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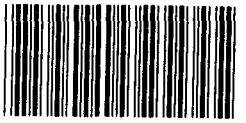
GAO

United States
General Accounting Office
Washington, D.C. 20548

Information Management and
Technology Division



B-247995

March 23, 1992

The Honorable Ernest F. Hollings
Chairman, Committee on Commerce, Science,
and Transportation
United States Senate

The Honorable Larry Pressler
Ranking Minority Member,
Subcommittee on Science, Technology,
and Space,
Committee on Commerce, Science, and
Transportation
United States Senate

On February 26, 1992, we testified before the Subcommittee on Science, Technology, and Space regarding the National Aeronautics and Space Administration's (NASA) development strategy for the Earth Observing System Data and Information System (EOSDIS). In response to your questions, we are providing the following answers as a supplement to our testimony.

Questions from Senator Albert Gore, Jr.

1. *Recommendation to Delay Contract*

Based on your findings, GAO has recommended that NASA "not award the EOSDIS Core System contract until specific plans have been developed and resources identified for (1) prototyping the full range of critical system elements and (2) guiding and accelerating research into key advanced technologies that will be essential for the system's ultimate success."

A. *Based upon your review of this subject, what is meant by a "critical system element" for EOSDIS?*

We used the term "critical system element" to refer to those aspects of the planned system that represent either new capabilities beyond what other earth science data systems have already provided or significantly more extensive versions of capabilities currently being offered

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on a small scale. These critical elements are all technically challenging, and their feasibility and appropriateness need to be tried out through prototypes before being developed for an operational system. For example, NASA has never before operated a widely distributed scientific data base holding billions of bytes of data that is intended to appear to researchers as an integrated, easily accessible repository of data. NASA's software approach for managing this huge distributed data base is a major example of a critical system element.

B. *Why did you single out these program elements? Are they representative of the type of prototyping that should be initiated, or are they the complete list of issues that GAO believes NASA must address?*

We discussed only representative examples of critical system elements in our report. The specific technology areas that prototyping should address were already established before we began our review. The National Research Council, in its assessment of EOSDIS plans for fiscal year 1991, recommended that EOSDIS prototyping be undertaken in the following areas:

- data display and user interface,
- browsing capability,
- data formats and media,
- accessibility of data and information,
- cataloging,
- search and query capabilities,
- model and data interaction,
- data structures,
- data reduction algorithms, and
- networking.

Our purpose in the report was not to attempt to enumerate all critical elements of the planned EOSDIS, but rather to point out the importance of a thorough and well-planned prototyping program, given the immense challenges and technical risks involved in the EOSDIS concept.

C. *GAO has also identified three specific technologies that will need to be developed for EOSDIS. Why couldn't NASA simply put off these advanced technology issues until some future time, or rather expect the contractor ultimately selected to develop these technologies?*

Given that the need for these specific technologies is clear and that EOSDIS cannot ultimately succeed without them, we believe it is important for NASA to lead their

development so as to better ensure that the technologies will be available for EOSDIS when they are needed. By putting off these technological issues, NASA is essentially putting off development of the real EOSDIS. If only the near-term capabilities of EOSDIS are pursued then NASA's $3 billion investment will have produced a system that may provide little more than what is offered by current, outmoded earth science systems.

The development of advanced technologies could be carried out by NASA's EOSDIS Core System contractor. However, NASA needs to clearly identify the technologies to be developed, establish milestones, and set aside resources to support the research. The planned EOSDIS Core System contract as currently structured is not sufficient for ensuring that this will happen because it is focused on the delivery of a system that must support the near-term data processing requirements of the EOS satellites rather than the long-term needs of the global change research community at large.

D. *If GAO's recommendations are not implemented, what effect will this have on the future success of EOSDIS?*

NASA's present development strategy for EOSDIS endorses prototyping and through its "evolutionary" approach acknowledges the need to incorporate advanced technology in the future. However, no specifics are laid out on how to achieve these goals. Our concern is that if our recommendations are not implemented, the EOSDIS program may fall far short of its goals as present development focuses on the delivery of a system to support the near-term data processing requirements of the EOS satellites. As a result, the system may fail to meet its objectives of providing the broad global change research community with ready access to the full spectrum of NASA earth science data.

2. *Global Change Researchers*

It is imperative that the scientific users of a data system this complex be involved from the beginning in its development.

A. *Based on your review, has NASA adequately involved global change researchers in setting the parameters of EOSDIS?*

We are currently performing a separate review of the issue of the involvement of the global change research community in defining the requirements for EOSDIS. We expect to issue a report on this subject in the near future. We

will provide this report to you as soon as it becomes available.

