it publicly on April 17th.

Yours sincerely,



Frank Press
Chairman

cc: L. Fisk, J. Alexander, S. Tilford, D. Butler—NASA
A. Bromley, K. Erb—Office of Science and Technology Policy
J. Hezir, J. Fellows—Office of Management and Budget
S. Harrison—National Space Council
R. Corell—National Science Foundation
Congressman George Brown, R. Byerly, P. Cunniffe—House of Representatives
Committee on Science, Space, and Technology
Senator Albert Gore, S. Palmer—Senate Subcommittee on Science, Technology,
and Space

NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS
2101 Constitution Avenue Washington, D.C. 20418-0001

Telephone: (202) 334-3061
Fax: (202) 334-2154
BITNET: (CPSMA@NAS)

April 9, 1992

Mr. Daniel S. Goldin
Administrator
National Aeronautics and Space Administration
400 Maryland Avenue, S.W., Room 7137
Washington DC 20546

Dear Administrator Goldin:

I am pleased to submit the interim report of the National Research Council's Panel to Review Earth Observing System Data and Information System (EOSDIS) Plans. This contains the panel's preliminary observations and recommendations on the current plans for EOSDIS, based on the information provided. The panel looks forward to an early opportunity to discuss these recommendations with NASA and other interested parties, as well as to issuing its final report in August 1992.

On behalf of the panel, I wish to thank all of those at NASA who responded quickly and professionally to our very substantial requests for information and to our many and often difficult questions. We could not have done our work without their full and ready cooperation.

I also wish to express our gratitude for the splendid cooperation from the staff of the National Research Council that enabled the panel's work on this interim report to be completed in less than two months.

Sincerely,

Charles A. Zraket / *cr*

Charles A. Zraket, Chair
Panel to Review EOSDIS Plans
National Research Council

National Research Council

Panel to Review EOSDIS Plans

Interim Report

This interim report identifies several issues regarding NASA's plans for developing the Earth Observing System Data and Information System (EOSDIS) and offers a number of recommendations that NASA should consider as it proceeds with procuring a contractor to build the system. This report does *not* respond in detail to the items in the terms of reference--that will be the subject of the panel's final report. Given the short time available for the panel's initial assessment, it has not been able to pursue the issues it identified to the depth it would like. The panel hopes, nevertheless, that NASA will find its interim conclusions and recommendations useful in the negotiations that will take place with the selected contractor to define the ongoing work plans for the EOSDIS Project.

The appendices of this report include NASA's letter of request for this study, the terms of reference for the task, a list of the members of the panel and brief biographies, the work done and the meetings held to enable the panel to write this interim report, a brief description of EOSDIS for readers not familiar with the Project, and a brief description of the U.S. Global Change Research Program and its objectives.

The panel was selected to have the competencies demanded by its charge--in understanding the needs of those who will use EOSDIS (including both EOS and non-EOS investigators), in the computer science and technology underlying EOSDIS, in the creation and implementation of large data systems, and in the recent history of large space-based data systems. The fact that the procurement for the EOSDIS Core System was concurrent with the panel's work required extreme care to avoid either the reality or perception of conflict of interest. Thus, in addition to following the National Research Council's standard procedures for dealing with bias and conflict of interest, the panel--and those who provided it information and briefings--took pains to consider only publicly available information. The panel, to the best of its knowledge, has not been provided with nor has it considered any proprietary information related to the procurement.

OBJECTIVES AND MAJOR FINDINGS

In combination with other programs of the U.S. Global Change Research Program, the Earth Observing System (EOS) is intended to reduce the current uncertainties about global climate change. Its Data and Information System (EOSDIS) is essential to the success of EOS. If EOSDIS fails, so will the Earth Observing System and so may the U.S. Global Change Research Program. The panel has been told repeatedly by responsible government officials that EOS is critical to the larger, global change program--one involving many agencies of government, and other national and international participants--and that EOSDIS offers a unique opportunity to begin building a national, and eventually, international, information system for global change research.

To achieve these aspirations, EOSDIS will have to evolve to meet the changing needs of global change research over the next two decades and beyond. The panel believes that the recommendations offered in this report are necessary to ensure that growth and evolution. Specifically, the panel offers its judgments in terms of the following objectives it believes essential to the success of EOSDIS:

- EOSDIS must facilitate the integration of data related to the aims of the U.S. Global Change Research Program. Without this integration, the multidisciplinary and interdisciplinary research objectives of the U.S. Global Change Research Program will not be achieved. The EOSDIS program must be structured and managed to facilitate interactions with the other agencies involved in the U.S. Global Change Research Program so that existing data and future data collected by NASA and by other national and international organizations--using research and operational satellites as well as in situ sources --are available to all global change research scientists.
- EOSDIS must serve a large and broad set of users to facilitate the aims of the U.S. Global Change Research Program in supporting a community concerned with understanding the earth as a system. To serve that larger community, EOSDIS must provide its information in a manner that is simple, transparent,

and inexpensive; it also must assure availability of its data to both the earth science community and the larger scientific community.

- EOSDIS must ensure that service to current users--including those involved with Version 0--will not be interrupted as the development of the system proceeds, and that Version 1 and subsequent versions will be implemented as soon as possible to meet the needs of the users, both in the EOS program and in the larger U.S. Global Change Research Program.
- EOSDIS, as it evolves, must maintain the flexibility to build rapidly on relevant advances in computer science and technology, including those in databases, scalable mass storage, software engineering, and networks. Doing so means that EOSDIS should not only take advantage of new developments, but also should become a force for change in the underlying science and technology where its own needs will promote state-of-the-art developments. Flexibility also requires organizational and management structures and processes that can respond to evolving requirements and implement the means for meeting them.
- EOSDIS needs substantive user participation in the design and development of the system, including involvement in the decisions on data acquisition and archiving, standard or ad hoc product generation, and interfaces that directly affect science users.
- The structure of the EOSDIS management organization and the attention it gives to the project should reflect the importance of the program in terms of its role as one of the major and most costly programs NASA has ever undertaken as well as its central role in the U.S. Global Change Research Program.

The EOS program was recently restructured from a mission consisting of two large, orbiting platforms containing a total of 30 instruments to a series of six smaller spacecraft containing a total of 20 instruments. The amount of data expected to be collected from EOS, however, has decreased only slightly: from 330 gigabytes/day to 240 gigabytes/day. The estimate for the total amount of processed data (from the EOS spacecraft and the other missions and instruments that will be flown) that will be managed by EOSDIS changed from 1300 gigabytes/day to about 1100 gigabytes/day, a reduction of only 15 percent. Furthermore, the

capabilities of the EOSDIS System are tied to the existence of the seven Distributed Active Archive Centers (DAACs) and the data they contain, more than to the flight rates. Although the panel will certainly examine this issue further for the final report, it appears that the recent restructuring of the EOS flight program has had little effect on the requirements for EOSDIS and thus does not affect the preliminary conclusions of this interim report.

In general, the panel does not see any serious risk to the EOSDIS program due to unavailable or inadequate technology. The panel believes that the prototyping plans of the EOSDIS Project Office, to be implemented after the contractor is selected, should be accelerated in order to assure that Version 1 is completed in accord with design objectives.

There are risks, however, in two aspects of the planning for EOSDIS. One area of risk derives from the scale and pace of changes in computer and data management technology that can be expected over the long-term life of the program, and from the great diversity of users who must interface with EOSDIS. NASA needs to focus immediate attention on planning how EOSDIS will evolve to continue to be a useful system as the scientific needs and the technology change over time.

Another area of risk concerns the management structure of EOSDIS. EOSDIS is an exceptionally large and complicated project that will cost several billion dollars, involve thousands of people, and continue for many years. The management will involve a complex mix of government, contractors, and a scientific community that is diverse and spread around the world. Each has an important role to play, and each will interact in a variety of ways with the other elements. In its recommendations in this interim report the panel has attempted to provide a number of mechanisms and approaches that it believes will help define these roles and interactions.

NASA, of course, must have the ultimate responsibility for implementing EOSDIS. To do so effectively, however, NASA should first ensure proper internal management attention and should use its own earth and computer science personnel, who can contribute significantly to the successful design of the system. Secondly, NASA needs to bring the scientific user community into the project as a partner, rather than regarding users simply as customers. Finally, NASA must accept the leadership role necessary to provide the essential unity among the user community (including other federal agencies and international participants), DAAC elements (management and scientific), and contractors. The complexity of this project demands that a structure be developed to ensure that all interests are properly integrated into the design of EOSDIS.

The panel believes that NASA can proceed prudently with the procurement process for EOSDIS, *provided* the agency builds in the flexibility to make the adjustments necessary to ensure the success of the project. The conclusions and recommendations offered in this interim report can help NASA to incorporate that flexibility into work plans during the contract negotiations that will soon take place. This flexibility could be accommodated within the scope of the current procurement as long as it is planned ahead of final contract negotiations and the contract terms are compatible with this approach. The panel believes that its recommendations should not materially affect the EOSDIS schedule and that they can be implemented in work plans resulting from the pending contract negotiations. It is important to all users that EOSDIS implementation proceed as closely as possible to the planned schedule.

The panel has divided its assessment into three parts: user interactions, EOSDIS architecture, and EOSDIS management. The recommendations for each area offer actions that NASA should consider in order to meet the objectives for EOSDIS described above without halting the current procurement. The panel also recognizes that requirements may change over time and that NASA may have to adjust its work plans over the life of the project.

In order to be of service to NASA during this important stage of negotiating with the selected contractor, the panel believes that it is necessary to provide this advice now, in this interim report. The final report will expand on the issues discussed in this interim report and will respond in detail to the terms of reference.

CONCLUSIONS AND RECOMMENDATIONS

The following are the panel's judgments concerning the user interaction, architecture, and management issues that it believes must be addressed if EOSDIS is to meet the objectives integral to its success. In each instance, the panel points to strengths and weaknesses in the program, and offers recommendations.

USER INTERACTIONS

Strengths

NASA has stated its intention to incorporate user feedback throughout EOSDIS development and evolution. The panel applauds this approach. The ability of EOSDIS to serve the broad spectrum of users will be the final measure of EOSDIS success. In this context, it should be acknowledged that NASA has led other agencies in developing the Global Change Master Directory, which will be a comprehensive description of all global change data sets. The panel also commends NASA for its plan to share software code and toolkits with users who wish to import them for their own systems.

Panel Concerns

In its review, the panel has identified several areas in which an augmentation or strengthening of critical user interactions could substantially improve the likelihood for success of the EOSDIS program. Areas of concern are NASA's Science Data Plan, links with other agencies, use of Pathfinder data sets, treatment of operational and historical data, long-term archiving, involvement of nontraditional communities, and ability to provide customized data sets.

Science Data Plan. Version 0 science data requirements are being compiled into a Science Data Plan by the EOSDIS Project through regular interactions with the user community. The intent is to solicit regular review of these requirements from the science community to make certain that evolving needs are adequately reflected in the EOSDIS Project planning. Care must be taken to ensure that the Science Data Plan continues to emphasize the links between global change research objectives and the acquisition of individual data sets. A clearer picture of base-level requirements can be achieved by a continuing assessment of science objectives, existing holdings that might meet the objectives, and requirements for future data streams.

The panel recommends that the Science Data Plan identify the links between global change research objectives and existing and planned data sets.

Interagency Links. The research priorities of the U.S. Global Change Research Program cut across the missions of individual federal agencies. The distribution of current holdings as well as data to be acquired underscores the need for interagency interoperability and cooperation. NASA has been an active participant in interagency efforts for the U.S. Global Change Research Program through a variety of working groups, and is currently a full partner in developing a tri-agency (NASA, NOAA, USGS) data and information

implementation plan, of which EOSDIS is a critical component. The panel endorses the efforts of these agencies to work cooperatively.

The Global Change Master Directory is an excellent first step in helping users to identify relevant data sets for global change research. A similar effort is needed in achieving interoperability for access to the data. Success will require both technical developments and leadership in order to integrate and provide broad access to disparate data types currently distributed throughout the agencies. The panel believes that NASA is the logical agency to initiate this step in the context of EOSDIS. Moreover, EOSDIS will be much more effective in broadening its user base if it serves as the vehicle for integrating data.

The panel recommends that NASA expand its efforts to increase interagency links by assuming an active leadership role among the agencies in achieving interoperability not only at the level of the Global Change Master Directory, but also at the level of providing access to the actual data.

Pathfinder Data Sets. Prototyping has been a routine component of EOSDIS planning and Version 0 implementation by the Project Office. NASA has been successful in establishing prototype earth science data systems that are currently acquiring, processing, distributing, and archiving pre-EOS data. Lessons from such prototyping activities can identify problems associated with the manipulation and distribution of extremely large data sets.

Pathfinder data sets provide an early means to evaluate the handling of large data sets, the development of products, and the distribution of data and products. NASA and NOAA are cooperating in a Pathfinder data program for selected satellite data. This program will be extremely valuable to the U.S. Global Change Research Program and to the prototyping of various functions of the overall data and information system.

The panel recommends that NASA develop ways to integrate the efforts of existing data centers and centers of data supported by NSF, DOE, and USGS with the NOAA/NASA Pathfinder activities. Further, the Pathfinder data program now under way should be accelerated.

Operational and Historical Data. Data from past and currently operating satellites already are being provided to several DAACs. NASA has shown considerable foresight in recognizing the importance of data streams from NASA, NOAA, DOD, and foreign

satellites in establishing long-term data sets for global change research. Although the EOSDIS Request for Proposal addresses data management of NASA's EOS platform instruments as well as NASA's commitment to maintaining data sets acquired by pre-EOS sensors, the panel wishes to emphasize the need for the accessibility of non-EOS instrument data streams to EOSDIS users.

The panel believes that the full benefit of EOSDIS to the U.S. Global Change Research Program will not be realized until an effort similar to that for EOS data is undertaken to manage the immense collection of historical data related to global change research already collected through operational observing systems. This collection includes the routine data from the space-based and surface-based observing systems of NOAA and DOD, as well as the routine and special data collected by USGS, USDA, EPA, DOE, NSF, and the Census Bureau. Integration, interpretation, and synthesis of such data, as part of a modern data and information system for long-term operational measurement, are critical to the goals of the U.S. Global Change Research Program and the interpretation of EOS measurements.

The panel recommends several ways to address the issue of integrating the operational and research data from other agencies into EOSDIS:

- a. NASA should articulate a plan for incorporating operational and non-EOS instrument data streams into EOSDIS. Where EOS and non-EOS instruments have similar functions, NASA should develop a strategy to enhance the use of both data streams. This strategy should also include consideration of cross-calibration between basic radiometric data and higher-level products of an EOS instrument with a non-EOS instrument.**
 - b. To test the interoperability of EOSDIS and to integrate the critical long-term operational data that now exist at Affiliated Data Centers into a global change data and information system, NASA should perform a full-function test of the EOSDIS architecture and software on some of the Affiliated Data Centers, in particular, centers with holdings (such as long-term satellite or in situ data records) critical to the U.S. Global Change Research Program and to the synthesis and interpretation of data from EOS instruments.**
-

- c. NASA should articulate its policy on how Affiliated Data Centers will move up through the different levels of interoperability that are specified for linkage with EOSDIS.

Long-Term Archiving. Long-term archiving of EOS data is an issue that has not been addressed. Long-term commitment to maintaining data collected as part of EOSDIS is a critical component of the U.S. Global Change Research Program. NASA, in its response to questions from the panel, correctly pointed out that the issue of maintaining long-term archives is one that must be addressed by all participating federal agencies. Without a concrete plan and agency coordination for establishing permanent data archives, however, the overall objectives of EOS, and, therefore, of the U.S. Global Change Research Program, are jeopardized. As in the case of increasing interagency links, the panel believes that NASA can provide the leadership in addressing this need.

The panel recommends that NASA develop an adequate plan and technology for long-term data archiving in conjunction with the other federal agencies participating in the U.S. Global Change Research Program.

Involvement of Nontraditional Communities. NASA has identified ways for broadening the user community and providing information about EOSDIS to those unfamiliar with the system through professional journals and newsletters. Such publications may be adequate for reaching users in certain disciplines but may be ineffective for those in other fields, particularly in the nonphysical sciences. For example, one of the science priorities identified in the U.S. Global Change Research Program is to assess the human dimensions of global change. A detailed plan for involving potential user communities beyond the traditional disciplines associated with the earth and environmental sciences has not been clearly delineated for the panel.

Many approaches could be taken to encourage users from nontraditional communities (e.g., legal, educational, political, and social). A useful approach could include the distribution of sample products that would allow users to become familiar with the various types of data sets available and to judge whether those data would be helpful to their research.

The panel recommends that NASA take an active role in facilitating access to EOSDIS by other, nontraditional disciplines through a program that includes representatives from those disciplines in NASA's user advisory groups and develops products useful to them.

Customized Data Sets. NASA clearly recognizes the importance of involving the user community in the development of EOSDIS. An approach to encourage active user participation is to provide customized data integration and synthesis of various products. The availability of software tools that conform to standards in an open architecture environment would facilitate participation by active users. For example, these tools might enable a user to assemble a customized set of specific time- and/or space-averaged data that could not otherwise be assembled without the user having to develop new software.

The panel recommends that NASA encourage broad user participation by providing greater opportunities to create customized data sets.

EOSDIS ARCHITECTURE

Strengths

The panel in its several lengthy discussions with EOSDIS technical staff was impressed by the staff's competence and motivation. The staff has devised a process for designing the EOSDIS Core System that would rely on open systems, including multiple levels of interoperability for both users and the DAACs as well as the ability to handle evolving international standards. These two approaches--use of an open system and adoption of standards even though they will change over the lifetime of EOSDIS--will strengthen the program.

The Project plans to deliver EOSDIS in incremental stages (via Versions 1 to 6 and Data Product Levels 0 to 6) that are expected to provide the flexibility necessary to meet user needs, to respond to budget uncertainties over the next decade, and to adjust to EOS flight schedules.

Panel Concerns

Design Control. Any large software system requires design criteria that are set by project management and articulated clearly and precisely throughout the project hierarchy. This is particularly true for EOSDIS because of four reasons: (1) the unprecedented size of the

system's storage and processing capacity; (2) the extraordinary heterogeneity of both user computation systems and user requirements; (3) the large variation in scale of both the mass stores and the granules of data to be simultaneously managed; and (4) the high degree of evolution expected in the system. The combination of these factors will make the design, implementation, and evolutionary control of the system a substantial architectural challenge.

Although NASA has assured the panel that EOSDIS will serve the needs of global change researchers, the EOSDIS Core System Statement of Work and the Functional and Performance Requirements documents of the Request for Proposal seem to be based on the management of data holdings resident with or owned by NASA or the DAACs and the created data products related to those holdings. It is entirely likely that data and/or data archives that are not within the exclusive purview of NASA or the DAACs will need to be made accessible to users through EOSDIS, without changing ownership of the data or the autonomy of the data repository. In anticipation of the need for accessibility, EOSDIS software should be built in the form of modular components with open, configuration-controlled interfaces so that other national and international agencies will be able to link with the system and provide products and services to the broader global change research community.

The panel believes that responsibility for the design criteria and for their enforcement to guide the system architecture must reside with the government. The government must assure that the contractor's detailed architecture and implementation decisions follow the directions given by the government system architects.

The panel recommends that NASA produce a clear, concise statement of the design criteria for EOSDIS that focuses on facilitating global change research and that NASA communicate these criteria throughout the Project hierarchy.

The panel recommends that NASA strengthen its internal system architecture team by acquiring additional experienced people and that it give them the responsibility, authority, and budget to ensure that the design criteria are met as the system design and implementation proceed. A technical project of the magnitude and complexity of EOSDIS should have the very best system architecture team possible. NASA should make every effort to acquire such talent.

Logically Distributed System. The research that will be possible through the resources provided by EOSDIS is difficult to characterize at present. Some research will focus on narrow disciplinary questions, while other work will be interdisciplinary. Since we cannot, indeed should not, attempt to specify the future directions that earth science research will take, EOSDIS must be flexible enough to respond to a wide variety of approaches. Furthermore, EOSDIS will be only a part, albeit a major one, of the efforts directed at managing data and information for global change research.

The EOSDIS development plan provides for centralized control over the specification and implementation of the system. Each DAAC will implement an Information Management System that will be centrally developed by a single contractor. Although a centralized system is desirable for the management, operation, and control of the satellite and its instruments, the data will be distributed and dispersed among geographically separate and discipline-specific DAACs. Achieving the proper balance between the common elements that should be developed centrally and those that should be developed in a distributed fashion is critical to the success of the overall U.S. Global Change Research Program. At present, it appears as though the EOSDIS development plan is too heavily oriented toward a centralized approach.

The panel recommends that the EOSDIS Project adapt its development plan to ensure a more logically distributed system, including:

- a. Designing EOSDIS so that all users (EOS and non-EOS investigators, DAACs, other data centers) can easily build selectively on top of EOSDIS components. EOSDIS should not constrain local implementation of diverse functions by users and DAACs. The development plan should reflect a philosophy that it is "easy to interact with EOSDIS" with minimum loss of autonomy. EOSDIS must be able to tolerate different versions of functionality and partial sharing of the components and toolkits it exports.
 - b. Identifying those areas of interdisciplinary research that will require special interfaces among discipline-specific products and formats. The Project should specify the interfaces, build prototypes, and run simulations to exercise them, permitting users to evaluate them prior to developing final specifications and proceeding to full implementation. A contractor team that resides at each DAAC and works closely with the
-

DAAC as well as the contractor's "central core" team should facilitate the development of these prototypes.

This type of distributed development can be accomplished within the scope of the current procurement as long as it is planned ahead of final contract negotiation, and contract terms are compatible with this approach.

Incremental Prototyping. The current EOSDIS development plan closely ties the availability of the distributed archive and product generation functions to the EOS flight schedule. There is much work that should be done, however, prior to the first scheduled launch of EOS instruments in 1998 to strengthen prototyping efforts already under way. For example, there are both existing archives and data expected from pre-EOS satellites that will be invaluable to the U.S. Global Change Research Program. Although the EOSDIS Project team has initiated the early prototyping effort for Version 0, more can and should be done to benefit current global change research and to enhance user feedback for final system design.

The panel recommends that EOSDIS Project management extend its incremental development plan so that all user interfaces, all toolkits, and the end-to-end network system are:

- a. Specified in detail early in the development of Version 1 and prototyped or simulated sufficiently, and
- b. Evaluated in depth by users and DAACs prior to full implementation in Version 1. This will require a system network simulation and sufficient testing tools for users to assess and validate the specified functionality.

Usability Evaluation. Prudent practice in the design of complex data management systems ordinarily includes a means of measuring the usability of the data. To the extent possible, such measures should be quantitative. Early evaluation exercises should be designed to measure ease of use, quality of interface specifications, and convenience of interoperability of heterogeneous system components. These exercises should ensure that individual users and data archivers can acquire piecemeal both functional capabilities and data sets. It is also prudent practice to involve independent judgment by having this evaluation performed by a group other than those responsible for developing the system.

The panel recommends a usability evaluation program starting as soon as possible that involves:

- Selecting key functions, interfaces, and system behavior attributes for evaluation;
- Defining a set of metrics and expected values of those metrics for each parameter to be evaluated;
- Creating prototypes, simulations, and test suites to stress aspects of usability;
- Using the evaluations to guide final specification of system components; and
- Implementing this program so that most of the evaluation and validation is done by groups other than the prime contractor.

