Report of the Panel to Review EOSDIS Plans

On September 28, 1992, Chair Charles A. Zraket sent the following letter report to NASA Administrator Daniel S. Goldin.

I am pleased to submit this letter report of the National Research Council's Panel to Review Earth Observing System Data and Information System (EOSDIS) Plans. This letter is based on NASA's responses to the panel's Interim Report of April 9, 1992, two meetings of the full panel (May 15 and July 27-29, 1992), and several discussions between panel representatives and administration officials and congressional staff. By mutual agreement with NASA, as well as with the Office of Science and Technology Policy, the Office of Management and Budget, and the National Space Council, the panel will now suspend its activities. Agency officials and the panel agreed in July that because a contractor had not been selected for the core system of EOSDIS, the panel could not complete its work. In particular, without knowledge of the critical details of the work to be done by the contractor, the panel cannot respond fully to the questions posed in its terms of reference. The panel remains willing to reconvene once the necessary information is publicly available.[1]

The purpose of this letter is to reiterate and elaborate the panel's April 1992 recommendations on several critical areas that require concerted action over the next five to six months if the EOSDIS development program is to proceed on a course that eventually can meet the needs of the Global Change Research Program. The three critical areas are:

1. **The development of EOSDIS as an integral part of the Global Change Data and Information System (GCDIS)—in contrast to a program oriented solely to EOS.** NASA is to be commended for its recognition of the critical importance of EOSDIS to the success of the Global Change Research Program. This recognition is reflected in the early and substantial funding for EOSDIS and in NASA's involvement of a broad segment of the prospective user community. The panel is also encouraged by the response to its Interim Report from Drs. Lennard Fisk and Dixon Butler. They stated that NASA intends to implement many of the panel's recommendations, including those that addressed the enhanced development of the GCDIS in conjunction with other agencies and the formulation of Distributed Active Archive Center (DAAC) development teams that will include representatives from the user communities. Nevertheless, ensuring the success of the program and realizing the benefit of the early and significant funding are now dependent on NASA's establishing firm and specific plans and budgets for the development and operation of the GCDIS, in conjunction with other agencies.

2. **The formation, within NASA, of the management structure and the assembly of skills needed to execute the EOSDIS program and to assure its integration into GCDIS.** The panel is concerned by the lack of response to and action on to its previous recommendations to strengthen the management—both administrative and technical—of the EOSDIS program. In particular, the panel is concerned that its recommendations for substantial organizational changes in the EOSDIS program seem to have been ignored by management at the Goddard Space Flight Center. The panel believes that, unless these management deficiencies are addressed immediately, the EOSDIS program has a high risk of failure.

3. **The need to strengthen the computer science dimension of the project.** The panel believes that EOSDIS must be supported by an appropriate computer science research program at a level much greater than currently planned. The panel points out that the costs of an expanded computer science effort would still be a small part of the

planned EOSDIS budget, yet could potentially save major costs by avoiding possibly flawed decisions due to inadequate involvement of computer scientists.
Further details about these three critical areas—emphasizing development of a GCDIS, strengthening management, and adequately providing for the role of computer science—are provided below.

THE GLOBAL CHANGE DATA AND INFORMATION SYSTEM

The data essential to fulfilling the multidisciplinary and interdisciplinary research objectives of the Global Change Research Program are widely distributed among national and international agencies. That reality has been recognized by the effort to create a Global Change Data and Information System (GCDIS) by the federal agencies that constitute the Committee on Earth and Environmental Sciences. The purpose of the GCDIS to simplify the task of obtaining and using data related to global change. The panel believes that EOSDIS must be structured and managed as an integral part of the GCDIS, so that current and future data related to global change collected by NASA and by other national and international organizations are available in an integrated form to all global change research scientists.

These data reside in a variety of media formats and physical locations. Thus, it is essential to have coherent methods for data access that are simple, transparent, and inexpensive to users and that operate at a variety of levels. Providing such methods is a major management challenge. Currently, the GCDIS is being planned in the United States through an interagency group and is intended to exploit the resources and responsibilities of each agency. However, the agencies have widely differing capabilities in information systems technology and management; some lack the necessary resources and finances. Thus, it is not at all certain that, given the complexity and cost of the development effort, a unified and effective GCDIS will emerge. Since NASA is already moving ahead aggressively with EOSDIS, the panel recommends that NASA assume the lead role to plan the overall GCDIS and to develop the system architecture and network for a truly distributed, interoperable, interagency data system. In doing so, NASA must lead in forming partnerships with the other agencies, including international ones, to develop and operate the various parts of the GCDIS. Such partnerships require continuing dialogue and agreements early on, especially with respect to the operational and funding responsibilities of each participating agency. To facilitate agency cooperation, a national directive should give NASA the leadership role for planning and developing the GCDIS.[2]

The principles for a national data policy adopted as part of the interagency GCDIS[3] incorporate the concept of full international cooperation, both for setting priorities and for establishing standards. The principles are similar to those adopted by the international community as represented by the international Committee on Earth Observation Satellites, the Data and Information System of the International Geosphere-Biosphere Programme, and the World Data Centre System of the International Council of Scientific Unions. The panel endorses this recognition of the international aspect of data management and urges that EOSDIS fully incorporate those principles into its operation.