B. *How would delaying the award of the EOSDIS contract affect global change researchers? In your view, would a contract delay hinder efforts to get data to researchers early in this decade?*

In our report, we did not advocate imposing any substantial delay on the EOSDIS program. However, on the basis of lessons learned in the development of other less complex systems, we believe a short delay in the near term would avoid protracted delays over the long term and better ensure that the system meets the needs of researchers.

The current schedule for EOSDIS anticipates having a working system (Version 1) in 1996. Thus, whether this system is delayed or not, it will not be able to support global change research early in this decade.

3. *Current Prototyping Efforts*

The GAO report questioned NASA's prototyping activities in its Version 0, particularly in the Information Management System (IMS) project, which is intended to facilitate interoperability of existing data systems at the data archive centers. According to your report, GAO believes that NASA's IMS project is too limited in scope and is unlikely to produce results useful in proving the technical feasibility of the full-scale system.

It was reported earlier this month that NASA successfully used Version 0 hardware and software to link four of the EOSDIS Data Active Archive Centers (DAAC) and access existing earth science data. Does this test alleviate your concerns and does it adequately demonstrate the technology needed for this data system?

This test does not alleviate our concerns. It was a demonstration of the Information Management System (IMS) prototype discussed on page 21 of our report. This prototype offers users enhancements to current services in that, by connecting existing systems, it enables them to gain broader access to information about data held at geographically distributed data centers. However, it is too limited in scope to model advanced EOSDIS functions through which researchers are intended to easily access vast data sets. Observers of the demonstration noted that elements that still require prototyping include the capability of the system to provide satisfactory response times to a heavy load of queries as well as the ability

to browse the data itself. Although the demonstration provides an incremental enhancement to existing systems, much still remains to be accomplished if NASA is to gain solid experience on which to base development of the full-scale system.

Questions from Senator Pressler

1. *The recent GAO report on EOSDIS made several criticisms of the program. One was that NASA's prototype projects do not adequately address the technological hurdles involved in its planned data management system. What specifically would you have NASA change in its prototyping phase?*

Our chief criticism of NASA's Version 0 prototyping projects is that they do not go far enough or deep enough in demonstrating the viability of critical elements of the EOSDIS architecture. For example, a major Version 0 prototype involves setting up a network among the seven EOSDIS data centers to model some of the system's data transfer concepts. However, data traffic over this prototype network does not flow at nearly the high rates anticipated for the operational system. A more elaborate prototype is needed to prove the feasibility of handling the expected future EOSDIS communications loads quickly and efficiently.

Our specific recommendation is that NASA develop a detailed prototyping plan, identifying resources, milestones, and critical technologies to be addressed. Such a plan would offer better assurance that NASA's prototypes would address the right areas and would be substantial enough to offer significant results.

As discussed above, the specific technology areas that prototyping should address have already been established. (See answer to question 1B from Senator Gore.) The National Research Council's report stressed that prototyping should address the challenge of the immense size of EOS data sets, and it also noted that prototyping would be needed to learn how scientists will work with EOSDIS so that suitable data management schemes can be selected.

2. *If NASA does not step up its prototyping projects consistent with your recommendations, what problems in the EOSDIS data management do you foresee?*

If prototyping is not substantial enough to both prove the technological feasibility of key system functions as well as validate users' requirements, then NASA runs a high

risk of developing a system that may not work at all or may be inappropriate to meet users' needs. More specifically, rather than providing the more challenging, advanced features that distinguish the EOSDIS concept from previous earth science data systems, NASA's system might do little more than support the near-term data processing requirements of the EOS program's principal investigators. Such a system could end up holding an enormous amount of earth science data without being able to provide global change researchers with ways of deciphering the valuable information locked up in that data.

3. *The GAO report mentions that the full-scale EOSDIS will depend on data access, search, sorting, and display technologies that are new and untested. To what extent are these technologies incremental improvements over current knowledge or quantum leaps in computer technology?*

The technologies discussed in chapter 3 of our report, Earth Observing System: NASA's EOSDIS Development Approach Is Risky, will require significant advances over the current state of the art--quantum leaps rather than incremental improvements. Without these technological advances, EOSDIS will likely be unable to meet its ultimate goals of supporting the global change research community at large.

We are recommending that NASA take steps now, before awarding its EOSDIS Core System development contract, to ensure that these needed technologies are pursued throughout the course of EOSDIS development. Without taking specific measures to identify critical technologies now and focus research and development on them, NASA is taking the risk that other near-term demands on the system development effort will impede development of these technologies within the context of the EOSDIS program. The result could be a system that, despite a $3 billion investment, would provide little more than the limited capabilities available from current earth science data systems.