EOSDIS MANAGEMENT

Strengths

NASA is to be commended for developing the plans for EOS as its flagship for U.S. participation in global climate change research. NASA and the EOS Project are further to be commended for their dedication to producing an adequate data system for EOS and for its user community. The unprecedented level of funding allocated for EOSDIS and the high level of planned contingency funding are evidence of the commitment NASA has made to this important national research effort. The panel is impressed with the degree of dedication and commitment of the EOSDIS Project team. The team is working diligently and competently toward both prototyping key system and subsystem capabilities and planning for the procurement of the full EOSDIS system.

Panel Concerns

Visibility and Management Attention. Although EOSDIS appears to receive substantial attention from management at NASA Headquarters, in the panel's view, EOSDIS lacks the attention of senior management at the Goddard Space Flight Center. The EOS Project is the largest single development effort the Goddard Center has undertaken. Even without the flight hardware components, EOSDIS by itself probably satisfies that description. EOSDIS is an extremely complex interdisciplinary science project and must integrate the most advanced data and system technologies. EOSDIS also contains both the flight operations segment and the ground data system. The fact that schedules overlap and that the prime contractor probably will use different groups of personnel to implement these two very different elements will amplify the government's oversight and management challenge. Yet the panel has heard substantial evidence that from the management standpoint, EOS and EOSDIS are treated like ordinary projects within the Goddard Center. For example, the Project Manager for EOSDIS is two management levels down within the Flight Operations Directorate, which is only one of ten directorates at the Goddard Center. In addition, the Project Office is quite small for the task at hand, with plans for only 45 government employees when fully staffed. This small core of dedicated staff provides inadequate programmatic and managerial depth and expertise in the development of large, distributed data systems and in computer science and technology.

Given the preeminent position of EOS and EOSDIS in the U.S. Global Change Research Program, the panel believes that it is essential to increase the level of management visibility of the Project and the size and skills of the Project staff. In addition to learning from other government agencies that have had experience in the development and operation of large distributed data handling systems, NASA could, as needed, add to the Project experienced systems development personnel from other parts of the government.

The panel suggests that greater flexibility in defining success criteria and in using the process for setting award fees for direct feedback from the Project Manager to senior-level contractor management would help to assure that the contractor will do an outstanding job on EOSDIS. The panel commends NASA for including users in its performance board for contract evaluation and urges the active participation of users in setting award fees.

The panel recommends that the EOSDIS Project Manager have higher management visibility within Goddard Space Flight Center. The staff authorizations and skills should be sized to the scope and complexity of the

Project. Further, the Project could augment its staff with experienced personnel from other parts of the government in addition to NASA.

The panel recommends that the EOSDIS Project use the award fee process to best advantage through greater differentiation of success and failure criteria for evaluating contractor performance and by involving users in determining award fees.

Scientific Involvement at Goddard Space Flight Center. The Goddard Center's in-house earth scientists have a very limited role in the management and operations aspects of the EOSDIS Project. Although NASA has established a variety of science advisory and data working groups, such groups cannot replace the continuing and even daily involvement of the external scientific community and the Goddard Center staff to ensure that the eventual system is responsive to user needs.

Likewise, the nation's computer science community currently has very limited involvement in the Project, despite the fact that EOSDIS, to be successful, must implement the latest advances in scientific data management technology and, in some cases, stimulate the development of new technologies. The development of EOSDIS would benefit from substantive use of expertise in systems design and exploitation of information processing technology. Because underlying technologies, such as storage density, processor speeds, and transmission rates, are doubling roughly every three years, EOSDIS must be able to exploit rapidly expanding capabilities during its lifetime of a generation or more.

EOSDIS will also stretch the limits of what can be done by a mammoth database management system shared by a very diverse and demanding user community. Certainly, many of the underlying technologies such as storage will evolve on their own. Other technologies, however, will have to be encouraged, such as large-scale data management, visualization, and integration of heterogeneous information. Possible ways to stimulate technology include establishing an intramural computer science research capability comparable to those in other sciences, supporting and using the external computer science community, and using DAACs to establish formal and informal links with the computer science research community in their neighboring universities.

The panel recommends that NASA involve Goddard Space Flight Center earth scientists to a greater degree in the management and operations of EOSDIS and also involve computer scientists both inside and outside of NASA to explore

research and technology in those areas where EOSDIS will stress the state of the art in science and technology and where EOSDIS will evolve most rapidly.

DAAC Involvement. The DAACs are not well integrated into the EOSDIS management structure, particularly during the development phase. The DAAC managers do not have well-defined authority or accountability in building EOSDIS. DAACs should be involved early, in contrast to the current plan, in which their primary role appears to be to operate the hardware and software at their sites after delivery, and to deliver data products to users.

There should be mechanisms for feedback on scientific utility and operational effectiveness from the individual DAACs and associated archive centers to the central Project since the DAACs will be the primary sites for user interaction. There should be a coherent overall development, management, and science advisory structure that includes the DAACs. The panel understands that DAAC managers and scientists are involved in advisory roles. Advisory roles, however, are not sufficient for developing capabilities for and at the DAACs.

Overall, the centralized management of the design and implementation of EOSDIS functions at each DAAC is not conducive to active user involvement and responsiveness to changing technology. What is needed is a structure that strengthens the local role of each DAAC beyond the present DAAC advisory group and thus enhances the responsiveness of each DAAC in meeting the needs of its user community, gives the DAAC some control over its destiny, and yet ensures that an interoperable system is developed to meet the requirements of EOSDIS.

The panel recommends that NASA create, at each DAAC, a Development Team of full-time staff and active science users to address DAAC and user concerns. These teams should evaluate EOSDIS planning and implementation, including architecture, DAAC interface definitions, and other deliverables essential to ensuring that the DAACs will be responsive to user needs and that the EOSDIS system will be interoperable. In accomplishing these tasks, the teams should monitor the contractor's activities on behalf of user communities and prepare test data sets to verify system interfaces. Each DAAC Development Team should validate that DAAC's operational capability to use the evolving EOSDIS system as each of the program releases is implemented. Finally, NASA should provide the DAACs with modest funding to respond to specific user needs so that the DAACs will be able to parallel the evolution of the user community's ability to manipulate, integrate, and model data.

APPENDICES

- A. Letter of Request for Review of NASA's EOSDIS Plans
 - B. Terms of Reference
 - C. Panel Members and Biographies
 - D. Activities of the Panel to Review EOSDIS Plans
 - E. The EOSDIS System
 - F. The U.S. Global Change Research Program
-

Appendix A: Letter of Request for Review of NASA's EOSDIS Plans



National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

NOV 22 1991

Dr. Frank Press
President
National Academy of Sciences
Washington, DC 20418

Dear Dr. *Frank* Press:

NASA is restructuring the Earth Observing System (EOS) program to fly instruments on intermediate and small spacecraft as opposed to a series of large spacecraft. This action will make the program more robust and flexible in the face of future uncertainty and is consistent with the recommendations of a number of groups including the EOS Engineering Review Committee chaired by Dr. Edward Frieman. This restructuring will result in a different sequencing of measurements and changes in the volume of data relative to the original EOS program.

Now that we have a better understanding of how the EOS spacecraft will be configured, it will be necessary to adjust our data system requirements to reflect the needs of the program. Accordingly, as we discussed last week, I would like to request that the Academy undertake a high level review of our plans for the EOS Data and Information System (EOSDIS) to ensure that this effort is compatible with the restructured program and best serves the interests of a broad range of users. The EOSDIS is designed to process, archive, and make readily available the data from EOS as well as data from past, current, and upcoming Earth observing spacecraft that fly in advance of EOS. The user community will depend on this data to develop an understanding of the vital aspects of global change.

Your study should examine some of the fundamental questions regarding the EOSDIS, particularly its responsiveness to the global change research community requirements and its technical feasibility. In addition, you should review the EOSDIS in terms of flexibility and compatibility in addressing evolving requirements, adequate opportunities for user review and input, and balance between distributed and centralized elements.

2

NASA is determined to proceed as rapidly as possible with the restructuring of the EOS program in order that there will be no unnecessary delays in program implementation. It is important that your study be accomplished such that an interim or status report can be available to us by March 1992 and a final report of your findings by summer 1992.

I have asked Dr. Lennard A. Fisk of our Office of Space Science and Applications to work with you to define in more detail the terms of reference for this study and to provide full support for your activities. I appreciate your assistance in this important research initiative.

Sincerely,


Richard H. Truly
Administrator

Appendix B: Terms of Reference

The National Aeronautics and Space Administration is restructuring the Earth Observing System (EOS) to be configured to fly on a series of intermediate and small spacecraft, as opposed to a series of large spacecraft. This reconfiguration will result in a different sequencing of measurements and changes in the volume of the data compared to the original EOS program.

The EOS Data and Information System (EOSDIS) is designed to process, archive, and make readily available to a broad range of users the data from EOS and also from appropriate current and upcoming spacecraft that fly in advance of EOS. Accordingly, the EOSDIS architecture will need to be compatible with the program.

The National Research Council will convene a panel of technical experts to conduct a review of NASA's plans for EOSDIS. Members of the panel should be drawn from appropriate National Academy of Sciences and National Academy of Engineering bodies and the technical community in order to bring together a broad mix of expertise in space data systems, data archival and distribution systems and in global change research. A significant proportion of the panel should have expertise in the procurement, technical, and management aspects of large database systems outside the area of global change research. As recommended in the Report of the Earth Observing System (EOS) Engineering Review Committee, the goal of the review should be to validate the engineering and technical underpinnings of the EOSDIS; assess its potential value to scientific users; suggest how technical risk can be minimized; and assess whether current plans provide for sufficient resiliency to be adaptable to changing requirements (i.e., budget environments, data volumes, etc.).

The EOSDIS program is currently selecting an EOS Core System contractor through a competitive procurement. Consequently, access to information by the review panel will be constrained to publicly available documents and presentations. Furthermore, no member selected to participate on the panel should have a significant financial interest in any of the competing contractors.

The panel will review NASA's plans for EOSDIS in order to address the following questions:

- Does the current EOSDIS plan reflect the restructured EOS global change data traffic model (i.e., are EOSDIS features properly sequenced with the complexity of the instruments to be flown and other data sources)? Can/should some of these features be delayed given the current data traffic model?
 - Are the plans for EOSDIS technically realistic and appropriate to meet the
-

information systems demands of the EOS program, with adequate milestones and prototype demonstrations of capabilities? Do these milestones and demonstrations provide adequate benchmarks for monitoring the progress and performance throughout the development and operational phases of the EOSDIS?

- Does the EOSDIS plan meet the requirements of expected research users, especially the global change research community? Do the plans for EOSDIS provide adequately for involving university, national laboratory, government, and other users in influencing the character of each incremental phase of the system?
- Is NASA's plan for the development of EOSDIS sufficiently flexible to match the pace and scope of an observing program that is developed in an evolutionary fashion (i.e., is EOSDIS structured to respond to budget fluctuations or variations in the users demands)? If not, what actions would you recommend NASA taking to address this issue?
- Is NASA's EOSDIS management plan appropriate? For example, is the planned allocation of responsibilities between distribution and centralized elements of EOSDIS conducive to user utilization as well as efficiency and cost effective execution of the EOS program (i.e., is the allocation between distributed and centralized elements optimal)? If not, what actions would you recommend NASA taking to address this issue?
- Is the planning and design for EOSDIS sufficiently flexible to accommodate possible advances in computer hardware and software technologies that may occur over the lifetime of the system? Can/should additional flexibility be built into the design of the database?
- Does the plan for EOSDIS include provision for expansion of the system to include or access other data systems (e.g. National Space Science Data Center, National Geophysical Data Center, Earth Resource Observation System Data Center, and other national and international data systems)? What changes would be required to achieve sufficient flexibility to permit expansion?

Overall, the panel will provide a critical review of NASA's plans for EOSDIS, identify potential problems, and recommend actions that should be taken to address these problems. It will not be expected to offer a redesign of the system.

The panel will provide a status report in March 1992 summarizing the progress of the EOSDIS

review, including the principal issues identified by the panel for consideration, and will provide a final report summarizing the findings and conclusions of the review by August 31, 1992.

Appendix C: Panel Members and Biographies

PANEL TO REVIEW EOSDIS PLANS

Charles A. Zraket, *Chair*, Center for Science and International Affairs, Harvard University
D. James Baker, Joint Oceanographic Institutions Incorporated
Kenneth I. Daugherty, Defense Mapping Agency
Richard E. Hallgren, American Meteorological Society
John E. Hopcroft, Cornell University
Kenneth C. Jezek, Ohio State University
Anita K. Jones, University of Virginia
Thomas R. Karl, National Oceanic and Atmospheric Administration
Ethan J. Schreier, Space Telescope Science Institute
Gael F. Squibb, Harvard-Smithsonian Center for Astrophysics
Jeffrey D. Ullman, Stanford University

Staff

Richard C. Hart, Space Studies Board
Monica B. Krueger, Computer Science and Telecommunications Board
Norman Metzger, Commission on Physical Sciences, Mathematics, and Applications
Lorraine W. Wolf, Board on Earth Sciences and Resources

Biographies of Panel Members

Charles A. Zraket, *Chair.* Scholar-in-Residence, Center for Science and International Affairs, Harvard University. Past President and CEO, MITRE Corporation. S.M.E.E., Massachusetts Institute of Technology; Honorary Doctorate of Engineering, Northeastern University. Member, National Academy of Engineering; Fellow, American Academy of Arts and Sciences, I.E.E.E., AIAA, American Association for the Advancement of Science. **Research interests:** International and national security; global environment, science and technology policy.

D. James Baker. President, Joint Oceanographic Institutions Incorporated; Distinguished Visiting Scientist, Jet Propulsion Laboratory. Ph.D., Cornell University. Member, Global Change Research Committee, Committee on Environmental Research, Climate Research Committee, Joint Scientific Committee for the World Climate Research Program. **Research interests:** Physics of large-scale ocean circulation and climate; ocean and satellite instrumentation; research policy and management.

Kenneth I. Daugherty. Chief Scientist, Defense Mapping Agency (DMA). Ph.D., Uppsala University, Sweden. Former Assistant and Associate Director, Hawaii Institute of Geophysics; Former Deputy Director, Research and Engineering, DMA, and Director, DMA Systems Center. Fellow, IAG; Recipient, DOD Distinguished Civilian Service Award. **Research interests:** Geodesy; world coordinate systems; advanced surveying/positioning techniques; mapping technology and production systems.

Richard E. Hallgren. Executive Director, American Meteorological Society. Ph.D., Pennsylvania State University. Former Associate Administrator for Environmental Monitoring and Prediction, Assistant Administrator for Oceanic and Atmospheric Sciences, and Director of the National Weather Service. Member, Global Change Research Committee, National Committee for International Decade for Natural Disaster Reduction, Committee on Earth Sciences. **Research interests:** Meteorology, weather systems technology and management.

John E. Hopcroft. Joseph C. Ford Professor and Chair, Computer Science Department, Cornell University. Ph.D., Stanford University. Member, National Academy of Engineering, NASA Space Science and Applications Advisory Committee, and USAF Scientific Advisory Board. **Research interests:** Algorithms, modeling and simulation.

Kenneth C. Jezek. Director, Byrd Polar Research Center, Ohio State University. Ph.D., University of Wisconsin. Member, Committee on Geophysical Data, Committee on Glaciology, and Committee on Earth Studies. **Research interests:** Hemispheric-scale observations of the growth motion and decay of polar ice using spaceborne instruments.

Anita K. Jones. Professor and Chair, Department of Computer Science, University of Virginia. Ph.D., Carnegie Mellon University. Member, Defense Science Board. **Research interests:** Computer system design and construction; scientific databases; computer security.

Thomas R. Karl. Chief, Global Climate Laboratory, National Climatic Data Center, NOAA. M.S., University of Wisconsin. Member, NRC Climate Research Committee, WMO/UNEP Intergovernmental panel on Climate Change, NRC Effects Subpanel on "The Policy Implications of the Greenhouse Effect." Ex officio Chairman, American Meteorological Society Applied Climatology Committee. **Research interests:** Climate and climate change; Earth system information management

Ethan J. Schreier. Associate Director for Operations, Space Telescope Science Institute. Ph.D., Massachusetts Institute of Technology. Member, Astronomy Survey Committee Panel on Computing and Data Processing, NASA Astrophysics Division Science Operations Management and Operations Working Group. **Research interests:** Astronomy; observations of x-ray sources, active galaxies and jets; development and operations of astronomy satellites and distributed data systems for astronomy, including portable software, archives, networks.

Gael F. Squibb. Manager, Advanced X-ray Astrophysics Facility (AXAF) Science Center, Harvard-Smithsonian Center for Astrophysics. M.S., University of Southern California. Chairman, NASA Astrophysics Data System Study. Jet Propulsion Laboratory: Flight Director, Surveyor Project; Operations Director, Mariner Venus Mercury; Manager, Information Systems Sequence Section; Manager, Infrared Astronomical Satellite Project; Manager, Infrared Processing and Analysis Center. **Research interests:** Astronomy; satellite systems.

Jeffrey D. Ullman. Professor and Chair, Department of Computer Science, Stanford University. Ph.D., Princeton University. Member, National Academy of Engineering. **Research interests:** Database systems, especially deductive database systems; database integration.

Appendix D: Activities of the Panel to Review EOSDIS Plans

The panel met for the first time on February 14 - 15, 1992, at the National Academy of Sciences facilities in Washington, D.C., to review NASA's plans for EOSDIS. The panel was given the following background material: a copy of the EOSDIS Request for Proposal; summaries of Space Studies Board (SSB) reports on data management and on earth science from space; the 1991 *Report of the Earth Observing System (EOS) Engineering Review Committee* (Frieman report); the 1992 GAO report, *EOS: Information on NASA's Selection of Data Centers*; the 1991 *EOS Reference Handbook* (NASA/GSFC); the 1989 report of the Science Advisory Panel for EOS Data and Information, *Initial Scientific Assessment of the EOSDIS*; the CEES report, *Our Changing Planet: The FY1992 U.S. Global Change Research Program*; the 1991 NRC Committee on Geophysical Data report, *Solving the Global Change Puzzle: A U.S. Strategy for Managing Data and Information*; the 1991 SSB report, *Assessment of Satellite Earth Observation Programs, 1991*; and the 1990 NRC Committee on Global Change report, *The U.S. Global Change Research Program: An Assessment of the FY1991 Plans*. The panel also received a draft copy of the 1992 GAO report, *Earth Observing System: NASA's EOSDIS Development Approach is Risky*.

During the first meeting the panel received a number of briefings and presentations: (from NASA/HQ) L. Fisk, "EOS Overview"; S. Tilford and D. Butler, "NASA Plans for EOS"; (from NOAA) E. Shea, "Overview of the Global Change Program"; (from NASA/GSFC) J. Dozier, T. Taylor, H. Ramapriyan, and G. McConaughy, "NASA Plans for EOSDIS."

The panel was divided into three subpanels (User Interactions, Engineering Assessment of System Architecture, and Development/Procurement Process) that each produced a written set of questions for NASA. NASA responded with detailed, written answers. In addition, two of the subpanels visited Goddard Space Flight Center (the Development/Procurement subpanel on February 27 and the System Architecture subpanel on March 5) in order to gain further information from project officials.

The panel met for the second time on March 9 - 11, 1992, at the National Academy of Sciences facilities and heard additional information from NASA (J. Dozier, D. Butler, H. Ramapriyan, and G. McConaughy), a presentation on interagency data management efforts and NOAA data management activities (G. Withee), and a discussion with a DAAC manager (R. Dunkum, NASA Langley Research Center). During this meeting the panel prepared the draft of its interim report.

Appendix E: The EOSDIS System*

The U.S. government has undertaken a multiagency program designed to study the Earth from a global perspective to help develop sound national and international policies related to global environmental issues, particularly global climate change. NASA's contribution to this program is the Mission to Planet Earth, a series of scientific initiatives and spaceflight programs known collectively as the Earth Observing System (EOS). A central element of EOS is the Data and Information System (EOSDIS), a system to make the data obtained from the flight projects and scientific investigations available to the research community.

EOS will consist of a series of spacecraft that will be flown over a 15-year period to investigate the Earth's atmosphere and surface and the interactions between them that could influence global climate changes. Although originally conceived as two large polar-orbiting platforms with 30 instruments, EOS has recently been restructured to six smaller spacecraft with a total of 20 instruments. NASA hopes to fly three copies of each of the spacecraft over the 15-year period. In addition, a number of other U.S. and international space missions will examine various aspects of the Earth's environment. The data produced by this array of spacecraft will need to be processed, stored, and distributed to a research community estimated at 10,000 users. The EOSDIS is being planned by NASA to acquire, process, store, and distribute the spacecraft data; manage the information about the data; provide the networks necessary to access the data as well as the computing facilities necessary to analyze them; provide and maintain the standards and formats for the system; and administer the scheduling of observations and the command and control functions of the spacecraft and instruments. The EOSDIS program is to provide the tools needed to use the data, in activities such as the development and integration of algorithms for scientific products, communication and exchange of data among scientists, archiving of scientific products for access by others, checking on the health and calibration of instruments, and planning and scheduling for acquisition of new data. The system will be expected to manage a data volume of about 600 terabytes/yr.

EOSDIS will be structured around seven research science-oriented Distributed Active Archive Centers (DAACs) that will receive the raw data from the spacecraft, process them, and provide them to the users through a Product Generation System (PGS), which will produce standard sets of earth science data, an Information Management System (IMS), which will give users access to all the data throughout the EOSDIS system, and a Data Archive and Distribution System (DADS), which will serve as the archive and distribution mechanism for the data produced by EOS.

In addition to the Science Data Processing Segment of the DAACs, the architecture for EOSDIS will also include a Flight Operations Segment (FOS) for mission and instrument planning,

scheduling, control, and monitoring, and a Communications and System Management Segment for overall management and coordination of ground system resources such as inter-DAAC communications and interfacing to the NASA Science Internet.

NASA is currently developing a prototype of EOSDIS (Version 0) in order to improve access to existing data and to test the interoperability of existing systems. NASA will select a contractor to develop EOSDIS (Versions 1 through 6) in May 1992, with the expectation of having the full system operating by mid-1998.

***This description has been abstracted from the background material available to the panel (as described in Appendix D) and the briefing documents presented to the panel during the February 14 - 15, 1992, meeting.**

Appendix F: The U.S. Global Change Research Program

The U.S. Global Change Research Program (USGCRP) was established as a Presidential Initiative in the FY 1990 Budget to address global environmental issues, with particular emphasis on global climate change. The Committee on Earth and Environmental Sciences (CEES) of the Federal Coordinating Council for Science, Engineering, and Technology is the interagency group charged with the task of developing the program.* The primary goal of the USGCRP is to establish the scientific basis for national and international policies relating to natural and human-induced changes in the global Earth system. In accordance with this goal, the CEES has outlined the following objectives:

- To establish an integrated, comprehensive, long-term program of documenting the Earth system on a global scale;
- To conduct a program of focused studies to improve our understanding of the physical, geological, chemical, biological, and social processes that influence Earth system processes and trends on global and regional scales; and
- To develop integrated conceptual and predictive Earth system models.

The USGCRP is organized around seven science priorities: climate and hydrologic systems, biogeochemical dynamics, ecological systems and dynamics, earth systems history, human interactions, solid earth processes, and solar influences. These science priorities reflect the interdisciplinary approaches necessary for achieving the goal of the Program. In addition to increased understanding in each of these research areas, the success of the USGCRP will require an effective data and information management system. The CEES, through the Interagency Working Group on Data Management for Global Change, is currently planning such a system.