Having the lead role for implementing GCDIS, NASA will need to obtain a consensus among the participating federal agencies on an implementation strategy. Further, NASA should be prepared to assist other agencies in the design, development, and provision of common GCDIS software, database structures, and technical infrastructure for an interoperable network. Each agency, however, should be responsible for funding the operation and maintenance of its portion of the GCDIS as well as for procuring its own hardware and unique applications software, given that each agency will use the data for other purposes in addition to research on global climate change. The agencies must strive to obtain the funds necessary to accomplish these tasks. Such funds are quite

modest compared to the total government investment in the EOS program and, indeed, the entire observational effort required for global change research. It must be kept in mind that the agencies each have resources that are vital to achieving a successful GCDIS; for example, NOAA now has the preponderance of data essential to a GCDIS.

NASA must also develop a philosophy and an overall plan to govern archiving activities and to ensure user input to decisions that affect data retention and the transfer of archiving responsibilities to other agencies. Further, EOSDIS is unlikely to become the vehicle by which a GCDIS evolves if NASA tries to replicate the diversity and volume of databases residing throughout the agencies. It is crucial, therefore, that NASA nurture the active participation of the agencies within the EOSDIS framework.

NASA's EOSDIS Science Data Plan, issued in May 1992, recognizes the significance of NOAA's in situ and space-based climate data and proposes that these data be archived at NASA's DAACs.[4] The panel believes, however, that NASA should not try to duplicate NOAA's database within NASA's DAACs. Instead, the panel recommends that NASA expand by two the number of DAACs, to include NOAA's space-based and in situ data in a truly interoperable, interagency distributed information system, similar to its incorporation of DAACs from the USGS (Earth Resources Observation System, EROS) and from the DOE (the newly established Oak Ridge National Laboratory DAAC).

These NOAA data sets will be critical for adequate interpretation of EOS observations because they enable validation of results and provide a historical baseline to distinguish between natural and anthropogenic climate change. Again, NASA should not duplicate other agencies' databases, but rather should support their inclusion by developing a GCDIS—a truly interoperable, interagency data and information system.

NASA agreements with participating agencies should be formulated soon; otherwise, it will be difficult for EOSDIS to evolve as a major part of the GCDIS in a coherent and cost-effective way. Effective response will depend critically on federal leadership to assure that each agency participates as a full partner in developing plans and resources for handling its data, supporting its data centers, and facilitating its connection to EOSDIS.

PROJECT MANAGEMENT

The panel remains concerned with the inadequacy of EOSDIS Project management at the Goddard Space Flight Center (GSFC). Some of the key concerns expressed in the panel's Interim Report have either not been understood or cannot be addressed within the existing organizational structure. While the panel again judges the current EOSDIS Project staff to be highly dedicated and technically able, the reality is that the EOSDIS Project does not have the requisite visibility and organizational stature, or the necessary full complement of senior, experienced management and technical staff. Specifically, the project requires management experienced in building complex, integrated data systems costing in the billion-dollar range. Furthermore, EOSDIS is a large-scale distributed information system with goals that extend beyond the EOS flight components. Proper architectural design, technical decision making, and technical risk management must take into account the overall goals of GCDIS. Despite its importance, EOSDIS currently is managed at the GSFC as a standard flight project. Such an approach is unlikely to:

- Incorporate the necessary types and levels of information systems expertise;
- Allow for adequate user involvement in decision-making processes; and
- Provide the infrastructure to attract the expertise and the experienced personnel required to manage a project of this magnitude.

The panel believes that a continued "business as usual" approach will pose serious and unacceptable risks to the successful design, development, and implementation of

EOSDIS and certainly of GCDIS. The panel has seen no indication in its discussions with GSFC management that the required changes will be made.

The panel thus recommends that a comprehensive review of the management approach be undertaken immediately. It believes that several ideas should be considered:

- The EOSDIS Project should be elevated to report to the GSFC director and should be independent from the management of the EOS flight components;
- The EOSDIS Project organization should include a leadership role for practicing senior earth observation scientists respected in their research communities;
- The EOSDIS Project staff should have past experience in managing distributed information systems similar in scale to EOSDIS and should include a highly experienced leader of a systems architecture team, a leader greatly experienced in managing the acquisition of large-scale information systems, and senior computer scientists respected in their research communities; and
- The EOSDIS Project Office should contain a specific group charged with maintaining liaison with other agencies and countries involved in global change research in order to facilitate the evolution of the GCDIS.