4. *The GAO report also criticizes NASA for spending only $19 million dollars on the prototyping projects within the EOSDIS budget of $83 million. Given the tight fiscal restraints on NASA and other federal agencies, do you think this is a fair criticism?*

Prototyping plays a critical role in the successful development of a system as challenging and complex as EOSDIS; to give it short shrift risks increasing the long-term costs of the system or developing a system that does not meet needs. Given the criticality of prototyping, we believe it is NASA's responsibility to see that it is adequately funded within the

overall fiscal constraints of the EOSDIS program. It was clear, during our review, that the current Version 0 effort, funded at $19 million per year, was insufficient to develop prototypes that would be substantial enough to prove key design concepts and validate user requirements in a timely manner. Compared with the overall $3 billion investment being planned for EOSDIS, this level of funding seems disproportionately small. Once it prepares a more comprehensive plan for prototyping, NASA will need to identify appropriate resources throughout the entire development life cycle to ensure that EOSDIS prototyping is substantial and productive.

5. *The GAO report recommends delaying the award of the EOSDIS contract until NASA has made plans for prototyping the full range of system elements tested and for accelerating research into relevant advanced technologies. Doesn't this run the risk of causing considerable delay in the completion of the EOSDIS and of causing enormous increases in the cost of an already expensive program?*

We do not foresee any significant time delay resulting from our recommendations. The element that we feel is necessary prior to contract award is a set of specific plans for prototyping and advanced technology development. It will be up to NASA to determine whether these plans can be developed within current program milestones. The actual work of building prototypes and researching advanced technologies can and should take place over time, as overall system development progresses within the context of the planned contract.

Regarding delay in system completion, it should be pointed out that any system development effort runs the risk of delay in completion, particularly if it involves development of new technologies, as EOSDIS does. We feel that the greater risk in this case is that NASA may avoid the critical challenges inherent in the EOSDIS concept and instead build an overly conservative system that does not meet the goals and objectives of the program. In such a case, it would matter little that such an inadequate system had been completed on schedule.

We do not believe that a concerted approach by NASA to prototyping and advanced technology research should add to the overall cost of the program. Instead, program life-cycle costs may even be reduced and protracted delays avoided. We are not recommending adding new elements to NASA's program; NASA has already endorsed the concept of prototyping as integral to the development of EOSDIS. Providing better guidance for this process--through concrete objectives, milestones, and pre-allocated resources--should result in better control of EOSDIS development as a whole. In the long term, these measures should

contain or reduce costs because duplicative or otherwise inappropriate projects will be avoided.

6. *The GAO report focuses mainly on what is wrong with the EOSDIS program as currently planned. What do you see as the strengths of the plan?*

In the past, NASA frequently gave little advance attention to the processing and dissemination of data to be collected from its satellite missions. Principal investigators from these missions often were the only researchers who had the opportunity and the proper tools to use the data. EOSDIS represents a new approach to the handling of earth science data. NASA's commitment to make the data within EOSDIS readily accessible to researchers responds to past criticisms from the scientific community and is a major strength of the program. We feel it is important for NASA to make good on this commitment by taking steps to ensure that the system, as developed, is able to serve the needs of the global change research community.

7. *Earlier this month, four of the data centers to be used in EOSDIS were linked together by a computer in a test where Maryland-based scientists accessed earth science data from all four centers. I am proud that the EROS Data Center in Sioux Falls participated in that demonstration. As I understand it, the demonstration was a resounding success. Does this performance in any way affect the criticisms and recommendations in the GAO report?*

Please see our response to question 3 from Senator Gore.

8. *The GAO report also recommends that NASA take advantage of relevant data systems experience and knowledge in other programs and agencies. What are some of the cost savings and efficiencies gained by working with others experienced in data management?*

NASA is certainly not alone in the business of processing, distributing, and archiving earth science data. The National Oceanographic and Atmospheric Administration (NOAA), the National Center for Atmospheric Research (NCAR), and several other organizations and government agencies, including the Environmental Protection Agency and the Departments of Agriculture and Energy, all have important earth science data holdings. None of these organizations has undertaken or plans to undertake a system development effort on as big a scale as EOSDIS. However, the data-handling experience resident in these organizations could help reduce the cost both in time and dollars of developing and validating data-handling techniques for EOSDIS. For example, NCAR already has experience in

attempting to make large amounts of earth science data available on-line through its Mass Store System. By incorporating some of the lessons learned from NCAR, NASA may be able to avoid some of the same pitfalls, saving both time and money.

We appreciate the opportunity to testify before the Subcommittee and to provide this information for the record. If you have any further questions, please call me at (202) 336-6240.

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