*For a detailed overview of the USGCRP, see: *Our Changing Planet: The FY 1992 U.S. Global Change Research Program*, Committee on Earth and Environmental Sciences (CEES), Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), Office of Science and Technology Policy (OSTP), Washington, D.C., 1991; and *Our Changing Planet: The FY 1993 U.S. Global Change Research Program*, CEES, FCCSET, OSTP, Washington, D.C., 1992.

IC SYSTEMS MANAGEMENT PROCESS

- Project Cycle Objectives
- Project Management Elements
- The Project Cycle
- Project Planning
- Project Control
- Key Principles
- Lessons Learned

The Agency Project Cycle

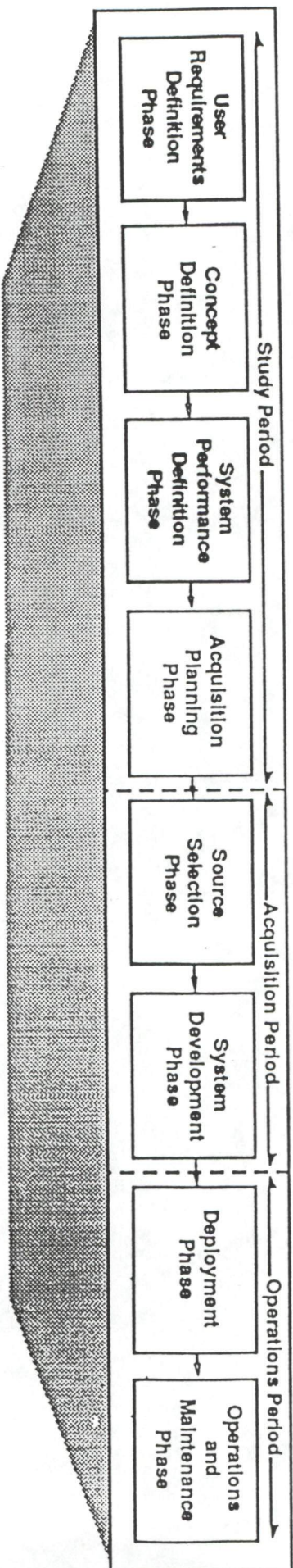
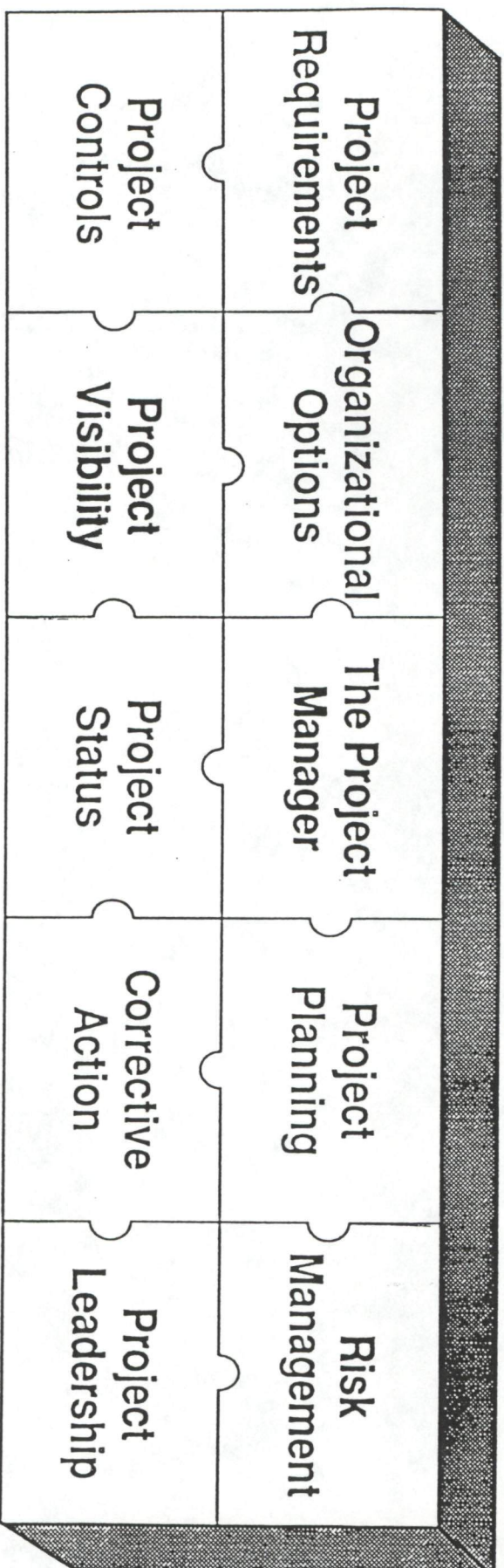


Fig. 4 - 11

Project Management Elements Overview



Application of the Management Elements to the Cycle

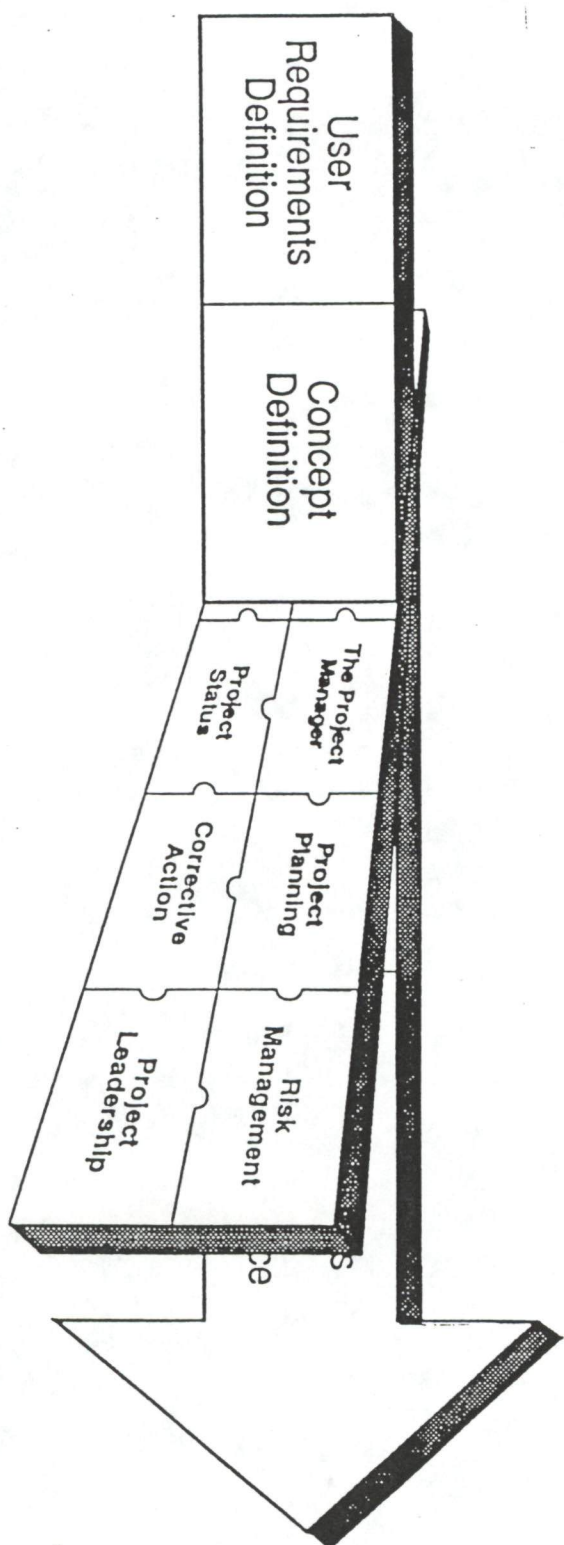


Figure 5-8

METHODOLOGY EXCHANGES WITH NASA

- NASA Sep 91 draft project cycle and "Vee" chart based on agency project cycle.
- Application of "Vee" chart is detailed in Mar 92 draft NASA System Engineering Handbook.
- Agency project cycle was included in NASA project management course.
 - Course Coordinator: Frank Hoban, Director NASA Project Management Training
 - Instructors: Dr. Kevin Forsberg and Hal Mooz, Center for Systems Management

PROJECT MANAGEMENT

- Lessons Learned

- Project requirements must be achievable and the required resources must be available to do the job.
- Government and Contractor team must work synergistically to achieve common project goals.
- All team members must be committed to the Project, the Project Management Process, and to their assigned responsibilities.
- All project participants must have clearly defined and unambiguous roles and responsibilities.
- Project managers must adhere to the disciplined Project Cycle with frequent control points to achieve project objectives.

PROJECT MANAGEMENT

- Lessons Learned (Cont)

- Risk must be identified early in the Project Cycle, and managed as integral part of the Project Management Process.
- The project environment must foster the identification and surfacing of problems, and facilitation of timely solutions.
- Executive management and service organizations must support the project and project goals.
- All government and contractor personnel must maintain a proper businesslike relationship and always comply with the established legal, moral, and ethical standards of conduct.
- The reward system must encourage achievement of project goals and satisfy personal and organizational needs.

ACTIONS

• Would like sanitized copies of as many VU's as possible w/ special emphasis on the lessons learned from each briefing.

(COTS: Common/Commercial Off the shelf systems/ software)

Withdrawal/Redaction Sheet

(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01. Letter	From: Paul Byerly Re: Satellite Photography [50 USC 403g, Sec 6] (1 pp.)	1/28/92	(b)(3)	

Collection:

Record Group: Bush Presidential Records
Office: Science and Technology Policy, Office of (OSTP)
Series: O'Neil, John F., Files
Subseries: Government Organization Files
WHORM Cat.:
File Location: NASA - Earth Observing System [2 of 3]

Date Closed:	5/27/2010	OA/ID Number:	62098-004
FOIA/SYS Case #:	2005-0336-F	Appeal Case #:	
Re-review Case #:		Appeal Disposition:	
P-2/P-5 Review Case #:		Disposition Date:	
AR Case #:		MR Case #:	
AR Disposition:		MR Disposition:	
AR Disposition Date:		MR Disposition Date:	

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Removed as a personal record misfile.

Freedom of Information Act - [5 U.S.C. 552(b)]

(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

CENTRAL TRADING SYSTEMS
Satellite Imagery Division



January 28, 1992

(b)(3)

I enjoyed our phone conversation of yesterday, and certainly appreciate the leads and ideas you provided concerning potential consumers in WDC for our Russian satellite photography. I am enclosing some background information on our company, and summary sheets on the range of photography available from the three "Cosmos" series camera systems. As you will see, there is nothing currently available on the commercial market which even approaches our product in terms of resolution, world-wide coverage, price, and timely delivery. I am convinced that there are a number of consumers within the USG and military services, if only we can get our product in front of them.

I have already spoken briefly to Linda Zall and fax'd an info package to her. She seemed quite interested, and mentioned that she needed the info by Wednesday for a meeting. I am also sending an introductory letter to the other party you mentioned. I will stay in touch with you as things develop. I hope to be in Washington within the next several weeks to follow up directly and to meet with some other contacts that Reuben Johnson has developed for us. I will keep you informed as my planning takes shape. Hopefully, we can arrange to meet for some detailed discussions.

Again thanks for your help, and let me know if you have any other thoughts on how I might go about breaking into the market inside the beltway. By the way, my colleague Velon Minshew, is a Phd geologist and a remote sensing\satellite imagery expert. He supplies the technical expertise in our operation and will likely be accompanying me to Washington. I would like for him to meet you.

Sincerely,

Paul
Paul

Bush Library Photocopy

CENTRAL TRADING SYSTEMS
Satellite Imagery Division



This is to introduce the Satellite Imagery Division of Central Trading Systems (CTS), and to provide an overview of the wide range of satellite photography that we offer. CTS is the exclusive distributor in the western hemisphere for Russian high-resolution space imagery and related services. Extensive world-wide coverage is available without restriction. Since 1988, many international and domestic oil companies, aerospace corporations, academic and research institutions, government agencies, and mapping organizations have become our regular customers.

We offer a quality product and timely delivery at a very competitive price. The resolution of our Russian space photography far exceeds anything currently available from other commercial sources. Enclosed are summary sheets which outline the nature and technical specifications of the photographs acquired from three separate "Cosmos" series satellite camera systems. A price list for each product is attached. A computer inventory search for a particular area of interest to a customer can usually be accomplished within 24 hours. Should you desire, a representative sample photograph can be provided for inspection a loan basis.

CTS would welcome the opportunity to discuss with you in more detail the Russian space imagery we have to offer. We are confident that you will be impressed by our product, and hope that you will call upon us for your satellite photography needs.

Paul M. Byerly

Director of Marketing

CENTRAL TRADING SYSTEMS
Satellite Imagery Division



611 Ryan Plaza Dr.
Suite 700
Arlington, TX 76011

(817) 459-0423
(817) 461-4312 Metro
(817) 459-0721 Fax

Velon H. Minshew, Ph.D.
General Manager



CENTRAL TRADING SYSTEMS
Satellite Imagery Division

611 Ryan Plaza Dr.
Suite 700
Arlington, TX 76011

(817) 459-0423
(817) 461-4312 Metro
(817) 459-0721 Fax

Paul M. Byerly
Director of Marketing



CENTRAL TRADING SYSTEMS
Satellite Imagery Division

MK-4 PHOTOGRAPHS

MK-4 photographs were made available for the first time for sale on December 8, 1988, coinciding with President Gorbachev's visit to New York City. The MK-4 is the most sophisticated of the Soviet Union's large format topographic cameras whose products are being marketed by Central Trading Systems.

The MK-4 is a true multi-spectral camera with data recorded on three separate black and white film bases which may be combined to produce a synthesized false color image. The resolution of the MK-4 is about six meters and the product is excellent for cartographic and demographic surveys. The film contains 25 fiducial points, enabling very high accuracy in enlargements.

Outlined below are selected characteristics of the MK-4.

Number of channels	4
Focal Length	300 mm
Frame Format	180 X 180 mm
Scale (depending on altitude of survey)	1:650,000 to 1:1,500,000
Longitudinal Overlap	60 Percent
Width of Survey Band	120-270 km
Possible Spectral Zones of Channels (nm)	400-700 460-505 515-565 580-800 635-690
Types of Films Used	Black and White, Spectroscopical, 2
Resolution	6 meters

Only photographic products are available at this time. These are available as film negatives or positive, and prints. All products are available in either black and white or color. Enlargements as much as 17 fold are available.

Normal delivery time for data available in archives is two weeks. New coverage can be contracted with Central Trading Systems for future acquisition with no additional surcharge. New coverage acquisition will be on a negotiated time frame delivery.

For further information contact:

Velon H. Minshew or Paul M. Byerly
Central Trading Systems
Satellite Imagery Division
611 Ryan Plaza Drive
Suite 700
Arlington, Texas 76011
Tel (817) 459-0423
Metro (817) 461-4312
Fax (817) 459-0721

PLEASE SEE ATTACHED PRICE LIST

CENTRAL TRADING SYSTEMS
 SATELLITE IMAGERY DIVISION
 611 RYAN PLAZA DRIVE
 ARLINGTON, TEXAS 76011
 TEL (817) 459-0423
 TEL (817) 461 4312 METRO
 FAX (817) 459-0721

MK-4 PRICE LIST

PRODUCT CODE	DESCRIPTION	SCALE	UNIT PRICE
SINGLE BAND			
13.	FILM POSITIVE	1:900,000	\$1050
14.	FILM NEGATIVE	"	1110
15.	FILM POS-NEG SET	"	1190
16.	POS. CONTACT PRINT	"	210
17.	POSITIVE PRINT	1:500,000	300
18.	POSITIVE PRINT	1:250,000	440
THREE BANDS			
19.	FILM POSITIVE	1:900,000	\$2520
20.	FILM NEGATIVE	"	2660
21.	FILM POS-NEG SET	"	2860
22.	POS. CONTACT PRINT	"	420
23.	POSITIVE PRINT	1:500,000	600
24.	POSITIVE PRINT	1:250,000	880
COLOR SPECTROZONAL			
25.	FILM POSITIVE	1:900,000	\$1950
26.	FILM NEGATIVE	"	2070
27.	FILM POS-NEG SET	"	2250
28.	POS. CONTACT PRINT	"	700
29.	POSITIVE PRINT	1:500,000	1020
30.	POSITIVE PRINT	1:250,000	1600
COLOR SYNTHESIS			
31.	FILM POSITIVE	1:900,000	\$3220
32.	FILM NEGATIVE	"	3470
33.	FILM POS-NEG SET	"	3800
34.	POS. CONTACT PRINT	"	750
35.	POSITIVE PRINT	1:500,000	1070
36.	POSITIVE PRINT	1:250,000	1600

Scale of original negative is variable due to differing altitudes of satellites. Three black and white films are included with each color synthesis film positive or negative. Add \$145 to each order for shipping and handling. Orders are shipped directly to customer by Federal Express from Moscow. Payment is due at the time the order is placed unless prior credit has been arranged.

KFA-1000 PHOTOGRAPHY

KFA-1000 photography is available in both panchromatic and color products, as film positive or negatives, and as photographic prints.

Original scale is between 1:220,000--1:280,000 on 30 X 30 cm film, but scales as large as 1:20,000 are also available. Each photograph covers about fifty by sixty miles, and there is normally a 60% overlap for stereoscopic coverage in a north-south direction. Each film has five fiducial points.

Characteristics of the MFA-1000 camera are listed below.

Focal Length	1000 mm
Frame Format	300 X 300 mm
Scale	1:220,000--1:280,000
Longitudinal Overlap	60%
Width of Survey Band by 2 Cameras	120 km and more
Spectral Zones of the layers	560-670 nanometers 670-810 nanometers spectrozoal 2-layer panchromatic
Resolution	4-7 meters

The KFA-1000 photography involves two cameras, each of which is aimed eight degrees right or left of the ground track so that each photography in actuality is a very slight oblique with an eight degree tilt.

The color film is spectrozoal, with two individual emulsion layers. The color of the final photographic product depends on the number of filters employed during processing. Two filters produce a pinkish tone and three filters produce a more natural earth tone. The three filter products have about 15% less resolution than the two filter products.

All photographic reproduction is done only from master original film negatives brought down from the satellites. Only first generation derivative products are marketed.

The resolution of the KFA-1000 photography is normally about five meters. The resolution will vary slightly due to atmospheric conditions and surface receptivity. Many researchers have reported resolution of less than four meters.

The KFA is a photographic product, but CTS is developing technology to digitize the original negatives at a kernel size of about 12 microns and provide it in a digital format compatible with EOSAT TM.

Delivery time for photographic products is normally about two weeks for archive products. If archive coverage is not available, CTS will contract to obtain new coverage at the same price as archival Data.

Any scene that has more than 25% cloud cover (by Sojuzkarta calculations) will be discounted in price directly proportional to the percentage of the cloud cover.

KFA photographic products are available on a worldwide basis.

For further information, please contact:

Velon H. Minshew or Paul M. Byerly
Central Trading Systems
Satellite Imagery Division
611 Ryan Plaza Drive
Suite 700
Arlington, Texas 76011
Tel (817) 459-0423
Metro (817) 461-4312
Fax (817) 459-0721

PLEASE SEE ATTACHED PRICE LIST

CENTRAL TRADING SYSTEMS
611 RYAN PLAZA DRIVE
SUITE 700
ARLINGTON, TEXAS 76011
TEL (817) 459 0423
METRO (817) 461 4312
FAX (817) 459 0721

PRICE LIST KFA-1000

CODE	DESCRIPTION	PRICE
1	FILM POSITIVE	\$1560
2	FILM NEGATIVE	\$1650
3	FILM NEG;POS SET	\$1770
4	CONTACT PRINT	\$ 550
5	CONTACT PRINT, 2X ENLG	\$ 820
6	CONTACT PRINT, 5X ENLG	\$1400

Original negatives of the satellite imagery are the property of the USSR and may not be purchased. First generation derivative products only will be produced and marketed. Black and white copies of original black and white negatives are produced and color copies of color negatives are produced. No black and white products will be produced from color negatives. All products are guaranteed to be first generation derivatives from the original negatives.

Scale of original negative is variable due to differing altitudes of satellites carrying the cameras. Original scale of the negatives is generally about 1:270,000.

Add \$145 shipping and handling to each order. Orders are shipped by Federal Express directly to customer from Moscow. Payment is due at time order is placed unless prior credit has been established.

KATE-200 PHOTOGRAPHS

The KATE-200 is one of the earlier of the camera systems whose product is offered through Central Trading Systems. The resolution is variable, between 15 and 30 meters, comparable or slightly better than the EOSAT TM.

The characteristics of the KATE-200 are listed below.

Number of Channels	3
Focal Length	200 mm
Frame Format	180 X 180 mm
Scale (at survey altitude of 200 km)	1:1,000,000
Longitudinal Overlap	80, 60, 40, 20%
Width of Survey Band (Altitude of 200 km)	180 km
Channels Spectral Zones (nm)	500-600 600-700 700-850
Resolution	15-30 m
Type of film used	Panchromatic

Only photographic products are available at this time. These are available as film negatives or positives, and prints. All products are available in either black and white or color synthesis. Enlargements as much as 17 fold are available.

Normal delivery time for data available in archives is two weeks. New coverage can be contracted with Central Trading Systems for future acquisition with no additional surcharge. New coverage acquisition will be on a negotiated time frame delivery.

For further information contact:

Velon H. Minshew or Paul M. Byerly
Central Trading Systems
Satellite Imagery Division
611 Ryan Plaza Drive
Suite 700
Arlington, Texas 76011
Tel (817) 459-0423
Tel (817) 461-4312 Metro
Fax (817) 459-0721

PLEASE SEE ATTACHED PRICE LIST

CENTRAL TRADING SYSTEMS
 611 RYAN PLAZA DRIVE
 SUITE 700
 ARLINGTON, TEXAS 76011
 TEL (817) 459 0423
 METRO (817) 461 4312
 FAX (817) 459 0721

KATE-200 PRICE LIST

PRODUCT CODE	DESCRIPTION	SCALE	UNIT PRICE
SINGLE BAND			
37.	FILM POSITIVE	1:1,350,000	\$230
38.	FILM NEGATIVE	"	250
39.	FILM NEG-POS SET	"	280
40.	POS. CONTACT PRINT	"	100
41.	POSITIVE PRINT	1:700,000	140
42.	POSITIVE PRINT	1:350,000	220
THREE BANDS			
43.	FILM POSITIVE	1:1,350,000	\$550
44.	FILM NEGATIVE	"	580
45.	FILM NEG-POS SET	"	630
46.	POS. CONTACT PRINT	"	210
47.	POSITIVE PRINT	1:700,000	310
48.	POSITIVE PRINT	1:350,000	470
COLOR SPECTROZONAL			
49.	FILM POSITIVE	1:1,350,000	\$450
50.	FILM NEGATIVE	"	480
51.	FILM NEG-POS SET	"	510
52.	POS. CONTACT PRINT	"	200
53.	POSITIVE PRINT	1:700,000	280
54.	POSITIVE PRINT	1:350,000	420
COLOR SYNTHESIS			
55.	FILM POSITIVE	1:1,350,000	\$690
56.	FILM NEGATIVE	"	750
57.	FILM NEG-POS SET	"	790
58.	POS. CONTACT PRINT	"	235
59.	POSITIVE PRINT	1:700,000	300
60.	POSITIVE PRINT	1:350,000	450

Scale of the original negative is variable due to differing altitudes of satellites. Three black and white films are included with each color synthesis film positive or negative. Add \$145 to each order for shipping and handling. Orders are shipped directly to customer by Federal Express from moscow. Payment is due at the time the order is placed unless prior credit has been arranged.