The panel stresses the need for a strengthened system architecture group in the EOSDIS Project Office to help define an overall information system design that meets user needs and to ensure that detailed design decisions reflect this vision. The panel believes that the EOSDIS Project does not now have such a design philosophy and is relying on the contractor to provide it. For example, in response to a request for a statement of "design criteria," the panel received a list of good software engineering practices that could not be used to distinguish a distributed system from a centralized one, much less to guide the development of a system intended to focus on facilitating global change research. The necessary criteria should be crisply stated, should be user oriented, and should serve to guide day-to-day decision making. Such decisions would include defining important system interfaces and determining the need of end-users for commercial off-the-shelf software versus new specially designed software. The panel believes that a well-defined set of design criteria is an essential management tool.

COMPUTER RESEARCH PROGRAM

Computer scientists must be intimately involved in the development of EOSDIS as well as in EOSDIS Project management decision making. NASA seems to have assumed that by monitoring developments in the commercial sector, it will be able to obtain technology for long-term archiving, network technology, graphics, and other applications. The panel does not agree with this approach. It is likely that adequate hardware and software technology for data storage and retrieval and for data transfer will be available for the initial version of the system. However, the size, complexity, and heterogeneity of the global change data sets will certainly require the development of specialized technology for information management and intelligent query, retrieval, and correlation. The panel concludes that maintaining planned costs and schedules will be jeopardized if EOSDIS is implemented without funding a complementary computer science research program. The project must be prepared to sponsor such research to make long-term enhancements feasible.

The challenges and importance of EOSDIS warrant an investment by NASA in computer science research. In discussions with NASA, the panel has seen increased appreciation of this point but also has observed a misperception of what computer science research is, who does it, and what its payoff is. It is important for NASA to distinguish between research computer scientists and practitioners who are not necessarily researchers. The computer scientists that the panel recommends be brought into the program are active in developing understanding of computing activities, through mathematics and models, based on theory and abstraction.[5]

Although supporting computer science research will be a cost factor, the panel believes that NASA runs a greater risk and may potentially incur even greater expense by not supporting such research. The development and continuing evolution of EOSDIS can be facilitated, and major cost savings achieved, if NASA will now invest in a serious program of computer science research in areas relevant to EOSDIS and GCDIS. NASA should:

- Bring into advisory panels representation from the computer science research community;
- Develop a computer science research program that includes a mix of in-house and external personnel who represent the best the research computer science community has to offer. It is important that a critical mass of expertise be assembled.[6]

On behalf of the panel, I wish to thank all of those at NASA who responded quickly and professionally to the questions submitted by panel members. I would especially like to thank Drs. Fisk and Butler for their responsiveness in devoting much time to useful discussions with the panel on the substance and needs of the program. The panel looks forward to your comments on its recommendations.

Signed by
Charles A. Zraket
Chair, Panel to Review EOSDIS Plans

[1]NASA, in its Statement on Earth Data System Proposals of August 20, 1992, directed the offerers to submit revised cost estimates. Specifically, the NASA announcement stated that "the government's analysis clearly indicates that the offerers significantly underestimated the cost of the respective technical approaches. Accordingly, NASA is unwilling to select an offerer for further negotiations leading to award of a contract." NASA had directed the offerers to submit revised cost estimates by the end of August 1992, with a contract to be awarded by the end of September 1992.

[2]The National Space Policy Directive issued by the White House on June 5, 1992, indeed seems to support the eventual integration of NASA data systems into GCDIS, by giving NASA lead responsibility for "Space-based Global Change Observation System" activities.

[3]*U.S. Global Change Data and Information Management Program Plan*, Committee on Earth and Environmental Sciences, 1992. An NRC review of the initial plans for GCDIS is described in *The 1992 Data Forum: A Review of a Federal Plan for Managing Global Change Data and Information* (National Academy Press, Washington, D.C., 1992).

[4]*Science Data Plan for the EOS Data and Information System Covering EOSDIS Version 0 and Beyond*, Document Version 1.0, May 1992, Goddard Space Flight Center.

[5]The new NRC report on computer science and engineering, *Computing the Future: A Broader Agenda for Computer Science and Engineering* (National Academy Press, Washington, D.C., 1992), notes that:
. . . the "science" in "computer science and engineering" connotes understanding of computing activities, through mathematical and engineering models and based on theory and abstraction. . . . Computer scientists and engineers focus on information, on the ways of representing and processing information, and on the machines and systems that perform the tasks. (p. 19)

[6]Defining what is meant by a "critical mass" is difficult to do. However, the Panel suggests that, based on considerable experience in many projects, an investment of a few percent of a project's Research and Development funds would be a useful way to proceed. Such

an investment would provide for, perhaps, 20 to 30 independent computer science researchers to carry out an effective research program that supports EOSDIS development.