NATIONAL RESEARCH COUNCIL

COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS

2101 Constitution Avenue Washington, D.C. 20418-0001

FEB 5 1992

Telephone: (202) 334-3061
Fax: (202) 334-2154
BITNET: (CPSMA@NAS)

February 3, 1992

Dr. Karl A. Erb
Associate Director (Acting)
Physical Sciences and Engineering
Office of Science and Technology Policy
OEOB-428
Washington, D.C. 20506

Dear Karl:

On behalf of Mr. Charles A. Zraket, Chairman of the NRC Panel to Review EOSDIS Plans, I would like to invite you to attend the first meeting of the Panel on February 14, 1992.

The meeting will be at the National Academy of Sciences, 2101 Constitution Avenue, N.W., Room 250. Copies of the agenda, Terms of Reference for the study, and Panel membership list are attached.

We would also be pleased if you would join us for a reception at 6:00 p.m. in the Rotunda of the NAS Building.

Please contact me (202/334-3061) if you have any questions.

Sincerely Yours,



Norman Metzger
Executive Director

Enclosures



**COMMISSION OF PHYSICAL SCIENCES,
MATHEMATICS, AND APPLICATIONS**

PANEL TO REVIEW EOSDIS PLANS

February 14 - 15, 1992
Washington D.C.

PRELIMINARY AGENDA

February 14, 1992 -- NAS 250

8:30 am Continental breakfast

EXECUTIVE SESSION

9:00 Welcome and Introduction C. Zraket

9:15 Discussion of Charge to the Panel

10:00 Potential Sources of Bias N. Metzger

GENERAL SESSION

11:00 EOS Overview - history, timelines Len Fisk

12:00 noon LUNCH

1:00 pm Overview of Global Change Program R. Corell

1:30 NASA plans for EOS
(30 min presentation + 30 min questions/discussion) S. Tilford

2:30 NASA plans for EOSDIS
(60 min presentation + 60 min questions/discussion) J. Dozier, et. al.

4:30 Panel discussion

6:00 ADJOURN - Reception - NAS Rotunda

7:00 Panel Dinner - NAS Members Room

8:30 am Continental breakfast

EXECUTIVE SESSION

9:00 Panel discussion:

- Preliminary agreement on key issues
- Additional questions for NASA
- Additional presentations needed
- Agenda for next meeting

12:00 noon LUNCH

1:00 pm Panel Discussion (continued)

- Formation of Subgroups and assignments
- Schedule
- Other matters

2:30 ADJOURN

FINAL TERMS OF REFERENCE

[NASA - NSPC - OMB - OSTP]

The National Aeronautics and Space Administration is restructuring the Earth Observing System (EOS) to be configured to fly on a series of intermediate and small spacecraft, as opposed to a series of large spacecraft. This reconfiguration will result in a different sequencing of measurements and changes in the volume of the data compared to the original EOS program.

The EOS Data and Information System (EOSDIS) is designed to process, archive, and make readily available to a broad range of users the data from EOS and also from appropriate current and upcoming spacecraft that fly in advance of EOS. Accordingly, the EOSDIS architecture will need to be compatible with the program.

The National Research Council will convene a panel of technical experts to conduct a review of NASA's plans for EOSDIS. Members of the panel should be drawn from appropriate National Academy of Sciences and National Academy of Engineering bodies and the technical community in order to bring together a broad mix of expertise in space data systems, data archival and distribution systems and in global change research. A significant proportion of the panel should have expertise in the procurement, technical, and management aspects of large database systems outside the area of global change research. As recommended in the Report of the Earth Observing System (EOS) Engineering Review Committee, the goal of the review should be to: validate the engineering and technical underpinnings of the EOSDIS; assess its potential value to scientific users; suggest how technical risk can be minimized; and assess whether current plans provide for sufficient resiliency to be adaptable to changing requirements (i.e., budget environments, data volumes, etc.).

The EOSDIS program is currently selecting an EOS Core System contractor through a competitive procurement. Consequently, access to information by the review panel will be constrained to publicly available documents and presentations. Furthermore, no member selected to participate on the panel should have any financial interest in any of the competing contractors.

The panel will review NASA's plans for EOSDIS in order to address the following questions:

- Does the current EOSDIS plan reflect the restructured EOS global change data traffic model (i.e., are EOSDIS features properly sequenced with the complexity of the instruments to be flown and other data sources)? Can/should some of these features be delayed given the current data traffic model?

- Are the plans for EOSDIS technically realistic and appropriate to meet the information systems demands of the EOS program, with adequate milestones and prototype demonstrations of capabilities? Do these milestones and demonstrations provide adequate benchmarks for monitoring the progress and performance throughout the development and operational phases of the EOSDIS?
- Does the EOSDIS plan meet the requirements of expected research users, especially the global change research community? Do the plans for EOSDIS provide adequately for involving university, national laboratory, government, and other users in influencing the character of each incremental phase of the system?
- Is NASA's plan for the development of EOSDIS sufficiently flexible to match the pace and scope of an observing program that is developed in an evolutionary fashion (i.e., is EOSDIS structured to respond to budget fluctuations or variations in the users demands)? If not, what actions would you recommend NASA taking to address this issue?
- Is NASA's EOSDIS management plan appropriate? For example, is the planned allocation of responsibilities between distributed and centralized elements of EOSDIS conducive to user utilization as well as efficiency and cost effective execution of the EOS program (i.e., is the allocation between distributed and centralized elements optimal)? If not, what actions would you recommend NASA taking to address this issue?
- Is the planning and design for EOSDIS sufficiently flexible to accommodate possible advances in computer hardware and software technologies that may occur over the lifetime of the system? Can/should additional flexibility be built into the design of the database?
- Does the plan for EOSDIS include provision for expansion of the system to include or access other data systems (e.g. National Space Science Data Center, National Geophysical Data Center, Earth Resource Observation System Data Center, and other national and international data systems)? What changes would be required to achieve sufficient flexibility to permit expansion?

Overall, the panel will provide a critical review of NASA's plans for EOSDIS, identify potential problems, and recommend actions that should be taken to address these problems. It will not be expected to offer a redesign of the system.

The panel will provide a status report in March 1992 summarizing the progress of the EOSDIS review, including the principal issues identified by the panel for consideration, and will provide a final report summarizing the findings and conclusions of the review by August 31, 1992.



COMMISSION ON PHYSICAL SCIENCES,
MATHEMATICS, AND APPLICATIONS

PANEL TO REVIEW EOSDIS PLANS

Membership List

(as of 1/31/92 - additional members may be added)

Chairman

Charles A. Zraket
Scholar in Residence
The Kennedy School of Government
79 John F. Kennedy Street, Room P-18
Cambridge, MA 02138
(617) 271-2356 (MITRE)
(617) 495-8132 (Harvard)
FAX: (617) 271-7999 (MITRE)
FAX: (617) 495-8963 (Harvard)

Members

D. James Baker
Joint Oceanographic Inst.
1755 Massachusetts Ave.
Washington, DC 20036-2101
(202) 232-3900
FAX: (202) 232-8203

Kenneth Daugherty
Chief Scientist
Defense Mapping Agency
8613 Lee Highway
Fairfax, VA 22031
(703) 285-9178
FAX: (703) 285-9374

Richard E. Hallgren
American Meteorological Society
45 Beacon Street
Boston, MA 02108
(617) 227-2425
FAX: (617) 742-8718
Washington DC office (202) 466-6070

Mailing Address
6121 Wayside Drive
Rockville, MD 20852

Kenneth C. Jezek
Byrd Polar Research Center
125 South Oval Mall
Columbus, Ohio 43210
(614) 292-6531
FAX: (614) 292-4697

Anita Jones
Chair, Computer Science Department
University of Virginia
Thornton Hall
Charlottesville, VA 22903
(804) 924-7605
FAX: (804) 982-2214

John E. Hopcroft
Department of Computer Science
Cornell University
4130 Upson Hall
Ithaca, NY 14853
(607) 255-7416
FAX: (607) 255-4428

Ethan J. Schreier
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218
(301) 338-4740
FAX: (301) 338-4767

Staff

Norman Metzger
Executive Director
Commission on Physical Sciences,
Mathematics, and Applications
(202) 334-3061
FAX: (202) 334-2154

Richard C. Hart
Space Studies Board
(202) 334-3477
FAX: (202) 334-3701

Gael F. Squibb
Center for Astrophysics
60 Garden Street
Cambridge, MA 02138
(617) 495-7061
FAX: (617) 459-7356

Jeffrey D. Ullman
Professor of Computer Science
Stanford University
Stanford, CA 94305
(415) 723-1512
FAX: (415) 725-7411

Ferris Webster
College of Marine Studies
University of Delaware
Lewes, DE 19958
(302) 645-2532
FAX: (302) 645-4007

Monica Krueger
Computer Science and Telecommunications
Board
(202) 334-2605
FAX: (202) 334-2791

Lorraine Wolf
Board on Earth Sciences and Resources
(202) 334-3368
FAX: (202) 334-1377

(16) Linda Fall

Hirsch asked Fall for info on EOSDIS. Dozier is sending it to Fall tonight.

Dozier feels (301) 286-8228

- Freeman & Banks not experts on info systems.
- Banks has his own agenda.
- Felt that Freeman's study was poorly done.
- The EOSDIS structure is just fine.

Linda spoke to Lee Hamerstrom Fri. (DoD is organizing its R&D into 7 areas. One is communications & surveillance. Which is relevant to EOSDIS.) Faga & Reiss have agreed that he will run this technology area for all DoD. Has "Global End Concept."

Hirsch & Lee will talk soon.

Fall told her about DAB memo to Gates. Very excited.

Reiss just asked Lee to put together topics for Jason's.

(Paper Prepared for the DDS&T in response to Senators David Boren and Al Gore:
May 1990)

CAPABILITY OF XXXXXXXXXXXX SATELLITE SYSTEMS TO PERFORM THE MISSION OF THE GLOBAL CHANGE RESEARCH PROGRAM

THE U.S. GLOBAL CHANGE RESEARCH PROGRAM

The U.S. Global Change Research Program will attempt to document and comprehend how the Earth works as a system. As part of this, the international scientific community is organizing research efforts to advance our knowledge of both natural and human-induced global change. This Global Change Program contains NASA's Mission to Planet Earth, which contains among its initiatives the Earth Observing System (EOS) and Earth Probes.

EOS consists of a space-based observing system, a Data and Information System (EOSDIS) and a scientific research program. It represents the initiation of a comprehensive, global observing system with broad and high-resolution spectral and spatial, as well as long-term temporal, coverage of the earth. The space component will consist of two series of polar-orbiting platforms with launch of the first platform in FY 1998. EOS will be supplemented by companion European (European Space Agency) and Japanese platforms and will provide the first coordinated, simultaneous measurements of the interactions of the atmosphere, oceans, solid earth, and hydrologic and biogeochemical cycles. A multitude of remote sensing instruments will be housed on these platforms, which include passive and active microwave, spectral (visible, infrared, thermal, multispectral, hyperspectral), Fourier Transform spectrometers (for ultraspectral-gases), ranging lasers, and laser sounders, altimeters, and scatterometers.

Earth Probes will provide a focus on observing specific Earth processes where smaller platforms and/or different orbits from EOS are required.

EOSDIS will be a state-of-the-art information system to foster rapid and easy access of data for the worldwide network of users. There also will be a lower orbiting manned version, more familiarly known as the space station.

The EOS approach is one of an integrated effort combining satellite and ground-based measurements, modeling, and data analysis. Generally, no single EOS instrument will be able to fully address any global change question. However, the simultaneous set of measurements provided by the EOS platforms would provide the full set of essential satellite data needed to answer any specific set of scientific questions. The following will address the topics listed in Senator Gore's 12 January 1990 letter to Senator Boren, the desired sensor suites needed, and the Intelligence Community's ability to perform any part of the mission.

LAND SURFACE PROPERTIES

Snow and ice Cover

Snow and ice are two land surface properties that will be addressed by EOS. Scientists are interested in area coverage, spectral albedo, and for snow, its grain size, and contamination amount in the near surface layer. To remotely obtain these parameters one needs data from the 0.45 micron, 1.1 micron (near IR), and 1.6 micron (SWIR) spectral bands. Besides these three important bands, spectral data should be collected at 10 to 30 nanometer intervals on either side of the bands to obtain a more comprehensive spectral signature. (For snow, we can get away with 30 nanometer intervals sampling scheme.) These applications demand near daily coverage, with sensors having broad area coverage at one half kilometer spatial resolution.

Radar will also detect some important snow characteristics such as depth, density, and free liquid water content (how much water is contained in the snow). Although there are still some experiments, investigators believe three frequencies of radar are needed to determine all of the important snow characteristics. These frequencies are the L band (1.4 gigahertz), C band (6 gigahertz), and X band (10 gigahertz) at a 30 to 40 meter spatial resolution. The longer wavelengths L and C band data penetrate the snow and therefore determine snow depth, and consequently the amount of snow. These bands, because they do penetrate the snow, would enable us to estimate surface boundary conditions. The SAR instrument on EOS is not funded.

Passive microwave techniques will also contribute information. The desired microwave frequencies are the 18 and 37 gigahertz regions at two polarizations. Scientists currently acquire microwave information on snow and ice from the Sensor System Microwave Imager (SSM/I) which flies on the Defense Meteorological Satellite Program (DMSP). SSM/I provides all-weather, day/night data for computing sea ice extent and age-type. This sensor has four channels (19.3, 22.2, 38.0, and 85.5 gigahertz) with a 25 kilometer spatial resolution. The 25 km spatial resolution is not always useful for snow and ice applications in the mountains and plains. EOS has proposed a similar microwave imager, but with a better spatial resolution (hopefully at 2Km). C band SAR is also desired for sea ice properties. The passive microwave data is useful for broad coverage, but the SAR would add characterization of the smaller surface features on the ice.

EOS will measure ice sheet volume with its proposed onboard laser altimeter. The altimeter will be able to accurately measure changes in height, daily if necessary. This data will be used to, for example, help determine where the water is coming from that causes the 1 to 2mm rise per year of sea level. (This is a bit of an enigma, for both Antarctica and Greenland are growing.) The altimeter will allow scientists to keep track of the ice surface. The laser altimeter's profile of measurements would be accurate to approximately a few centimeters of absolute altitude.

Intelligence's Community's contribution to Snow and Ice

The Intelligence Community XX
 XX
 XX

XX
 XXXCXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 XXXXXXXXXXXXXXXX-----XXXXXXXXXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Vegetation Indices

Since the advent of the civil satellite remote program (LANDSAT), substantial research has been directed toward establishment of various indices for identification and quantification of resource phenomena such as crop development, crop identification, soil moisture changes, effect of background soil radiance on vegetation, etc. From EOS, scientists expect to gain much information on some of the vegetation indices, such as vigor and biomass, and also the area and degree of vegetative cover. One way to determine vigor is to measure the index of vegetation, or the "greenness", which is a measure of the health of the vegetation growing in a particular region. It can be calculated from spectral remote sensors and is currently being determined using data from the unclassified LANDSAT satellite. The index of vegetation is determined by ratioing the red minus the near IR bands (0.63 to 0.69 minus 0.73 to 0.86) and dividing by their sum.

Scientists are concerned with the efficiency of carbon dioxide uptake by plants and in particular how it relates to biomass (the amount of vegetation) and to net primary productivity values. These values will tell us how well crops are growing, and can be calculated by subtracting plant respiration from photosynthesis.¹ Photosynthesis can be determined, indirectly, by measuring the amount of cellulose and lignin material in the plant, as these materials are indices of the rate of photosynthesis. Carbon dioxide uptake is crucial for plant growth and the efficiency of this process can be inferred by the amount of photosynthesis. To remotely get at the quantities of cellulose and lignin in the vegetative area, we must obtain data from spectral sensors (hyperspectral) in the visible and near IR, and with a minimum of 80 channels. The preferred spectral resolution is 10 nanometers (at 20 nanometers, one loses critical spectral resolving power and we do not buy much at 5 nanometers). For important areas in the tropics, such as the Amazon, where the region is over half of the time cloud covered, a spectral sensor would be out of business. In this case biomass could be calculated from radar data, using both the L and C bands. Radar would see through the clouds and also through the leaves, thus getting to the wood to complete a biomass calculation. The EOS program is planning for a broad area radar

¹Photosynthesis is the synthesis of complex organic materials, especially carbohydrates, from carbon dioxide, water, inorganic salts, using sunlight as the source of energy and with the aid of a catalyst, such as chlorophyll, the green coloring matter of leaves and plants.

capability at 30 meters (large swath at low spatial resolution) but they also have a mode for a better spatial capability on just a sampling basis. (Because of data rate problems, they cannot map the world with high spatial resolution instruments.) EOS is not considering the X band for this application.

Evapotranspiration² can be determined remotely using spectral systems having the correct bandpaths. Transpiration is important, for if a plant is transpiring, it is healthy and has water and if not it could be a pre-drought manifestation. Scientists look at the temperature contrast between vegetation and the atmosphere to determine evapotranspiration rates. Temperature data is needed from both the ground and from the plants. To get the temperature of the ground, one must first determine the emissivity by collecting spectral data in all of the bands in the 8 to 14 micron region. The 2.1 & 2.2 micron region is also needed to get a handle on the amount of water present in the plant.

Intelligence Community's Contribution to Vegetation Indices

The Intelligence Community XX
XX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Soil moisture

The determination of soil moisture, remotely, is an intrinsically difficult problem. Soils are a complex biological and chemical medium; the chemically active clays and soil organic matter adsorb or retain water, and that moisture which is determined at the surface, using remote sensing, does not usually reflect the true soil condition. The surface of the soil dries out first and most of the moisture is hidden inside of the soil; therefore any remote sensing technique, such as visible or near infrared sensing that looks at the soil surface will not obtain the true soil moisture. There has been research showing that the passive microwave (i.e. 2 cm wavelength) region may have promise, as this region will penetrate and get thermal emission from within the soil. Active radar systems could be helpful, as their return is dependent upon many variables, such as moisture. Scientists also try to infer soil moisture from the state of the overlying vegetation, i.e. evapotranspiration, or other vegetative indices. As noted in the previous section, these indices are best obtained with spectral systems of high spectral resolution, in the appropriate spectral regions.

²Evapotranspiration is the combined loss of water from a given area during a specified period of time by evaporation from the soil surface and transpiration (water loss) from plants.

Intelligence Community's Contribution to Soil Moisture

The Intelligence Community XX

-----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XX

OCEAN VARIABLES

Sea Surface Temperature

Scientists are interested in measuring sea surface temperature accurately to help determine the extent of the Greenhouse³ Effect and global warming. If there is global warming, we should see its effect by the warming of our oceans. EOS will have onboard instruments that will measure ocean temperature. Scientists need the ocean temperature measurement to within 0.2 to 0.5 degrees (one could measure the temperature of land masses, but the ocean would be a more straightforward medium to measure). In order to get an accurate measurement of ocean temperature, one must account for the effect of the atmosphere. This is because the atmosphere, because it has its own spectral signature, will influence any measured radiance value obtained of the earth by a satellite. In order to correct for the atmosphere when there are no clouds, we need three discrete spectral bands in the infrared portion of the spectrum. The needed bands are in the 3.5 to 4.0 micron, the 10.5 to 11.5 micron, and the 11.5 to 12.5 spectral regions. Unfortunately there are clouds about half of the time; in this case one must obtain data from a multi-channel microwave sounder.

³The Greenhouse Effect is the effect produced by certain gases, such as carbon dioxide, on a planet's atmosphere by raising the equilibrium temperature of the surface of the planet, thus preventing the transmission of long-wave radiation from the surface but permitting the inward transmission of short-wave radiation from the sun to the surface.

Intelligence Community's Contribution to Sea Surface Temperature

XX
 XXXXXXXXXXXXXXXXXXXXXXXX-----

XX

Sea Ice Type

Scientists need to determine the location and the extent of sea ice. They also are interested in distinguishing first year from multiyear ice, and ice thickness and age. In order to do the analysis, scientists need a three frequency passive microwave capability in the 37, 18 and 10 gigahertz region, with a 10 km spatial resolution capability.

Intelligence Community's Contribution to Sea Ice Type

The Intelligence Community XX

XX

Sea Ice Motion

Scientists are interested in sea ice movement. They need C band Synthetic Aperture Radar (SAR), at a 30 to 50 meter spatial resolution, to note flow features so that they can draw ice motion vectors. They would utilize automatic change detection techniques to monitor this motion.

Intelligence Community's Contribution to Sea Ice Motion

The Intelligence Community XX
 XX

Sea Level Data

Accurate Sea level data is needed for a vast assortment of global issues. For example, scientists would like to measure the rebound of the land masses due to the retreat of the glaciers from the last ice age. However, there is the difficult problem of sorting out the relative contribution of sea level versus land rebound. To do this accurate measurement task, EOS proposes to use radar altimeter data in concert with tidal gages. The radar altimeter data is needed to map ocean surface topography which is then used to infer ocean circulation.

Intelligence Community's Contribution to Sea Level Data

The Intelligence Community XX

XXXXXXXXXXXX

Ocean Carbon Dioxide

As noted above in the section on sea surface temperature, scientists are trying to determine the extent of the Greenhouse Effect, as it pertains to Global warming. In this regard, scientists are interested in the role of the ocean as a carbon dioxide sink (anotherwards, what is the ocean's carrying capacity for carbon dioxide?) A portion of the carbon dioxide in the atmosphere is used for photosynthesis on both the land and in the ocean. The rate of photosynthesis is tied to the amount of chlorophyll and chlorophyll can be measured remotely using multi and hyperspectral sensors in the visible and near infrared region. EOS plans for a sensor devoted totally to the measurement of ocean chlorophyll. (The sensor will be a 64 band spectral system in the 0.4 to 1.0 micron region that tilts, to eliminate sunlight glint from the ocean surface.) In the deep ocean, scientists require a seven band spectral sensor; however, in the coastal regions, where the water is no longer clear but is laden with sediment, more spectral bands are required (perhaps 20 bands). A one km spatial resolution is the EOS specification for this mission.

Intelligence Community's Contribution to Ocean Carbon Dioxide

The Intelligence Community XX
XXXXXXXXXX

Ocean Circulation Patterns

Ocean circulation is inferred by using the measurements of ocean temperature, chlorophyll and sea level as discussed above. In addition, a scatterometer placed on EOS would obtain sea state by measuring surface roughness; a low spatial resolution active microwave radar is also appropriate for this application. (The Intelligence Community XX)

GEOPHYSICAL VARIABLES

Plate Motions

Scientists now know that the earth is composed not just of a thick rock overburden over a molten core, but that there are in fact huge semi-rigid continental size plates of rock "floating" over the earth's mantle. The movement of these plates is called plate tectonics. Plate motion has major implications; for example, many earthquakes (i.e. Californian) are caused by

the Pacific ocean plate thrusting itself under the North American Plate. The Himalya Mountains were formed by the collision of two continental plates. Geologists are interested in measuring the direction and rate of motion of these plates in order to better understand the earth's past and future tectonic processes. These measurements would give geophysicists accurate information, for example, on the rate that the North American plate moves with respect to the pacific plate. Also, space based measurements could enable precise measurements, by triangulation, of movements along faults. EOS plans for a Geodynamics laser ranging system that will precisely measure plate and fault motions using ground corner reflectors.

The enormous heat and pressure caused by the collision of plates causes catastrophic changes in the mineralization (and thus in the composition) of the associated rock materials. Geologists can see the effect of plate collisions by noting massive changes in rock materials within vast regions. For example, when the rock material ophiolite is present, it is indicative of both past collisions on the sea floor and of the smashing of continents. Specific rock types (geologists use the word lithologies) can be determined remotely using spectral sensors having the appropriate spectral coverage and spectral resolution. An important area for this application is the 8 to 14 micron thermal infrared region, where geologists use emissivity values obtained from this region to identify the rock minerals. The 8 to 14 micron region is most suitable for geologic applications, with a 1/3 micron or better spectral resolution, and with a NEdeltaT greater than 0.25 degrees. Spatial resolutions of about 60 meters is appropriate (a better spatial resolution would be beneficial, but we must trade off needed data with the capability of EOS to handle large volumes of data).

Intelligence Community's Contribution to Plate Motions

The Intelligence Community XX

 -----XXXXXXXXXXXX

GEOLOGY AND SOILS

Geologists and soil scientists are interested in remote sensing techniques that give them rock and soil composition. This information would be used to create worldwide soil and geologic maps; the soil maps would be invaluable for agricultural and civil engineering projects, and the geology maps are needed as basic data for petroleum and mineral exploration programs and to understand the structural and tectonic history of the earth. We do not have comprehensive worldwide soil and geologic maps. Many areas of the world have difficult access, which makes the mapping task often impossible; in these areas, remote sensing would be the only method that could acquire the data.

An important application of both the United States's EOS and also of the Japanese polar platform is for mineral exploration. The use of remote sensing data by commercial mineral and also petroleum companies is rarely publicized in the scientific literature because of the proprietary nature of the information. (Remote sensing techniques are often more straightforward for mineral exploration than they are for petroleum exploration; this is because we can often directly detect the presence of minerals, but the presence of hydrocarbons usually has to be inferred by various sorts of collateral geologic and geophysical information.) With mineral exploration, geologists look for halos of hydrothermal alteration. Hydrothermal alteration is simply the altering of the host rock or soil material by heat, water, and the presence of the ore deposit. Remote sensing techniques spectrally identify the altered material, which then acts as a lead to the presence of a valuable metal deposit. Different rock minerals are indicative of different types of alteration; for example, argillic (clayey) minerals, such as kaolinite, jarosite, and gypsum are associated with ore deposits like silver, copper, and zinc. The preferred spectral bands to observe argillic alteration are in the near infrared spectral region, with spectral resolutions of about 50 nanometers. Some of the important spectral band centers are 2.165, 2.205, 2.260, 2.330 and 2.395 microns.

Silicic alteration, on the other hand, is commonly associated with gold, such as the altering of the rock to quartz. Indeed, quartz is a search light in the 8 to 14 micron region, so if there is silicic alteration associated with minerals such as with gold, you pick it up in the 8 to 14 region. The 8.3 to 8.65 spectral region is a superb region to identify silicic alteration. This spectral region will not pick up the alteration by itself, as you must have spectral information in other bands for contrast, such as the 10.6 and 11.3 micron region. Other important spectral bands for rock type discrimination are the 8.65 and 9.10 micron region.

Ore deposits are also associated with geobotanical anomalies; these anomalies are defined as changes in the overlying vegetative cover caused by the presence of a, say, toxic metal buried beneath the surface. For example, massive nickel deposits have been found in New Guinea because the overlying vegetation was stressed by the poisonous nickel in the soil, and from a remote perspective, anomalies in vegetation growth patterns could be identified. Sometimes these changes are extremely subtle, but a spectral system can be used to detect these changes.

For petroleum exploration, geologists are also interested in the extent of carbonate rocks; carbonate rocks are indicative of previous coral or limey environments, areas which can contain hydrocarbons; carbonates are most easily detected in the near infrared portion of the spectrum.

Finally, the Japanese are greatly interested in detecting areas of hydrothermal, or geothermal, activity-- areas which could be sources of natural energy. Geothermal energy is often localized along faults. Although it is difficult to locate these areas from space, the Japanese hope to use a combination of thermal remote sensing, combined with more standard visible-near infrared multispectral techniques, to locate these prime areas.

For these geological applications, the spatial resolution desired in the near infrared is about 30 meters, and in the thermal infrared, about 90 meters (to obtain the required ΔT in the thermal infrared region, a larger spatial resolution, or spot size, was required; it was not possible, due to weight restrictions, to use a larger mirror.)

Another geological application for the sensors on the polar platforms is sand dune mapping, which, by monitoring the occurrence and migration of the dunes, would show the extent of desertification. The sand dunes generally contain a lot of quartz, and as noted above, quartz shows up beautifully in the thermal infrared. By monitoring the extent and the movement of the dunes, scientists will be able to get a handle on the extent of desertification. Monitoring would be conducted with a combination of the thermal bands, and also with some visible bands.

For soils, the 8 to 14 micron region is also considered optimum, but this is still a matter of discussion among soil scientists. There has not yet been enough spectra of soils measured to determine this.

Intelligence Community's Contribution to Geology and Soils

The Intelligence Community XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

CLIMATE AND ATMOSPHERIC VARIABLES

An important mission of EOS will be to support meteorology. In order to make accurate weather forecasts, we need daily global measurements of atmospheric surface temperature and water vapor profiles. Our current weather satellites provide these data, but EOS plans for a new generation of instruments. In order to make these measurements, we must have both an infrared sounder, in the 3 to 17 microns regime, and a multi channel microwave radiometer or sounding capability, which would make measurements through the clouds. Some of the sensors needed to pursue climatology include:

Visible; repetitive mapping
Cloud Amount

Visible and Near IR
cloud fractional area
cloud optical thickness

Thermal (8 to 14)

Cloud top temperature
 cloud top height
 cloud base height
 cloud thermodynamic phase
 cloud particle effective radar

Visible and Thermal IR

Cloud 3-D structure
 Cloud field size distribution

Thermal IR

Cloud emissivity

As part of the climatology mission, EOS hopes to accurately measure tropical precipitation, at least on a daily basis. Ninety percent of the world's rainfall falls in our tropical regions. A desired approach is to use an active radar system that can measure radar backscatter from raindrops, and thus could provide values for rates and volumes of rainfall over the tropics.

EOS will also pursue fundamental issues related to atmospheric chemistry and physics of both the lower atmosphere (the troposphere) and the upper atmosphere (the stratosphere). These issues include: 1) the increase, in the troposphere, of gases implicated in greenhouse warming; 2) the increase in tropospheric ozone; 3) the precursors of acid rain; and 4) the exchange of gases with the stratosphere leading to stratospheric ozone depletion. To do this mission, scientists must understand the transport and distribution of gaseous species both in the troposphere, and the exchange of some of these species between the troposphere and the stratosphere. These transported species include the noxious chemicals which enter the atmosphere from our industrial cities, such as the nitrogen oxides generated by car emissions and power plants. Chemical reactions involving these nitrogen oxides contribute to the buildup of tropospheric ozone (ozone in the lower atmosphere is toxic to plant life.) Scientists are also interested in the amount of atmospheric carbon monoxide, as carbon monoxide is toxic to humans. Carbon monoxide is generated by industrial facilities, but it is also caused by the slash and burning practices in the Amazon and in Africa. These slash and burn practices have caused dramatic increases in atmospheric tropospheric carbon monoxide. Scientists are also interested in the exchange of gases between the upper and lower atmosphere. For example, the notorious chlorofluorocarbons (CFC) that are used for aerosol propellants, and also in refrigeration, have been implicated in destroying stratospheric ozone. The CFC's must pass upward through the troposphere into the stratosphere, and part of the mission of EOS will be to track the global distribution of these and other atmospheric chemicals.

The solution to the measuring of all of these gaseous species is global monitoring, to insure that we can get a global perspective of where the species have come from, and where they are going in the atmosphere. EOS includes with its payloads the instruments necessary to study the global processes which control the stratospheric ozone layer and to monitor changes in tropospheric gases. In order to do these measurements, we must have a

high resolution FTS spectrometer. To measure accurately atmospheric circulation, we must have a laser atmospheric sounder. Such a sounder would measure the backscatter from aerosols in the lower atmosphere, and by watching aerosol movement, would give us an accurate handle on wind speed and direction. (The EOS program is greatly interested in monitoring tropical winds.)

Intelligence Community's Contribution to Climate and Atmosphere

The Intelligence Community XX

-----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX-----XXXXXXXXXXXX

LIMITATIONS OF XXXX/XXXX/XXXX IMAGERY FOR EOS MISSIONS

XXXXXXXXXX reconnaissance systems are designed primarily to
XXXXXXXXXXXXXXXXXXXXXXXXXXXX The goal of the XXXXXXXXXXXXXXXXXXXXXXXX programs
has been to XXXXXXXXXXXXXXXXXXXX-----

---- Advances in sensor technology of the late -----

The focus of -----

Nonetheless, our archival XXXXXXXXXXXXXXXXXXXXcould be very useful to the EOS program, as a baseline historical record of portions of the earth.

TOPOGRAPHIC SUPPORT TO THE EOS PROGRAM USING THE XXXX

The Defense Mapping Agency (DMA) XX

There are some constraints, however, in the value of this data. First and foremost, XX XXXX-----

---XXX

DATA HANDLING SUPPORT TO EOS

There is much concern about the high data rates and supporting transmission, relay, and ground support technology to be developed for EOS. The Intelligence Community XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXX
XXXXXXXXXXXXX-----
-----XXXXXXXXXXXXXXXXXXXXX

CAN EOS INSTRUMENTS HELP THE INTELLIGENCE COMMUNITY?

Many of the sensor packages that are proposed for the EOS platforms
XXX

-----XXXXXXX

Perhaps a way of phrasing a response to Congress should be:

"Ask not what classified sensors can do for the civil community..."
"But rather,... What civil sensors can do for the Intelligence Community."

[illegible][illegible]

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

[illegible][illegible]

Call Lee on MKV's
recommendation.

Document Originally
Attached to
Following Page

Withdrawal/Redaction Sheet

(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
02. Report	Statement of Issue (2 pp.)		(b)(1)	

Collection:

Record Group: Bush Presidential Records
Office: Science and Technology Policy, Office of (OSTP)
Series: O'Neil, John F., Files
Subseries: Government Organization Files
WHORM Cat.:
File Location: NASA - Earth Observing System [2 of 3]

Date Closed: 5/27/2010	OA/ID Number: 62098-004
FOIA/SYS Case #: 2005-0336-F	Appeal Case #:
Re-review Case #:	Appeal Disposition:
P-2/P-5 Review Case #:	Disposition Date:
AR Case #:	MR Case #:
AR Disposition:	MR Disposition:
AR Disposition Date:	MR Disposition Date:

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Removed as a personal record misfile.

Freedom of Information Act - [5 U.S.C. 552(b)]

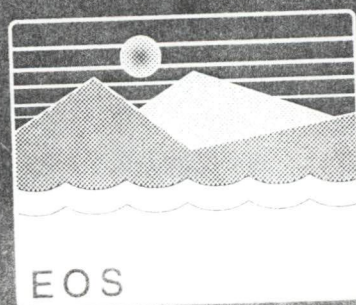
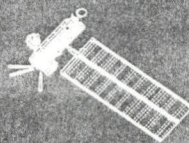
(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

EOS Reference Handbook

1991

NASA

**Goddard Space
Flight Center**



E A R T H O B S E R V I N G S Y S T E M

EARTH OBSERVING SYSTEM

BACKGROUND

We already know from geological investigations that the Earth has undergone significant changes in its physical configuration since the time of its formation some 4.5 billion years ago. Indeed, the entire history of the Earth should be seen as a dynamic continuum, with changes taking place at all time scales. The dynamic character of the Earth makes it difficult and interesting from the scientific viewpoint. What is disturbing, however, is that there now exist data that indicate that the rate of change of several key components of the Earth system is increasing, and that human activity is a likely impetus for this increased rate of change. Changes are now occurring so rapidly that within the span of a single human lifetime we can measure significant ecological and economic effects on our home planet.

To monitor these perceived changes, a baseline of “normal” performance characteristics must be obtained. For the Earth, these baseline characteristics are needed on a global scale and over a long enough period of time that the variation imposed by seasonal variations and other cyclical or periodic events may be included in analyses. These observations must provide both a characterization of the state of the whole planet and detailed measurement of its regional variations. They must also enable quantification of the processes that govern the Earth system. Remote sensing of the Earth’s environment from space provides the only truly global perspective available, although making the full set of observations goes well beyond the capabilities of any single satellite and many of the detailed measurements can only be made *in situ*. In order to obtain the global perspective, we must use a polar-orbiting observation platform; equatorial or near-equatorial orbits will not allow us to view the entire Earth. To provide the range of cyclical or periodic events, the

duration of the observations must include a solar cycle and several El Niño events.

In short, then, we must begin to look at the Earth as a complex, integrated system. This requires suitable data collection in such areas as the geosphere, hydrosphere, atmosphere, cryosphere, and biosphere. Indeed, not only must we address these disciplines, but we must begin to understand the complex interactions between them, so that we can begin to comprehend the Earth’s behavior.

THE EARTH OBSERVING SYSTEM

The National Aeronautics and Space Administration (NASA) has a history rich in planetary exploration, but, ironically, has not devoted as much attention to developing a detailed understanding of our own planet. With the inception of the U.S. Global Change Research Program (GCRP), NASA, along with several other Government agencies, has been charged with the task of addressing this lack of information. NASA’s institutional response—the Mission to Planet Earth—will consist of a series of scientific and flight opportunities known collectively as the Earth Observing System (EOS).

The EOS mission combines the means for making observations and interpreting data with a scientific research effort to ensure that the planning and execution of the mission fulfills its intended purpose. This integrated approach is best characterized as an information system providing the geophysical, chemical, and biological information necessary for intense study of planet Earth. The EOS information system will build up over 10 years, then function for at least 15 years at its full capacity to allow accurate modeling of the processes that control the environment.

Designing and implementing the Earth Observing System is a tremendous task, one that the United States as a nation cannot hope to accomplish alone. Of necessity, it becomes an international effort. The EOS program involves the cooperation of the United States, the European Space Agency (ESA), and the Japanese National Space Development Agency (NASDA). As we attempt to understand the Earth's processes on a global scale, political and economic boundaries cannot be allowed to interfere with this important effort. The science and technology is available to begin the measurement and analysis of the Earth system; we have but to commit ourselves to the task, and to begin.

THE BUILDING BLOCKS OF EOS

The EOS mission is made up of three primary components:

- The EOS Scientific Research Program
- The EOS Data and Information System (EOSDIS)
- The EOS Observatories.

EOS SCIENTIFIC RESEARCH PROGRAM

The foundation of EOS is its scientific research. This effort is already underway, building on and complementing the Earth science research efforts of NASA, other U.S. research agencies, and their international counterparts. Within the U.S., this coordination is taking shape under the aegis of the U.S. GCRP, with coordination on the international level through the International Geosphere-Biosphere Program (IGBP) and the World Climate Research Program (WCRP).

EOS research currently focuses on:

- Use of existing satellite data
- Preparation for use of new types of data expected from satellite missions preceding EOS and from new aircraft instruments providing a preview of EOS capabilities
- Determination of detailed requirements for future observations
- Development of numerical models that can assimilate or help interpret current and future data sets.

The insights from these research activities are guiding the development of the EOS observatories and the EOSDIS. Through an EOS Graduate Fellowship Program and the involvement of graduate and postdoctoral students in EOS research, provision will be made for growth in the number of Earth scientists ready to use EOS data.

EOS DATA AND INFORMATION SYSTEM

A fundamental goal of the EOS program is to enhance the use of EOS data by the research community and cooperative interactions within this community. Past experience has shown that data systems are more effective when they are developed through an organic process involving active user participation. Thus, EOSDIS plans call for an evolutionary developmental approach, with extensive input from and testing by the research community. Functionally, EOSDIS will provide computing and networking facilities supporting EOS research activities, including data interpretation and modeling; processing, distribution, and archiving of EOS data; and command and control of the EOS observatories.

The EOSDIS development effort formally began with the EOS new start in FY 1991. Initial efforts will ensure that existing Earth science and applications data systems are adequately supported to work with currently available data. Where appropriate, these systems will evolve into nodes of a distributed EOSDIS. This step will be complemented by investment in computing facilities supporting the many individual EOS research activities. Building on this initial experience, an experimental version of the EOSDIS processing, distribution, and archiving activities will be put in place for testing by the research community. This early system will also provide user services for existing data. Based on user feedback and the results of an ongoing prototyping effort, the EOSDIS will achieve full functionality well before the launch of the first EOS platform. The full scope of EOSDIS will be made available for use in testing the EOS observatories and instrument algorithms, as well as for enhanced support of ongoing EOS research. After launch, EOSDIS will continue to evolve and grow in response to lessons learned through its use. This continuing evolution will permit exploitation of advances in data system technologies.

THE EOS OBSERVATORIES

In parallel with EOSDIS development, the EOS observatories system will be realized. The capabilities of the observatories are determined by the individual instruments and their deployment in orbit. The EOS instruments are designed to measure the following environmental variables:

- Cloud properties
- Energy exchange between Earth and space
- Surface temperature
- Structure, composition, and dynamics of the atmosphere, winds, lightning, and precipitation
- Accumulation and ablation of snow
- Biological activity on land and in near-surface waters
- Circulation of the oceans
- Exchange of energy, momentum, and gases between the Earth's surface and atmosphere
- Structure and motion of sea ice; growth, melting, and flow rates of glaciers
- Mineral composition of exposed soils and rocks
- Changes in stress and surface elevation around geologic faults
- Input of solar radiation and energetic particles to the Earth.

Full characterization of some of these elements will require sets of multiple instruments. To maximize the scientific utility of EOS data, these sets of instruments are planned for flight on the same space platform.

The EOS observatories will focus primarily on global observations from near-polar orbits at specific times of day and night. Some instruments are planned for deployment in low-inclination orbit, providing intense tropical observations and sampling of the full diurnal cycle. The number of instruments needed to supply the scientific measurements together with sampling requirements dictate most aspects of the deployment strategy for EOS, with launch logistics and engineering detail determining the rest. These requirements have led NASA and allied U.S. operational meteorological agencies, the European Space Agency, Japan, and Canada to plan a system of five polar platforms that would operate simultaneously. Two of these five platforms will be supplied by NASA as part of EOS. As originally conceived, each observatory (i.e., platform-

payload combination) would be replaced at 5-year intervals to provide for 15 years of continuous data. Thus, NASA's original EOS mission obligation entails six platforms and three copies of each selected instrument. Recent studies conducted by the National Research Council (NRC) confirmed NASA's rationale for the first series of EOS platforms (EOS-A), but asked that NASA study the deployment of instruments planned for the EOS-B series. These studies will be completed in 1991.

The following sections of this Handbook provide greater detail on all aspects of the EOS program as currently envisioned. ☆

EOS Data and Information System (EOSDIS) Architecture

EOSDIS ARCHITECTURE (Preliminary Design)

A high-level schematic diagram of the present EOSDIS architecture is offered as Figure 3. As EOSDIS evolves, details of this design may be modified; however, the overall concept has been studied and endorsed by two industrial teams, with the EOSDIS Science Advisory Panel actively involved in all aspects of the examination. Among the key principles guiding EOSDIS development are the following:

- EOSDIS must serve a broadly distributed Earth science community.
- The system must be designed to evolve continuously in capability.
- The processing, distribution, and archival functions of EOSDIS must be openly accessible to the research community.
- The command and control of the EOS observatories must be secure and highly reliable.

The key functional objectives of EOSDIS are to provide:

- Command and control of the NASA EOS observatories
- Processing and reprocessing of EOS data
- Data access and distribution for EOS and other NASA Earth science data
- Networking capabilities

- Transfer of data to permanent archives
- Data quality monitoring and data accounting
- Exchange of data, commands, algorithms, etc., with NOAA, ESA, Japan, Canada, and possibly others.

EOSDIS COMPONENTS

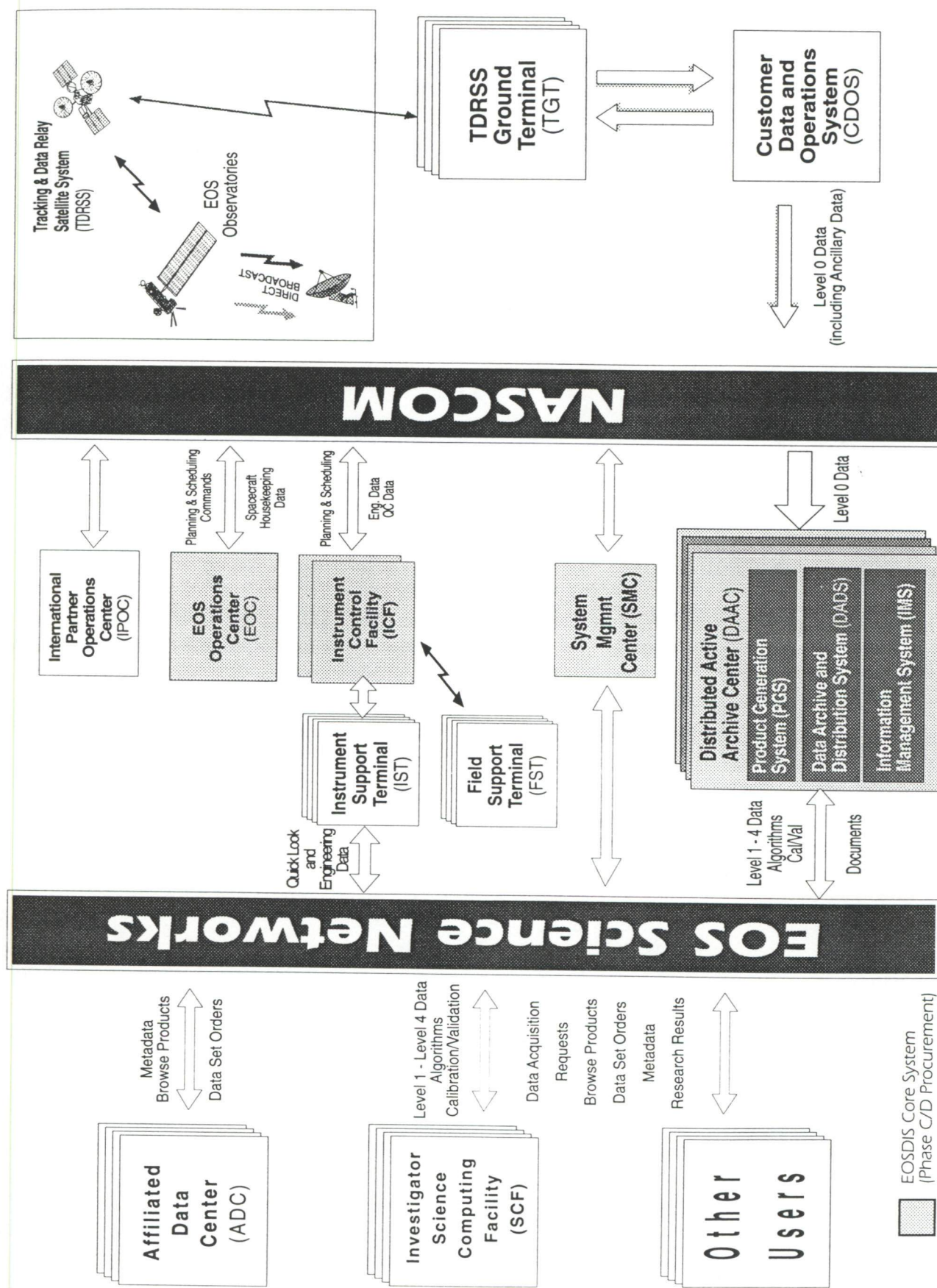
The EOSDIS architecture is composed of several types of elements, most of which will be geographically distributed, thereby providing resilience.

The EOS Operations Center (EOC) is responsible for mission control, mission planning and scheduling, instrument command support, and mission operations. Communications with the platforms and instruments all go through the EOC, which coordinates with external (i.e., non-EOS) systems such as the Customer Data and Operations System (CDOS), which in turn connects EOS with the Tracking and Data Relay Satellite System (TDRSS). The International Partner Operations Centers (IPOCs) perform functions similar to those of the EOC for the International Partner observatories.

The Customer Data and Operations System (CDOS) provides data capture and production processing of telemetry data from Earth-orbiting satellites. This NASA institutional facility provides for the uplink of commands through the TDRSS. Production processing involves the separation of composite downlink transfer frame data streams into individual payload/instrument data packet streams (i.e., level 0 processing, see page 17 for level definitions). The CDOS also serves as a long-term backup archive of the level 0 processed data. The uplinking of commands to and the acquisition of level 0 data from EOS instruments on the International Partner observatories will be handled via interfaces to the respective ground systems.



Figure 3 EOSDIS Architecture



The Tracking and Data Relay Satellite System (TDRSS) relays data to and from low-altitude, Earth-orbiting satellites, the Space Shuttle, and so on. This NASA system includes specialized communications satellites located in geosynchronous orbit both east and west of the continental United States (providing coverage of virtually the whole globe) and redundant TDRSS Ground Terminals (TGTs) at White Sands, New Mexico.

The Instrument Control Facility (ICF) consists of several Instrument Control Centers (ICCs). Each ICC plans and schedules instrument operations, generates and validates command sequences, provides the capability to forward commands and to store them for later transmission, monitors the health and safety of instruments, and provides instrument controllers with status information on their instruments. Two ICFs are planned: One at Goddard Space Flight Center (GSFC) and one at the Jet Propulsion Laboratory (JPL). The International Partner ICCs will perform similar functions for their instruments on EOS observatories.

The Instrument Support Terminals (ISTs) reside at Instrument PI and Team Leader sites. The ISTs are used to access ICCs for information on the health and safety of individual instruments. They enable PIs and their engineering support teams to provide command inputs to the ICCs, and to participate with instrument and mission controllers in the diagnosis and resolution of performance anomalies.

A Distributed Active Archive Center (DAAC) is an EOS-funded facility that processes, archives, and distributes EOS data and products for the duration of the EOS mission. EOS active archives are institutional responsibilities, thus distinct from facilities that are under the purview of an investigator team. An EOS DAAC contains functional elements that include a Product Generation System (PGS), a Data Archive and Distribution System (DADS), and an Information Management System (IMS). Other (non-NASA) agencies may share management and funding responsibilities for the active archives under terms of agreements negotiated with NASA. During the EOS operational lifetime and beyond, NASA may make arrangements to transfer some or all EOS data and products from EOS active archives to permanent archives.

The Product Generation System (PGS) performs data processing functions, including routine generation of standard products, quick-look products, metadata, and browse data sets. These operations also extend to reprocessing of data and retrospective production of new standard products. Computational support for other activities, including research and special product trials, can also be included in these facilities.

The Data Archive and Distribution System (DADS) is responsible for archiving and distributing EOS data and information. This includes level 0 and higher level data products, ancillary and correlative data, metadata, command histories, algorithms, documentation, and procedures for requesting special observations from EOS. Data will be distributed from DADS to EOS scientists, other EOS facilities, and other research users electronically via networks or on high-density storage media, such as optical disks, depending on the requested volume.

The Information Management System (IMS) is the user interface for EOSDIS. The IMS provides information about data, both in EOS and in external archives, on a 24-hour basis; accepts user orders for EOS data; provides information about future data acquisition and processing schedules; accepts and forwards data acquisition and processing requests; and maintains information on system status, management, and coordination.

Affiliated Data Centers (ADCs) are non-EOS data centers with which agreements will be made to provide access to non-EOS data or to special non-EOSDIS services required by the EOS program. Examples of planned ADCs include the Consortium for International Earth Science Information Networks (CIESIN), NOAA/National Environmental Satellite, Data, and Information Service (NESDIS), and the University of Wisconsin.

A Permanent Archive is a facility funded independent of the EOS budget that may take responsibility for the permanent archival of EOS data and products during and beyond the scope of the EOS mission, receiving these data and products from an EOS active archive and providing long-term access to them. Agreements with these archives will be negotiated by NASA Headquarters, with EOS Project coordination, and these agreements will become part of the EOS Project Data Management



Plan. Examples of permanent archives include the U.S. Geological Survey (USGS)/Earth Resources Observation System (EROS) Data Center (EDC) and NOAA/National Environmental Satellite, Data, and Information Service (NESDIS).

The Science Computing Facilities (SCFs) involve those capabilities provided by the EOS program to scientists at Team Member, PI, and Interdisciplinary Investigator computing facilities for development and maintenance of algorithms/software for generation of standard data products, quality control of products, data set validation, instrument calibration, scientific analysis, modeling, research, generation of special data products, instrument operations planning, and interface to scientists' institutional facilities.

Networks will be used for electronic distribution of EOS data and information to all nodes within the system and to the scientific research community at large, including the International Partners. This will be accomplished through standard network protocols, interfacing with widely used scientific networks where possible. EOSDIS networks will allow concurrent, distributed analysis of EOS data, facilitating communication between researchers as well as easing access to data sets. Audio and visual links may be incorporated to enhance this function.

Field Support Terminals (FSTs) will provide mobile communications to coordinate platform data acquisition with field experiments and the necessary display capabilities to support field campaigns.

The long-term science plan for the EOS observatories will be provided to the EOS Project by the IWG. The EOS investigators will be able to access all mission planning and scheduling information via the IMS, using their SCFs as remote interfaces. Requests for future data from instruments that require advanced scheduling will be placed through the IMS, but should be coordinated with the Instrument PI or Team Leader (e.g., by electronic mail) prior to request to ensure that it is reasonable given the overall scheduling priority guidelines for the instruments as approved by the instrument team and the IWG. The long- and short-term scheduling plan for each instrument will be the responsibility of the Instrument PI or Team Leader (working within the science plan guidance established by the IWG), who will communicate electronically with the ICC through his/her

IST in order for the ICC staff to prepare the command streams that will be transmitted to the EOC and thence to the instruments on the spacecraft. Scheduling priorities will be based on the guidelines set by the IWG and carried out under the direction of the Project Scientist or his deputy who will be available onsite at the EOC.

Instrument and ancillary data transmitted to ground via TDRSS will be level 0 processed in the CDOS, and the level 0 data sent to the EOSDIS DAACs for further processing and distribution. The IMS will be updated automatically whenever new data or products are available in the DADS for distribution. Users will obtain information and place one-time or standing orders for data by interacting electronically with the IMS. They will also be able to request all supporting algorithms, models, documentation, etc., through the IMS. A user support office will be available for direct telephone or electronic mail contact concerning questions or problems with accessing the data. Each data set will also have references to the PI or team responsible for the product for further information on the data utility and production history.

Quick-look data for engineering assessment of platform and instrument performance will be routed directly to the EOC and ICCs, where 24-hour monitoring of the platform and instrument health and engineering performance can be done. Instrument PIs and Team Leaders will be able to remotely monitor information available at the ICCs through their ISTs, and will be able to communicate directly with the ICC staff in resolving instrument anomalies in near-real time. The Flight Operations Team (FOT) at the EOC will be responsible for observatory health and safety.

A support office will also be provided by EOSDIS to assist EOS investigators and their teams in developing algorithm software to run in the EOSDIS computing environment. This office will provide guidelines on coding standards and documentation, and will also organize training programs for EOS science algorithm software developers.

EOS INVESTIGATOR DATA SYSTEM RESPONSIBILITIES

The following bullets encapsulate the general responsibilities of the EOS investigators with respect to the EOSDIS. The

specific responsibilities vary depending on whether an investigator is a Team Leader, Team Member, Instrument PI, or an Interdisciplinary Investigator:

- Algorithms (i.e., develop, code, debug, validate, integrate with other users of same instrument, optimize for EOSDIS environment, document, maintain archive)
- Develop specifications for standard data products, including quick-look, quality control, and browse data products; perform ongoing scientific quality control of products
- Develop requirements for SCFs
- Deliver special products and algorithms to be archived
- Provide ongoing scientific quality control for standard products
- Provide up-to-date instrument calibration data on an ongoing basis
- Manage the collection and processing of correlative data required to calibrate or validate the data products
- Participate in mission planning and scheduling and instrument operations.

SYSTEM MANAGEMENT

EOS investigators, especially Interdisciplinary Investigators, will need to assimilate data and information from several instruments in the course of their research; furthermore, EOS algorithm software will need to be portable across different computer elements within the EOSDIS environment. Hence, the adoption and development where necessary of a suite of standards for data structures, data formats, software code, and documentation will be essential for EOSDIS. The EOS Ground Systems and Operations Project at GSFC will work with EOS investigators and the EOSDIS Science Advisory Panel in identifying and developing these standards.

EOS data will continue existing measurements, some of which extend for more than a decade. Therefore, EOSDIS will be developed in an evolutionary manner to accommodate existing data sets, as well as new EOS data when they become available. A number of existing centers, where remote sensing data are intensively and routinely analyzed into scientific products, will form the heritage for development of the EOSDIS DAACs. The design and development of EOSDIS will proceed in a series of prototypes and "builds," which will provide early functional EOSDIS elements that can be used and evaluated by scientists using pre-EOS data in readiness for EOS launch. These evolutionary EOSDIS elements will be developed with the necessary standards and interfaces required for EOSDIS to function as part of the U.S. and international global change research data system.

The timely and efficient generation of various data products requires a high degree of coordination among the various distributed elements in the system. The System Management Center (SMC) will support a variety of functions to track system-wide resources, to ensure data flow, and to perform administration and accounting. The SMC and the EOC will be located at GSFC. The ICFs will be located at GSFC and JPL. As indicated, the PGS, DADS, and IMS functions will be co-located to form DAACs at a number of sites based on discipline and scientific research expertise, existing infrastructure, and institutional commitment to the activity. As currently envisioned, the long-term responsibility for management and distribution of EOS data will be transferred to the organizations that are partners with EOS in the data system activities (e.g., NOAA and USGS). The proposed distribution of DAACs follows:

- **Upper Atmosphere, Atmospheric Dynamics, Global Biosphere, Geophysics**
Goddard Space Flight Center—Experience with UARS, atmospheric sounding and tropospheric moisture sensing, and CZCS and AVHRR
- **Ocean Circulation, Air-Sea Interaction**
Jet Propulsion Laboratory—Experience with Seasat, TOPEX, NSCAT, SSM/I, and NODS



- **Radiation Budget, Aerosols, Tropospheric Chemistry**
Langley Research Center—Experience with ERBE and SAGE
- **Cryosphere (non-SAR)**
University of Colorado
National Snow and Ice Data Center—Experience with SMMR and SSM/I
- **Land Processes Imagery**
EROS Data Center—Experience with Landsat and AVHRR
- **Sea Ice, Polar Processes Imagery**
University of Alaska, Fairbanks—Experience with Alaska SAR Facility
- **Hydrology**
Marshall Space Flight Center—Experience with WetNet.

KEY EOSDIS TERMS

Standard Data Products. Data products that are generated as part of a research investigation using EOS data, are of wide research utility, are routinely produced, and in general are produced for spatially and/or temporally extensive subsets of the data are to be considered standard data products. All EOS instruments must have standard level 1 data products, and most will have standard level 2 data products. Some EOS interdisciplinary investigations will also generate standard data products. Specifications for the set of standard data products to be generated by the EOS Project will be reviewed by the IWG and NASA Headquarters to ensure completeness and consistency in providing a comprehensive science data output for the EOS mission. Standard data products will normally be generated in the EOS PGS.

Special Data Products. Data products that are generated as part of a research investigation using EOS data and that are produced for a limited region or time period, or products that are not accepted as standard by the IWG and NASA Headquarters, are referred to as special data products. Special data products will normally be generated at investigator SCFs (provided for

EOS investigators out of the EOS budget). Special products may be reclassified later as standard products upon review and approval by the IWG and NASA Headquarters; in which case, the algorithms and processing will migrate to the PGS and be placed under the appropriate configuration controls.

Level Definitions. The various levels of data referred to in this document are identical to those defined by the EOS Advisory Panel in its report and are consistent with CODMAC definitions. For some instruments, there will be no level 1B product that is distinct from the level 1A product. In these cases, the reference to level 1B data can be assumed to refer to level 1A data.

Level 0 - Reconstructed unprocessed instrument/payload data at full resolution.

Level 1A - Reconstructed unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (i.e., platform ephemeris) computed and appended, but not applied, to the level 0 data.

Level 1B - Level 1A data that has been processed to sensor units (not all instruments will have a level 1B equivalent).

Level 2 - Derived environmental variables at the same resolution and location as the level 1 source data.

Level 3 - Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.

Level 4 - Model output or results from analyses of lower level data (i.e., variables derived from multiple measurements). ☆



CHICAGO TRIBUNE
Jan. 10, 1992 Pg. 1

Army lures volunteers to retire

By David Evans
Chicago Tribune

WASHINGTON—On Christmas Eve, the Pentagon sent an unprecedented message to Army posts worldwide: It would give some officers at least \$500,000 and some non-commissioned officers at least \$200,000 to leave the Army.

That was the good news. Last Friday, Army headquarters sent out another message with the dark side: If enough officers don't accept the offer, there will be wholesale firings. Officers who don't accept departure bonuses will have their service records reviewed by special boards that will convene in mid-March and forcibly cull officers with the lowest performance records.

These sweet and sour messages are the latest in a concerted plan to reduce the size of the Army by 175,000, or nearly 25 percent, from today's level of about 710,000.

Lt. Gen. William Reno, the Army's top personnel officer, said, "Right now, I am marching to a drummer that would take us down to 535,000 by fiscal 1996."

With the end of the Cold War, all four military services are cutting personnel and recalling troops from overseas bases.

It is a far more dramatic reduction-in-force than occurred after the Vietnam War, Reno said. Some of the drawdown will be accomplished by reducing enlistments and through normal attrition, but the planned troop reduction is so large that the Army now is offering more money to induce soldiers to get out than it pays those with highly valued skills to re-enlist.

For example, the Army will pay

MANPOWER...from Pg. 5

incentives" to lure soldiers out of the armed forces.

In either case, there will be substantial costs associated with the manpower shrinkage before the Pentagon begins to realize the savings of a smaller force.

Thus, Pentagon officials are expected to argue to lawmakers that faster reductions would have even stiffer upfront costs, as well as a demoralizing effect on the military.

"What we hope is that the number of involuntary separations will be close to zero," Christopher Jehn, the Pentagon's manpower chief, said Friday. "These are quality people who have just won the Cold War, just won the war in the Persian Gulf. They are people who have made a commitment to the military and to the country, and we didn't think that we ought to violate that commitment."

"Not only is it an issue of fairness," Jehn said. "There's a practical side as well. If the military is viewed as an organization that doesn't keep its promises... in the future, we're going to find that it's hard to find people who are willing to make promises to us."

an enlisted linguist trained in Arabic or Korean up to \$20,000 to re-enlist for six years, a small fraction of the money the service is paying to encourage soldiers to leave.

Those who voluntarily leave won't be ending their relationship with the Army entirely: They must agree to serve in the ready reserve.

"If we have a war, they're eligible to be recalled," said Lt. Col. Tim Decker, an Army staff officer.

The latest inducements to leave the active Army are part of a growing number of programs designed to reduce troop levels.

The Army already has an "early-out" program for junior enlisted personnel, giving them the option to leave before the end of their contracted period of service, and 13,000 troops have accepted this offer, Reno said.

Excess lieutenants are being

ARMY...Pg. 7

MILITARY SPACE

Jan. 13, 1992

Pg. 1

Fight brews over reconnaissance photos

The Air Force should unveil its long-secret spy satellite programs and, for the first time, allow their reconnaissance photos to be used for environmental research, say congressional and private analysts.

Pictures from the highly classified KH-11 "Keyhole" spacecraft could save NASA billions of dollars in its program to study Earth from space, says Rep. George Brown, D-Calif. The evaporation of the Soviet threat allows use of many of the high-quality Keyhole photos without harming national security, argues Brown and other defense analysts.

But the Air Force has no plans to release any of the hundreds of thousands of photos taken by the Keyhole satellites since the first was launched in 1976.

"What is totally stupid is that we have a classification system which persists in perpetuating the fiction that this material is secret and that such a fiction contributes to our national security," Brown said recently in a speech on the House floor.

Though the Keyholes were intended primarily to monitor Soviet troops, missiles and tanks, the \$300 million satellites could now be used for advanced research of croplands and toxic waste sites. The proposal comes at a time of increased environmental awareness while NASA, citing budget shortfalls, is slashing funding for its Earth-observing satellite program, Landsat.

"No other country is so stupid," Brown said. "We are buying the products of other national systems, including the French and the Soviet systems, because of our shortsighted policies. Within 10 years, we will have ceded a multibillion dollar market to our competitors for the product of technology that we invented."

Following the Soviet Union, imaging spacecraft have been developed by France and India, and now Canada, Japan, China and Brazil plan to get into the market. "With the sensing capabilities of small satellites, I think you'll see a lot more countries developing their own capability," said Clark Nelson at France's Spot Image Corp. U.S. headquarters in Reston, Va.

But the Keyhole is the king of imaging spacecraft. Built by TRW, the 15-ton, 64-foot-long spacecraft has a resolution of about 15 centimeters, compared to 15 meters for NASA's Landsat. Three advanced Keyholes, sometimes called KH-12s, have an infrared imager. A total of six operable Keyholes are believed to be in orbit, transmitting their digital images to a ground station at Fort Belvoir, Va.

Landsat tying DOD to NASA

This isn't the first time Brown has raised a ruckus over the Air Force's spysat programs, but this time he might make more headway. During the 1980s, while a member of the House Intelligence committee, Brown was sharply critical of the secrecy-cloaked National Reconnaissance Office, the CIA-Air Force organization that runs the programs.

"That's one reason why Brown isn't on the intelligence committee anymore," a key House staffer told *Military Space*. "But with the continued de-escalation of tensions in Europe, this is a much better time to press for declassification of military space systems."

The Air Force declassified other black programs recently when it appeared they would be killed by Congress. For example, in 1990 the service unveiled its stealth F-117 fighter and B-2 bomber programs to deflect criticism of the expensive stealth technology.

Air Force still tongue-tied

The Air Force satellite programs have always been secret because of the military custom to never acknowledge reconnaissance activities. That practice made sense when the U.S. military had the only remote-sensing capability in the world, but not now, Brown says.

Meanwhile, the Air Force still has not publicly acknowledged that the satellites even exist. "I can't say anything about them — and I can't even say that I can't talk about them," one service spokesman said last week.

Leading space reconnaissance analysts believe that more than 90% of KH-11 photos could be declassified without affecting national security,

FIGHT...Pg. 8

Army retirement plans

The Army is encouraging soldiers with more than 6 years of service to leave. Those who leave voluntarily may choose between a lump-sum payment or payments over several years. Soldiers forced to leave the Army receive a smaller separation payment. Here are some examples:

Rank	Years of service	Involuntary separation	Voluntary lump sum*	Voluntary annuity*
Major	14	\$56,200	\$140,500	\$449,600 over 28 years
Capt.	9	29,600	74,000	163,000 over 18 years
Staff Sgt.	13½	25,600	60,000	176,000 over 27 years
Sgt.	11	18,100	43,000	109,000 over 22 years

*Includes separation pay
Source: U.S. Department of Defense

Pentagon Manpower Plan May Force Dismissals

By MELISSA HEALY
TIMES STAFF WRITER

WASHINGTON—The Pentagon, which had hoped to focus its budget cuts on hardware, is now preparing a plan dubbed "Base Force II" that would accelerate troop reductions and virtually ensure the first personnel dismissals since the period following the Vietnam War.

The plan, which would be implemented over the next three years, is a retreat from the "base force"—the troop level that Secretary of Defense Dick Cheney last year said represented the "absolute rock-bottom minimum" needed for national defense.

While Pentagon officials said

reductions beyond the "base force" would be slight, they warned that the latest plans call for an active-duty military smaller than 1,653,000 troops, the number at which they previously had hoped to hold the line.

The change is an effort to counter mounting congressional pressure for major manpower cuts, which some say would deliver large short-term savings that could be used for other domestic priorities. Still, Congress is likely to press for faster and larger military personnel reductions.

President Bush's 1993 budget package is expected to force military rolls down about 20% from 1987 levels. The Pentagon proposal

would reduce the number of troops by almost 170,000 in 1993 alone—a modest acceleration of a drawdown that Cheney announced in 1991.

Overall, the reductions are projected to speed up the process of winnowing the Army's strength from 18 to 12 active-duty divisions, the Air Force's active-duty air wings from 24 to 15 and the Navy's aircraft carriers from 14 to 12.

Government budget analysts estimate that over five years such an acceleration in manpower cuts could reduce Pentagon spending by \$10 billion to \$15 billion. They project only modest savings—less than \$2.5 billion—in 1993 and 1994 together.

The manpower savings are part of a larger package of defense reductions, expected to reach \$50 billion, which the Pentagon is now expected to propose in a 1993-1997 spending plan to be unveiled later this month. In drafting the spending blueprint, Pentagon leaders said they have struggled to stave off much deeper cuts in military manpower than those already planned.

To do so, officials said the Pentagon has agreed to significant cuts in the development and procurement of future weapons systems as well as sweeping changes in the nation's strategic nuclear arsenal.

Such changes, including the President's decision to terminate production of the B-2 bomber after 20 such aircraft are built, reflect the Administration's belief that the nation's nuclear-deterrent needs have changed more than has its need to maintain a conventional force capable of fighting military brush fires throughout the Third World.

"It's the nuclear equation that's been transformed," a senior Administration official said. "Our [nuclear] targeting requirements aren't as stressing as they used to be, so there's a lot of room for maintaining a prudent level of deterrence with less than we planned to do. And that's where you'll see big changes."

Those changes are expected to include the early retirement of several of the Navy's ballistic-missile-carrying submarines and the accelerated retirement of some of the nation's older nuclear missiles and bombers.

While those changes will bring some quick savings in the military's operations accounts, Pentagon budget makers discovered that they could not elude further and faster manpower cuts if they were to meet the President's five-year

targets for savings.

For Cheney and Gen. Colin L. Powell, chairman of the Joint Chiefs of Staff, the accelerated manpower cuts present a political problem as well. Last year, both men told Congress that their blueprint for manpower cuts represented a base force that could not safely be reduced further.

"On this glide path, we will reach a base force which I believe is not prudent to go below if we wish to match enduring defense needs with enduring realities," Powell said last March. He warned that the nation risks forfeiting its status as a superpower if it cuts more deeply into military rolls.

Now, with the Pentagon expected to make modest reductions beyond that level, a knowledgeable defense official said that Cheney and Powell are seeking "a little wiggle room" from their earlier statements. "We have sort of become victims of our own rhetoric here," the official said.

But Pentagon officials continue to insist that while they can reduce their ranks a bit faster than planned, the nation's military commitments will not allow them to shrink the military significantly more than already has been planned. As a result, officials said that manpower cuts below the current level of 1.65 million will be slight.

Even reducing faster, however, is nearly certain to result in some dismissals, which military leaders have said they desperately want to avoid.

"The services have exhausted the easy way to do this, and it gets more painful" to move faster, said Martin Binkin, an expert in military manpower at the Washington-based Brookings Institution. "If you're going to go beyond what's currently planned, you're pretty much going to have to go into what are considered the root-cause areas. They're going to have some RIFs [involuntary reductions-in-force] as it is now."

Further, defense officials have begun to challenge the widespread belief that manpower cuts always produce quick savings in Pentagon spending.

Congress has adopted measures providing severance pay for most enlisted people who are dismissed. And if the Pentagon is to make rapid reductions while minimizing dismissals, it will have to offer costly "voluntary separation

MANPOWER...Pg. 6

WASHINGTON TIMES Jan. 13, 1992 Pg. B3

National Guard in Virginia faces severe cutbacks

THE ASSOCIATED PRESS

The Virginia Army National Guard could lose as much as a third of its work force under proposed cuts, senior officers say.

The Army told the Virginia Guard it can expect to lose at least eight large units employing 1,750 people. Additional cuts in the Virginia Guard could reduce the force by an estimated total of more than 3,000, or a third of its manpower.

The cuts are part of the Army's post-Cold War trimming.

Only non-combat units will be cut. But if the Army follows through on all proposed cuts, the state Guard would lose virtually every non-combat unit.

As now envisioned, the cuts will fall on what the military terms combat support and combat service support units, leaving intact the 29th Light Infantry Division.

Roughly two-thirds of Virginia's Guardsmen are combat troops in the 29th, which also includes units in Maryland. The remainder — called "non-divisional units" — perform combat support and combat service support missions, such as transportation, personnel administration and engineering.

Maj. Gen. John G. Castles, the state Guard's adjutant general, said the cuts may not be as severe as now planned. Congress has been reluctant to cut the reserve components in the same proportion as the active-duty military, he said.

Even so, Gen. Castles said whole

units will be eliminated. He would not be specific, saying he did not want to damage morale.

During Operation Desert Storm, 10 Virginia Guard units were mobilized for active duty and eight, with 777 men and women, were deployed to the Middle East. The eight were all combat support and combat service support units.

About 9,500 men and women serve in Army National Guard units in more than 50 Virginia communities.

An additional 1,250 men and women serve in the Virginia Air National Guard.

The Army said the cuts conform to an overall force structure plan and were planned without regard to the units' performance. Virginia Guard officials argue that performance should be a key factor in deciding which units should be retained.

In 1991, the Virginia Army Guard made 96 percent of its management goals, which include drill attendance, military specialty qualifications and equipment condition, according to the National Guard Bureau at the Pentagon.

Meanwhile, only two other states exceeded 85 percent on the management indicator. The national average was 68 percent, the Guard Bureau said.

The Guard, through its largely federally paid salaries and its capital expenditures, has an economic impact on Virginia of more than \$300 million annually.

PHILADELPHIA INQUIRER

Jan. 12, 1992

Pg. 3

Cambodia gives possible war remains

Two small caskets hold what may be the remains of two Marines killed in a 1975 rescue attempt.

Associated Press

PHNOM PENH, Cambodia — Cambodia yesterday gave the United States what could be the remains of two Marines killed in the Vietnam War, amid growing bilateral efforts on determining the fate of Americans missing in action.

Officials said the remains might be among those of five Marines missing in the May 15, 1975, attempt to free the American merchant

ship Mayaguez, which had been seized by Khmer Rouge guerrillas for sailing close to an island.

The Khmer Rouge eventually released the ship, but not before a U.S. Marine assault force landed on the island of Koh Tang to rescue the 40 crew members. The five Marines were among 38 killed in the operation.

After being given over to U.S. officials, the two sets of remains, in small wooden caskets topped with folded American flags, were placed aboard an Air Force C-130 transport plane to be flown to Army laboratories in Hawaii.

For more than a decade, efforts to determine the fates of 83 servicemen missing in Cambodia were stalled because the United States supported the non-Communist guerrillas trying to topple the Cambodian government.

The signing of a U.S.-backed peace accord in October, however, paved the way for increased cooperation on the issue.

"The authorities here have been providing full cooperation, and it has only gotten better," said Charles Twining, the top U.S. diplo-

mat in Phnom Penh. "They have pledged full cooperation in carrying out more of these activities in the next several weeks, and we are trying to figure out a whole plan of activities in the coming year."

Twining said Phnom Penh previously has turned over at least six sets of remains, but none has yet been identified as that of an American MIA.

He said the two sides planned to work this year on excavating plane crash sites, researching documents and investigating the authenticity of photographs purporting to show Americans still held in Indochina.

Also on the flight yesterday carrying the remains were six Cambodian government officials who will hold discussions on future bilateral MIA investigations in Cambodia.

The Cambodians also provided two dog tags that correlate with Americans reported missing in action, said Chief Warrant Officer James Webb. The names on the dog tags were not released.

Searches for other remains will be conducted this month, he said.

LOS ANGELES TIMES

Jan. 10, 1992

Pg. D4

Hughes Gets \$15.5 Million in Frozen B-2 Radar Funds

■ **Defense:** The auditor's decision frees money withheld since 1986. But a whistle-blower suit on the alleged improper billing is headed for trial.

By RALPH VARTABEDIAN
TIMES STAFF WRITER

A Defense Department agency has released \$15.5 million that had been withheld from Hughes Aircraft since 1986, when government auditors alleged that the firm improperly billed the Air Force for development of the B-2 bomber's radar system.

The Defense Contract Audit Agency asserted in a memo only last March that Hughes had overcharged the government by pooling costs—under a secret, so-called commonality agreement—for developing three different radar systems and not disclosing the arrangement to the government.

In 1986, the audit agency issued a finding of "suspected irregularity" and referred the matter to the Department of Justice, alleging that Hughes had overcharged the government \$29 million through the arrangement. No criminal action was ever taken.

Hughes allegedly charged the B-2 radar program for improvements to the F-15 fighter's radar and work on two other fighter radar programs at its Radar Systems Group in El Segundo.

Hughes has fervently denied wrongdoing in the case, arguing that the government misunderstood the facts and that all the costs were properly allocated among the programs. Hughes attorneys said it was the Air Force that encouraged the firm to save money by using common technology and hardware on different programs.

In November, the audit agency apparently had a change of mind, released the \$15.5 million and now

HUGHES...Pg. 10

WASHINGTON TIMES

Jan. 10, 1992

Pg. 9

Russia to aid MIA search

MOSCOW (Reuters) — Russia said yesterday it was setting up a joint parliamentary commission with the United States to seek information on Americans missing in the Korean and Vietnam wars.

Foreign Ministry spokesman Vitaly Churkin said both sides were eager to set up such a commission in the near future but that there was no guarantee new information would emerge.

"Please don't get up expectations too much. It's not that we're about to pull out of our sleeve some new information, because we don't have it," he told reporters.

"But since it is a very acute humanitarian issue, we feel we

should do everything we can in order to leave no ambiguities in this matter," Mr. Churkin said.

The commission would be made up of U.S. congressmen and Russian members of parliament. Mr. Churkin indicated that intelligence experts on both sides also would participate.

The move, discussed at a meeting yesterday between U.S. Ambassador Robert Strauss and Foreign Minister Andrei Kozyrev, follows reported sightings of an American POW in the Central Asian republic of Kazakhstan, formerly part of the Soviet Union.

A total of 2,267 Americans are still listed as missing in Southeast Asia.

ARMY...from Pg. 7

the person that opts out [earlier]," Reno said.

For those who survive the impending wave of separations, greater career opportunity awaits.

"There is personal and professional gain for those who stay in the Army," Reno said. "You have fewer people competing... Retiring a lot of people early will allow us to promote at a higher rate and faster."

Reno said the current plans are designed to avoid repeating the morale-breaking trauma of the cuts that followed the Vietnam War.

"After Vietnam, we salami-sliced in class after class, again and again and again... for three years running. If you were sitting out there as a captain in year-group 1966, you would be in turmoil all the time," Reno said.

In contrast, a captain in the Army today will face a one-time reduction-in-force board.

FIGHT...from Pg. 6

said Jeffrey Richelson, author of "America's Secret Eyes in Space."

"With the higher resolution, you can see crop diseases and environmental damage," Richelson told *Military Space*. Other Keyhole photos—such as those containing new military targets or high-quality images "at the limit of capability"—are rightly classified, he said.

"But there are probably a lot of photos you could release without

creating any national security damage," Richelson said.

Brown complains that neither the White House or Congress has confronted the issue, even though both sides recognize its "irrationality."

"The excessive and unnecessary system of secrecy which surrounds this program will fall of its own weight in the near future," Brown predicted. "And when it does, I will be accused of the crime of being prematurely right—a very serious crime indeed for a member of Congress."

forced out. "We now have lieutenant retention boards," Reno said, "and ... we've already identified 700 lieutenants. They'll be separated very quickly, by the end of February."

And at the top end of the rank scale, the Army is forcibly retiring lieutenant colonels and colonels. A special board is scheduled to convene Tuesday to identify between 1,500 and 1,700 lieutenant colonels and colonels having up to 28 years service who would be eligible for forced retirement.

To minimize the number of senior officers—majors and above—being forced out, the Army has been urging them to ask for early retirement.

"We want to take care of our people, and we are allowing these officers to retire at the end of January 1993. It gives them a year to get out, and it gives them the next pay raise as an inducement to retire early," Reno said. (In contrast, the Marine Corps has been giving its forcibly retired colonels only six months to leave.)

Early retirement, Reno explained, means officers would leave earlier than they planned, but they still must have a minimum of 20 years' service. There is a financial penalty, since retirement pay is based on years of service, but medical benefits would remain intact.

The newest incentive to leave is aimed at Army officers and non-commissioned officers with between 6 and 20 years of service. They can choose a lump-sum payment or annual payments spread out over twice the number of years served in the Army.

For example, a staff sergeant with 13½ years service who chooses the lump-sum payment would get \$34,000, plus the standard separation pay of \$25,000, for a total of nearly \$60,000. The same individual who chooses time payments would receive \$25,000 plus 27 annual checks of \$5,600, or about \$176,000.

For a major with 14 years' service, the total payments over 28 years would total about \$450,000.

Nick Timenes, a senior manpower official in the defense secretary's office, said, "It's serious money, but less than we would pay overall to a retiree."

A typical lieutenant colonel who retires after 20 years receives lifetime retirement pay worth more than \$1.2 million, assuming an average life span.

The Army has advised officers commissioned in 1978 and 1982, in particular, to consider taking advantage of the new separation incentives. Officers in these year-groups soon will be eligible for promotion to major and lieutenant colonel; the Army wants to cut the number of candidates before promotion boards convene.

Those officers forced out by the March separation board—possibly

During investigation of CAIG ...

INSPECTOR GENERAL WAS PRESSURED TO LIMIT SCOPE OF INQUIRY, USAF OFFICIAL SAYS

The DOD Inspector General restricted the scope of an internal review of independent cost estimating in the Pentagon after receiving pressure from one of the offices responsible for producing cost estimates, an Air Force financial officer charged last month. A. Ernest Fitzgerald says that IG investigators initially intended to examine the estimates produced by independent cost estimators on specific programs, but the study eventually focused only on the process by which estimates were generated. After reviewing a draft IG report of independent cost estimating, Fitzgerald said it appeared that Program Analysis & Evaluation (PA&E) chief David Chu and David McNicol, who heads PA&E's Cost Analysis Improvement Group (CAIG), had successfully steered the IG away from a potentially damaging analysis of actual program estimates.

"At the time of last year's interview, it was common knowledge that PA&E, more particularly the OSD CAIG leadership, was trying to change the focus of the IG's review to focus exclusively on 'processes' and not get into specific program estimates," Fitzgerald wrote in a Dec. 12 memorandum regarding the IG report. "In fact, I heard at the time that Mr. McNicol, Mr. Chu's Deputy for Resource Analysis, was refusing to cooperate with the IG unless the IG would agree to his proposition."

Fitzgerald, who is management systems deputy to the assistant secretary of the Air Force for financial management, is a well-known critic of Pentagon cost-estimating and spending practices. His memorandum, which was obtained by sister publication *Inside the Air Force*, was written for Air Force officials seeking comments on the IG's Nov. 7 draft report, "Review of Independent Cost Estimating for Major Defense Acquisition Programs."

The investigation was requested by Rep. Andy Ireland after a 1989 IG audit revealed that the CAIG was not complying fully with the law requiring independent cost analysis. Ireland has been highly critical of the CAIG, charging that the CAIG "failed miserably" in its responsibility to provide the defense secretary with independent cost estimates of the Navy's now-defunct A-12 aircraft program. In order to ascertain whether the CAIG was generating independent estimates, Ireland asked the IG to examine the cost estimates provided during OSD reviews of major aircraft programs, such as the Air Force's B-2 stealth bomber, the Advanced Tactical Fighter, the C-17 transport, and the Army's Commanche helicopter.

Inside the Pentagon reported last June that IG investigators were initially critical of the CAIG because it often relies upon the Services for cost data, rather than independently developing its own estimates. Fitzgerald's memo suggests, however, that the IG decided to restrict the scope of its investigation and moderate its criticism.

Ireland was unavailable for comment regarding the memo, but the Florida lawmaker told *Inside the Pentagon* last June that during a meeting with Chu and McNicol, he was "stonewalled" and "given evasive answers" when he questioned them about the CAIG's handling of cost estimates in the A-12 program. McNicol declined to be interviewed on the subject.

Fitzgerald's criticism of the IG report reflects his own view that the CAIG does not provide Pentagon leaders with independent estimates of program costs. He contends that the estimators and programs used by Pentagon organizations, particularly the CAIG, do not really generate useful cost estimates. "As I read it, the CAIG is refusing duty on the independent estimating responsibility which raises the very serious question of why we need a CAIG at all," he wrote.

Under current laws, the defense secretary cannot approve a major acquisition program unless he has reviewed an independent cost estimate, which must be prepared by an office outside the military department carrying out the program. The CAIG performs this function for top OSD officials. Ireland requested the IG investigation to insure that the CAIG is carrying out its duties, but the narrow scope of the investigation will likely increase, rather than assuage, his concerns. "The IG's abandonment of basic objectives was so blatant that it's bound to attract even more attention to the subject," Fitzgerald told his supervisors. "Unless Congressman Ireland gets a sudden attack of timidity, this will only rouse his competitive spirit." -- Stephen C. LeSueur

as many as 1,400—will get only the standard separation allowance rather than the lucrative inducements now being offered.

Reno said the Army doesn't expect to force out career non-commissioned officers. However, if the Army must go below 500,000 personnel, then they, too, may be ousted; it will depend on how many take the separation bonuses.

"Enlisted troops with 12-20 years in the Army are not inclined to take the incentives as much as one would hope, because they lack the safety net of medical coverage," Reno said.

"You cannot underestimate the importance to a sergeant—or more

Radon caused radiation at Maine air base

LIMESTONE, Maine — Radiation that contaminated a dozen workers at an air base came from radon gas that accumulated naturally and not from the improper disposal of nuclear weapons, the Air Force said yesterday.

The discovery means the workers who were contaminated at

importantly to the wife and kids—of having the medical care that accrues to the retiree, versus none to

Loring Air Force Base near the Canadian border are less likely to suffer long-term health problems, the Air Force said.

The workers were searching for toxic waste sites Thursday when they were contaminated after drilling into the wall of the building, which had been sealed since the 1960s.

Radon gas accumulated in the building because the two-story structure was made of brick and because of the length of time the structure had been sealed, said 2nd Lt. Bridget Reeder, an Air Force spokeswoman.

"Document Control"

TYPE: INFORMATION

DOCUMENT NUMBER: 9125280

ORIGINATOR: 02

STATUS C

DIRECTORATE STATUS

FROM: TRULY, Richard H.: NASA

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 12/26/91

SUBJECT: HE IS PROVIDING DR. BROMLEY WITH A REPORT DESCRIBING
THE TECHNICAL AND PROGRAMMATIC ELEMENTS OF THE
RESTRUCTURING PROCESS OF THE EOS PROGRAM AND THE
RESTRUCTURED PROGRAM ITSELF.

DIRECTORATE STAFF
ASSIGNED: ASSIGNED:

ACTION STAFF
REQUIRED: ACTION:

SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
PHYSICAL SCIENCES
ENVIRONMENT

WHITE HOUSE TRACKING #: CONTACT PERSON:
REMARKS: PHONE: EXT:

OSTP RECEIVED: 12/31/91 DEPT RECEIVED:
FILE: PHYSICAL SCIENCES-SPACE
CENTRAL FILES:



National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

5280 I
RECEIVED

DEC 26 1991

01 DEC 31 AM 1:34

CST
MAIL ROOM

The Honorable D. Allan Bromley
Assistant to the President
for Science and Technology and
Director, Office of Science and
Technology Policy
Executive Office of the President
Washington, DC 20506

Dear Dr. Bromley: 

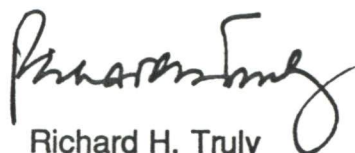
I am pleased to inform you that the National Aeronautics and Space Administration has completed its restructuring of the Earth Observing System (EOS) program. I have enclosed for you and your staff a report describing the technical and programmatic elements of both the restructuring process and the restructured EOS program itself.

NASA conducted an effort over the last few months to restructure the EOS program to fly the EOS instruments on intermediate and small spacecraft. In this restructuring, we sought to preserve the highest priority science goals of the U.S. Global Change Research Program (USGCRP) and the Intergovernmental Panel on Climate Change (IPCC). As such, the EOS instruments and spacecraft will focus on the key issue of global change research: to determine the extent, causes, and regional consequences of global climate change. The restructured program includes many of the recommendations of the EOS scientists, and it is fully consistent with the recommendations of a number of other external groups, including the EOS Engineering Review Committee (chaired by Dr. Edward Frieman) and Congress.

The restructured EOS program is more robust and flexible, and it accommodates the funding guidelines outlined by the Congress as part of the FY 1992 budget. Although some instruments will fly later than originally planned, the new configuration of spacecraft will allow us to accelerate the initiation of some important measurements compared to the original schedule. It also maintains our strong commitment to international cooperation in global change research, particularly with the European Space Agency, Canada, and Japan.

The restructured EOS program is an important part of Mission to Planet Earth (MTPE), providing critical space-based measurements for the USGCRP. It is also integrated into a carefully planned set of international global change research efforts. I would be pleased to arrange a briefing for you and your staff on the current status of the restructured program and its contribution to global change research. Please do not hesitate to contact me if I can be of further assistance.

Sincerely,

A handwritten signature in black ink, appearing to read "Richard H. Truly". The signature is fluid and cursive, with a large loop at the end.

Richard H. Truly
Administrator

Enclosure

THE RESTRUCTURING OF THE EARTH OBSERVING SYSTEM

NASA has completed the restructuring of the Earth Observing System (EOS) from a program in which the instruments were to be flown on a series of large platforms to one in which the instruments will fly on intermediate-sized and smaller spacecraft. The restructuring was undertaken (i) to provide the EOS program with greater resilience and flexibility; (ii) to adjust the program to the reduced levels of funding expected from the Congress; and (iii) to take advantage of new launch opportunities for the EOS spacecraft, particularly, the expected availability of Atlas IIAS launch vehicles from the west coast. The restructuring effort was guided, in part, by the report of the EOS Engineering Review Committee chaired by Dr. E. Frieman (the Frieman Committee), and the results of the restructuring are wholly consistent with its recommendations. Further, the restructured program fully meets NASA's commitments under the Space Station Freedom international agreements for the polar platforms.

The following sections, and the accompanying figures, describe the essential outcome of the restructuring effort. Further details on each of these sections are available.

The Evolution of the Payload: NASA has undertaken a systematic process, involving input from the Frieman Committee and a thorough review and analysis by EOS investigators, to determine the optimum payloads for intermediate-size and small-size EOS spacecraft. Figure 1 illustrates the evolution of the payloads during this restructuring exercise.

The outer edge of the figure illustrates the baseline EOS program, prior to restructuring. Each of the instruments is listed by its acronym, which is defined on an accompanying page. The instruments in the upper portion were to fly on the EOS-A1 platform, which was a large platform to be launched on an upgraded Titan IV. The instruments in the lower portion were candidates for the EOS-B platform series, whose configuration had not been determined. Also shown are the US instruments that were to fly on the European and Japanese spacecraft which are complementary to NASA's Mission to Planet Earth.

The next inner circle illustrates the payloads that were presented to the Frieman Committee in La Jolla, California, in July 1991, and endorsed in their report as the preferred "proof of concept" for an EOS which contains a "favorable measure of resiliency." The payloads were expected to be launched on Atlas IIAS-class vehicles. Note that the program would consist of two primary spacecraft, each in sun-synchronous polar orbits, but with different crossing times -- one AM and one PM. Also included are an additional Atlas-sized spacecraft for an altimeter and atmospheric instruments (ALT, MOPITT, and HIRDLS), and a smaller spacecraft for the tropospheric instrument, TES. The payload configurations satisfy the highest priority simultaneity requirements critical to the science objectives of the EOS program, without requiring that the spacecraft fly in formation.

On each of the next circles, from outside inward, are illustrated (i) the payloads that were discussed at the Seattle meeting of the Investigator Working Group of all EOS investigators in August 1991; (ii) the modifications to the Seattle payloads that were considered by NASA for further analysis by the EOS project; and (iii) the payloads that were endorsed in Easton, Maryland, in October 1991 by the Payload Advisory Panel, a committee comprised of the EOS interdisciplinary investigators that have the responsibility for the use of the EOS data, and is formally charged with recommending EOS payloads to NASA.

Finally, illustrated on the inner most circle are the payloads that NASA plans to implement as the restructured EOS program. These payloads are described in more detail in Figure 2. The final payloads satisfy the recommendations of the Payload Panel with the caveat that some of the instruments will fly later than recommended. The Payload Panel would prefer to fly the scatterometer instrument (STIKSCAT), the atmospheric instruments (HIRDLS and MLS/SAFIRE) and the altimeter before 2000, but budget constraints may preclude this.

The final payloads, with some rearrangement of instruments, are very similar to the La Jolla payloads endorsed by the Frieman Committee. There are three basic intermediate-size spacecraft and one smaller payload (requiring a Delta-class launch vehicle). The first intermediate-size spacecraft, labeled EOS-AM, has an AM crossing time, the other, EOS-PM, has a PM crossing, and the third, EOS-CHEM, carries the atmospheric instruments TES, HIRDLS, and SAGE-III, and the scatterometer STIKSCAT. The smaller mission labeled EOS-ALT conducts altimetry measurements.

A principal difference between the final payloads and the La Jolla payloads concerns the scatterometer instrument, STIKSCAT. The Frieman Committee assumed that STIKSCAT could be deleted in favor of the European C-band measurements. The Payload Advisory Panel does not share this judgment and recommends that NASA fly STIKSCAT. In the final payloads STIKSCAT is flown on the third intermediate-class spacecraft. An alternative noted in Figure 1 might be to fly STIKSCAT on the Japanese ADEOS-II mission in the year 2000, which is earlier than in the final payloads. This alternative, however, would require more funding in the early years of the EOS program than may be available, and would also necessitate discussions with the Japanese, which have not yet occurred.

The final payloads also include two small missions (requiring Pegasus-class launch vehicles) -- EOS-AERO to fly the SAGE-III and EOSP instruments in a 57 degree inclination orbit, and EOS-COLOR to fly the SeaWiFS instruments for ocean color measurements, instead of the MODIS-T instrument. There is also a need to identify flights of opportunity for the small ACRIM and SOLSTICE instruments, and for either the MLS or SAFIRE atmospheric instruments, each of which is descoped from its original version. Finally, NASA plans to enter into discussions with ESA concerning flight of the SAGE-II instrument on their polar platform.

Launch Vehicles: All of the intermediate-size EOS payloads in the restructured program will be flown on spacecraft with 12-foot diameters that are compatible with the proposed Atlas IIAS launch vehicle, using a standard Atlas faring. The payload on EOS-PM has the largest volume and, although difficult to fit in an Atlas faring, can be accommodated.

It should be noted that in discussing the La Jolla payloads with the Frieman Committee it was assumed that the Atlas faring could be extended by 3 feet, and possibly up to 7 feet. Subsequent analysis revealed that the 7-foot extension is not possible and the 3-foot extension may be difficult. Detailed engineering studies by the EOS project have led to innovative packaging of instruments and spacecraft subsystems which permit the EOS payloads to fly in the standard Atlas faring.

Focusing the Science Objectives -- Deletion of Instruments: Of all the global change issues that could be studied, the one that is in most need of an improved scientific understanding, in order to make sound policy decisions, is global climate change. Accordingly, the restructured EOS will emphasize studies of global climate change and use the scientific priorities documented by the Intergovernmental Panel on Climate Change (IPCC). The restructured EOS will thus make only limited observations of stratospheric chemistry and solid Earth physics. This focusing of the science objectives and the resulting deletion of instruments has been endorsed by the Frieman Committee.

In particular, the restructured EOS does not include funding for the proposed stratospheric instrument, SWIRLS, or for the non-descoped version of the MLS and SAFIRE instruments. The geodynamics portion of the GLRS instrument, GLRS-R, the secondary instruments GOS, IPEI, and XIE, and the lightning instrument LIS are deselected from the program. The Laser Atmospheric Wind Sounder (LAWS) is an important instrument for global climate change studies but must be postponed (See discussion of the potential contribution of the Departments of Energy and Defense.) As in the recommendations of the Frieman Committee, the MODIS-T instrument is also deleted; its measurements of ocean color will be provided by the reflight of the simpler SeaWiFS instrument on a small, separate spacecraft and from MODIS-N measurements on both the EOS-AM and EOS-PM spacecraft.

Simultaneity Requirements: The sensitivity of the EOS instruments is such that they generally require simultaneous measurements from other instruments, through the same column of air, in order to make atmospheric corrections and/or to pursue their science objectives. Figure 3, which was prepared for the Frieman Committee, outlines the simultaneity requirements for the instruments that were to fly on the original, large EOS-A1 platform. The horizontal columns list the instruments that provide simultaneous measurements; the vertical columns list the instruments that use these measurements. The circled symbols indicate the most critical simultaneous measurements.

In the restructured EOS, in which the instruments are flown on intermediate-size platforms, the simultaneity requirements shown in Figure 3 are satisfied primarily by flying the MODIS-N instrument on two separate spacecraft, EOS-AM and EOS-PM. This solution for simultaneity is also used in the La Jolla payloads recommended by the Frieman Committee. Note by comparing Figures 1 and 3 that with MODIS-N on the EOS-AM spacecraft, the critical simultaneity requirements are met for ASTER, CERES, and MODIS-N. With MODIS-N on the EOS-PM spacecraft, the critical simultaneity requirements are met for AIRS, AMSU-A, MHS, CERES, MIMR, and MODIS-N.

It should be noted that, in principle, it is possible to fly MODIS-N on only one of the intermediate-size spacecraft, and then fly the other in close formation so that MODIS-N can provide the needed simultaneous observations for the latter's instruments. However, by duplicating MODIS-N on each spacecraft, it is possible to choose the optimum crossing time for each payload. The payload with ASTER, MISR, and MODIS-N primarily observes surface features, and thus the AM-crossing time, when cloud cover is at a minimum, is the preferred orbit. In contrast, the payload with AIRS, AMSU-A, MHS, CERES, MIMR, and MODIS-N has a PM-crossing time. This is due to the desire to (i) fly AIRS, a candidate next-generation atmospheric sounder for deployment on future NOAA operational satellites, at a time most useful for contributing data for meteorological forecasting, as well as (ii) obtaining observations from CERES and MODIS-N at a second time during the day, thus improving estimates of diurnal variability. Further, MODIS-N is the central instrument in EOS, and with it flying on two separate spacecraft, the program has important redundancy.

The MOPITT instrument (See Figure 3) has a critical simultaneity requirement for atmospheric temperature observations from AIRS which is not met in the restructured EOS. However, this deficiency is not considered to be serious since the MODIS-N instrument, which will fly together with MOPITT, can provide some temperature measurements with reduced resolution in altitude. The scatterometer instrument (STIKSCAT) has a critical requirement for passive microwave observations from MIMR. This requirement can be met by placing the EOS-CHEM spacecraft which includes STIKSCAT in a similar orbit with the EOS-PM spacecraft that includes MIMR. If STIKSCAT is flown on the Japanese ADEOS II mission instead, it is likely that there will be an appropriate Japanese instrument to provide the needed microwave measurements. The simultaneity requirements of LIS and MODIS-T instruments are not considered since these instruments have been deleted. Finally, it should be noted that with MISR on the EOS-AM spacecraft, and AIRS and MHS on EOS-PM, the critical simultaneity requirements for MISR are not fully satisfied. Although this is a deficiency in the restructured program, the alternative of flying the spacecraft in formation to meet this requirement is considered less desirable than permitting each payload to have its optimum crossing time.

Launch Sequence: The large EOS-A1 platform was scheduled to be launched in December 1998. In the restructured EOS program, the EOS-AM spacecraft will be

launched six months earlier, in June 1998. This launch date is determined by the time required to develop, test, and calibrate the instruments. The EOS-AM spacecraft will be followed two and a half years later, in December 2000, by the EOS-PM spacecraft, and in 2002 by EOS-CHEM with the scatterometer and the atmospheric chemistry instruments. The smaller missions, EOS-COLOR, EOS-ALT, and EOS-AERO, are interspersed among the intermediate-size missions.

The EOS-AM spacecraft is scheduled to launch first because (i) it will yield important measurements of both clouds and radiation and surface characteristics, and (ii) it is more straightforward to execute than the EOS-PM spacecraft. The EOS-AM spacecraft includes only one challenging US instrument, MODIS-N, whereas the EOS-PM spacecraft includes both the MODIS-N and the AIRS instruments. Thus, the cost and schedule for EOS-AM are less demanding. Indeed, within the funding levels expected for EOS in the next few years, EOS-PM cannot be launched before 1999 and, if first, would delay the acquisition of EOS data. The Payload Advisory Panel, in consideration of the schedule and budget requirements for the EOS-AM and EOS-PM spacecraft, recommended that EOS-AM launch first.

EOS Data and Information System (EOSDIS): With the restructuring of EOS, there will be delays in some of the observations from what was expected in the original program. The EOS-AM spacecraft will fly in advance of the original large platform; however, the EOS-PM spacecraft is delayed. Thus, the EOSDIS that will be required by the year 2000 will be smaller than was originally envisioned. This adjustment can be made without altering the basic architecture, or the evolutionary design of EOSDIS, which is to be a flexible, distributed system, developed in successive versions, each version building on the experience of the previous version. The budgets for EOSDIS, however, can be reduced substantially, and scale approximately with the reduced cost of the space hardware for EOS. The National Research Council is being asked to convene a panel of experts to review NASA's plans for EOSDIS, including the validation of its engineering and technical underpinning, and to assess whether current plans provide sufficient resiliency to be adaptable to changing requirements.

Funding Requirements: The restructured EOS program, including the spacecraft (AM, PM, CHEM, ALT, AERO, and COLOR), EOSDIS, and the supporting science (the latter two items representing approximately half the cost) has been designed to accommodate the \$11 billion funding cap through FY2000, as directed by Congress. The restructured program requires relatively modest growth over the FY1992 funding level in FY1993 and FY1994. However, it is essential that this funding profile be maintained in order to preserve the launch schedule for the EOS-AM spacecraft in 1998 and EOS-PM in 2000. The funding requirements for the restructured program increase substantially in FY1995. This increase is necessary to execute the complete set and sequence of spacecraft required for the restructured program.

The spacecraft in the restructured program will be funded with the normal reserves for major NASA flight programs. Further, in compliance with the recommendations of the Frieman Committee, the restructured program has additional budget flexibility in that the launch dates of the CHEM, ALT, AERO, and COLOR spacecraft can slip within a modest range without drastically impacting the science observations. Every effort, however, will be made to preserve the launch dates of the AM and PM spacecraft.

The cost estimates for the instruments that were to have flown on the original large EOS-A1 platform and the EOS-AM spacecraft bus are well understood since both elements are under contract (although the spacecraft contract will be modified to reflect the current downsized configuration). Cost estimates for subsequent spacecraft and for the instruments that are not currently under development are preliminary, based on derivation from the current EOS-AM definition and development estimates and analogy with previous flight project experience. These estimates will be updated before beginning development of these spacecraft and instruments.

Missions in Advance of EOS: A calendar of the launch dates for all of the missions that will make observations of global change in advance of EOS is shown in Figure 4. This era is known as Phase 1 of the Mission to Planet Earth. It is important to note that all of the instruments that will fly on EOS have important, but less capable versions, or in some cases even identical versions, that will fly on these Phase 1 missions. Thus, the Mission to Planet Earth is an evolutionary program. It is providing important information on global change today, will provide more such information throughout Phase 1, and will evolve into more comprehensive and detailed observations when the EOS spacecraft fly.

The Role of the Departments of Energy and Defense: As noted by the Frieman Committee, the DOE and DOD can make important contributions to the Mission to Planet Earth. In particular, the DOE may be able to provide an additional spacecraft to Phase 1 of the Mission to Planet Earth. Although there are a large number of missions that fly during Phase 1, several review committees have noted that there is a discontinuity in Earth radiation budget observations, between NASA's ERBE measurements on ERBS and NOAA 9 and 10, and NASA's CERES measurements on the Japanese TRMM mission and subsequent EOS spacecraft. The DOE is considering providing one or more small spacecraft which can provide these observations. To be useful the observations need to commence no later than 1995, since TRMM flies in 1997, and their calibration needs to be well understood to help provide continuity between the ERBE and CERES observations.

Further, the DOE and DOD may be able to assist in the development of new technologies for use in subsequent generations of EOS instruments. The restructured EOS does not include a Laser Atmospheric Wind Sounder, an advanced Synthetic Aperture Radar, or a light-weight, high-resolution imaging spectrometer. These instruments will be important for global change studies. It would be very helpful for the

DOE and DOD to execute technology demonstration projects that would lead to reliable, more compact, and less expensive versions of these and other advanced instruments.

It should be noted that the DOE and DOD are not expected to develop technology for the first generation of EOS spacecraft. The instruments for these spacecraft are currently under development using state-of-the-art technology. Similarly, the spacecraft designs are straightforward extensions of previously successful NASA spacecraft.

Follow-on EOS Spacecraft: EOS is to be a long-term program, providing continuous observations of the causes of global climate change. The principal EOS spacecraft, EOS-AM, EOS-PM, etc., will thus be repeated twice on five-year centers for at least fifteen year coverage. However, the payloads on the follow-on EOS spacecraft could change, depending on the evolution of scientific understanding of global change and the development of technology. For example, the ASTER instrument on the first EOS-AM spacecraft could be replaced by the high resolution spectrometer, HIRIS, on the second EOS-AM spacecraft. Actual decisions on instruments to fly on follow-on spacecraft do not need to be made for some years. However, technology development efforts need to continue to insure that subsequent generation instruments are available when needed.



Descriptions of EOS Missions

Missions before the end of 2000

Missions	Instruments Planned	Instrument Description	Mission Science Objectives
NASA AM-1 698	CERES (2 Scanners)	Clouds and Earth's Radiant Energy System—Two broad-band scanning radiometers	• Physical and radiative properties of clouds • Air-land exchanges of energy, carbon, and water • Vertical profiles of CO and CH₄ • Volcanology
	MODIS-N	Moderate-Resolution Imaging Spectrometer—Global physical and biological processes	
	MISR	Multi-angle Imaging Spectro-Radiometer—Global maps of planetary and surface albedo, and aerosols and vegetation properties	
	ASTER (Japan)	Advanced Spaceborne Thermal Emission and Reflection Radiometer—High-resolution images of land surface, water, and clouds stereo	
	MOPITT	Measurements of Pollution in the Troposphere—Vertical profile of CO and CH ₄ column	
	WBDCS	Wide Band Data Collection System—Collects data from ocean buoys	
NASA SeaWiFS II 1998	SeaWiFS	Sea-Viewing Wide Field-of-View Sensor—Ocean color and productivity	• The oceans' role in carbon cycle
NASA Aero 2000	SAGE III	Stratospheric Aerosol and Gas Experiment III—Global profiles of aerosols, clouds, temperature, and pressure	• Tropospheric and stratospheric aerosol properties
	EOSP	Earth Observing Scanning Polarimeter—Globally maps radiance and linear polarization of reflected sunlight	

Descriptions of EOS Missions

Missions before the end of 2000

Missions	Instruments Planned	Instrument Description	Mission Science Objectives
NASA PM-1 1200	CERES (2 Scanners)	Clouds and Earth's Radiant Energy System—Two broad-band scanning radiometers	• Cloud formation, precipitation, and radiative properties • Air-sea fluxes of energy and moisture • Sea-ice extent and heat exchange with the atmosphere
	AIRS	Atmospheric Infrared Sounder—Clear-column temperature profiles	
	AMSU-A	Advanced Microwave Sounding Unit—Temperature sounding from surface to 40 km	
	MHS	Microwave Humidity Sounder—Atmospheric water vapor profiles	
	MODIS-N	Moderate-Resolution Imaging Spectrometer—Global biological and physical processes	
	MTMR (ESA)	Multi-Frequency Imaging Microwave Radiometer—Precipitation, cloud water, sea surface temperature and roughness, and ice, snow, soil moisture	
NASA ALT 2002	ALT	Altimeter—Dual frequency radar for topography	• Ocean altimetry and circulation • Ice sheet mass balance • Geological features application
	GGI	Global Positioning System (GPS) Geoscience Instrument—Tracks 18 GPS for 3-cm positioning, global geodesy, atmospheric temperatures, and gravity wave characterization	
	GLRS-A	Geoscience Laser Ranging System-Altimeter Only—Ice sheet and glacier topography	

Descriptions of EOS Missions

Missions after 2000

Missions	Instruments Planned	Instrument Description	Mission Science Objectives
NASA Chem 2002	HIRDLS	High-Resolution Dynamics Limb Sounder—Global distribution of temperature and greenhouse gases	• Chemistry of troposphere and lower stratosphere, including stratosphere/troposphere exchange • Air-sea chemical fluxes and forcing of ocean circulation
	TES	Tropospheric Emission Spectrometer—3-D profiles on a global scale of all infrared-active species from surface to lower stratosphere	
	STIKSCAT	Scatterometer—Sea surface wind vectors	
	SAGE III	Stratospheric Aerosol and Gas Experiment III—Global profiles of aerosols, clouds, temperature, and pressure	
2003 and 2005		Follow-on AM and PM missions with some substitutions are planned to ensure data continuity	

EOS A-I Instrument Synergy

FIGURE 3

Provider User	MODIS-N	MODIS-T	CERES	ASTER	MISR	EOSP	AIRS	AMSU-A	MHS	MIMR	STIKSCAT	MOPITT	LIS	HRDLS	ACRIM
MODIS-N		C/P	C	C/P	C/P	C/P	C/P	C/P	P	P					
MODIS-T				C	C/P		P	(P)	P	P	P				
CERES				(P)	P	C/P	C/P	P	P	P					
ASTER					P		P	(P)	(P)	(P)					
MISR				(C)		C/P	P	(P)	P	(P)					
EOSP					C/P		P		P	(P)					
AIRS							P	P	P	P					
AMSU-A							P		P	C/P					
MHS							P	P	P	P					
MIMR							P	(C/P)	P	P					
STIKSCAT										P					
MOPITT							P	P	(P)						
LIS							(P)	(P)	(P)	P					
HRDLS							(P)	(P)							
ACRIM															

KEY

C = Cross Calibration Connection

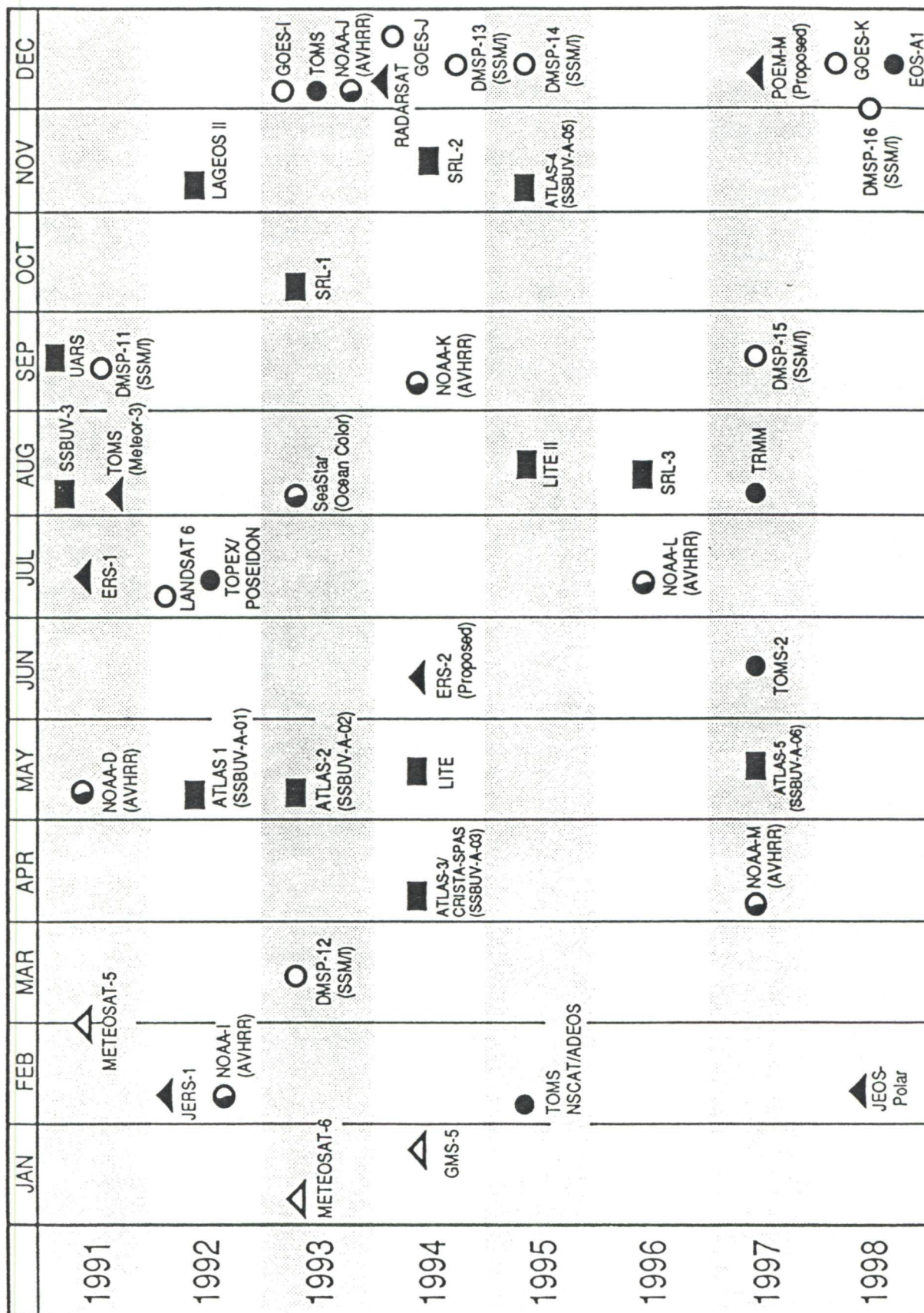
P = Observed Phenomena Connection

○ = Critically Required

 = Required

 = Potential Contribution

PHASE I OF MISSION TO PLANET EARTH*



* Dates for US Missions are Estimates and Reflect Current (August 1991) NASA Manifest and Planning, as Well as Planning by NOAA and DOD. Dates for Foreign Missions are Estimates Provided by Those Nations.

SHUTTLE
 ELV R&D
 ELV OPERATIONAL
 1/2 R&D 1/2 OPERATIONAL
 FOREIGN MISSION R&D
 FOREIGN OPERATIONAL

ACRONYMS

ACRIM	Active Cavity Radiometer Irradiance Monitor
ADEOS	Advanced Earth Observing Satellite (Japan)
AIRS	Atmospheric Infrared Sounder
ALT	Altimeter
AMSU-A	Advanced Microwave Sounding Unit
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
CERES	Clouds and Earth's Radiant Energy System
EOSDIS	EOS Data and Information System
EOSP	Earth Observing Scanning Polarimeter
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
ESA	European Space Agency
GGI	GPS (Global Positioning System) Geoscience Instrument
GLRS	Geoscience Laser Ranging System
GOS	Geomagnetic Observing System
HIRDLS	High-Resolution Dynamics Limb Sounder
HIRIS	High-Resolution Imaging Spectrometer
IPCC	Intergovernmental Panel on Climate Change
IPEI	Ionospheric Plasma and Electrodynamics Instrument
LAWS	Laser Atmospheric Wind Sounder
LIS	Lightning Imaging Sensor
MHS	Microwave Humidity Sounder
MIMR	Multifrequency Imaging Microwave Radiometer
MISR	Multi-Angle Imaging Spectro-Radiometer
MLS	Microwave Limb Sounder
MODIS-N	Moderate-Resolution Imaging Spectrometer-Nadir
MODIS-T	Moderate-Resolution Imaging Spectrometer-Tilt
MOPITT	Measurements of Pollution in the Troposphere
NOAA	National Oceanic and Atmospheric Administration
NSCAT	NASA Scatterometer
POEM	Polar Orbit Earth Observations Mission (ESA)
SAFIRE	Spectroscopy of the Atmosphere Using Far Infrared Emission
SAGE III	Stratospheric Aerosol and Gas Experiment
SAR	Synthetic Aperture Radar
SeaWiFS	Sea Wide-Field Viewing Sensor
SOLSTICE	Solar Stellar Irradiance Comparison Experiment
STIKSCAT	Stick Scatterometer
SWIRLS	Stratospheric Wind Infrared Limb Sounder
TES	Tropospheric Emission Spectrometer
TRMM	Tropical Rainfall Measuring Mission
XIE	X-Ray Imaging Experiment