156355

United States General Accounting Office

GAO

Testimony

Before the Committee on Science, House of Representatives

For Release on Delivery Expected at 10:00 a.m., EST Wednesday, March 6, 1996

EARTH OBSERVING SYSTEM

Cost and Research Issues

Statement of Brad Hathaway, Associate Director, Defense Management Issues, National Security and International Affairs Division

GAO/T-NSIAD-96-116

Mr. Chairman and Members of the Committee:

I appreciate the opportunity to testify before the Committee today on the National Aeronautics and Space Administration's (NASA) Earth Observing System (EOS). You asked us to discuss (1) our previous work for the Committee on the investment that will be required over the life of EOS and (2) our ongoing work on NASA's strategy for maximizing the science return on that investment by ensuring that an adequate research community will be available to analyze the large amount of data expected from EOS.

We reported to you last June that the estimated funding requirements of the baseline program would total about $33 billion over the life of the program.[1] Because of its constrained budget outlook, NASA had already begun looking for ways to reduce future EOS funding requirements. We will report to the Committee on NASA's cost-reduction efforts later this year, after we have reviewed NASA's latest funding estimates, which will be released later this month with the fiscal year 1997 budget submission.

A preliminary result of our ongoing work is that NASA's current EOS basic research community is relatively small compared to other pre-EOS earth science missions, and it is uncertain whether NASA can successfully expand it within future budget constraints. If NASA is not successful, there may be a growing imbalance between the number of funded investigations and the magnitude of the potential research opportunities created by data from EOS' instruments. This imbalance in EOS could limit the number of funded investigations designed to produce the best possible science return on such a large investment.

BACKGROUND

EOS is the centerpiece of Mission to Planet Earth, NASA's contribution to the governmentwide U.S. Global Change Research Program. EOS-related funding accounted for about $1 billion of the $1.3 billion total budget for Mission to Planet Earth that the Clinton administration requested for fiscal year 1996. EOS has three major components: (1) a system of satellites to collect at least 15 years of key climate-related data; (2) a data and information system to operate the satellites and process, archive, and distribute the data; and (3) teams of scientists to develop algorithms for converting sensor data into useful information and conduct research using the information.

EOS is currently designed to make 24 types of long-term measurements of solar irradiance and the earth's atmosphere, land cover, ice sheets, and oceans from orbiting

---

[1]That is, for fiscal years 1991 to 2022. As planned in 1995, the last EOS satellite will cease operations in 2020, after which there will be 2 years of data analysis. See NASA'S Earth Observing System: Estimated Funding Requirements (GAO/NSIAD-95-175, June 9, 1995).

spacecraft. According to NASA, these measurements are essential to detect, understand, model, and predict global climate change. The first EOS satellite is scheduled for launch in 1998. By 2002, when the full constellation will be in orbit, EOS will be generating data from 25 instruments on at least 10 spacecraft. Over the 20-year EOS data-collection phase, about 80 instruments will be launched on more than 30 satellites. See attachment I for the EOS instrument flight schedule.

Initial planning for EOS occurred during the 1980s, when NASA's budget was growing steadily. During this time, NASA's funding increased each year, essentially doubling from about $5 billion to $10 billion between fiscal years 1981 and 1989. In anticipation of continued budget increases, NASA planned to spend $17 billion on EOS through fiscal year 2000 when the program was initiated in fiscal year 1991. However, it soon became clear that NASA's budget would not increase as originally planned. In 1992, we reported on a growing gap between NASA's program plans and its future budgets that would likely be far lower than originally anticipated.[2]

Congressional concerns about EOS' affordability caused NASA to change the program's emphasis in fiscal year 1992 from a complete earth system measuring program that would have supported a wide array of global change investigations to a measurement program that will primarily support investigations of global changes to the earth's climate.[3] EOS was redesigned, and the estimated cost through 2000 was reduced to $11 billion. The program's budget through 2000 was further reduced to $8 billion in fiscal year 1993, and to $7.25 billion in fiscal year 1995. Through reductions in EOS funding and other programs over the last several years, NASA was successful in closing the affordability gap we reported on in 1992. However, substantially reduced outyear projections in the President's 1996 budget submission reopened the gap, requiring NASA to examine ways to reduce the cost of its programs and activities.[4]

EOS TOTAL LIFE-CYCLE COST

Although many of the past EOS budget discussions focused on the first decade of the program, EOS is planned to continue for another 20 years beyond that. At the Committee's request, we reviewed the total life-cycle cost of EOS. In June 1995, we

---

[2]NASA Budget: Potential Shortfalls in Funding NASA's 5-Year Plan (GAO/T-NSIAD-92-18, Mar. 17, 1992).

[3]For example, NASA dropped the measurement of mesospheric and ionospheric chemistry and solid earth processes.

[4]NASA Budgets: Gap Between Funding Requirements and Projected Budgets Has Been Reopened (GAO/NSIAD-95-155BR, May 12, 1995).

reported to you that the estimated funding requirements of the EOS baseline program would total about $33 billion for fiscal years 1991 to 2022.[5] This estimate was developed for the program as described in NASA's 1995 EOS reference handbook, and included costs for satellites, launch services, data systems, science, construction of facilities, and civil service personnel. NASA recognized that the program as designed in early 1995 was not affordable in an environment of declining budgets and was already studying ways to substantially lower future program costs through the use of advanced technology and increased collaboration with other agencies, international partners, and the commercial sector. NASA intended to apply these future savings to increasing the science supported under EOS and Mission to Planet Earth and to reducing the total cost of the program.

NASA'S STRATEGY TO BUILD AN EOS RESEARCH COMMUNITY

Like EOS-related space systems and information systems, the development of the EOS science community that will conduct EOS research will not just happen; it has to be developed. NASA recognizes that it needs to increase the size and broaden the membership of its EOS science teams and take other steps to develop and sustain an EOS-era research community. In 1995 and 1996, it began adding new investigators and reevaluating the current EOS science teams' investigations. NASA's success in adding investigators however, is uncertain within its expected future budgets, especially if the development of the EOS science community depends on realizing future savings in the program.

NASA's strategy involves (1) an open data access policy and (2) efforts to expand and change the current EOS research community by adding investigations, reevaluating the current science investigations, and recruiting new investigators.

EOS Data Policy

A vital part of the EOS data policy is that EOS data will be available to everyone: there will be no period of exclusive access for funded investigators. This has not always been NASA's policy. On some past earth observing missions, funded investigators had exclusive use of the data for an extended period of time.[6] EOS data users as a rule will not be charged more than the cost of distributing data to them. The data policy contemplates a variety of potential user groups, not all of whom will be engaged in basic research. Last year, NASA sponsored a conference that tried to better define the user groups. The conferees identified 12 potential user groups, of which only 3 were primarily

[5]This figure is in current dollars and includes future years' inflation.

[6]For example, the original investigators associated with the Upper Atmosphere Research Satellite had exclusive access to the first year's data for up to 2 years.

composed of scientists. The others included commercial users, resource planners, and educational groups.

Adding Investigations

NASA originally solicited proposals for EOS interdisciplinary science investigations in 1988 and selected 29 interdisciplinary science teams in 1989 and 1990, with other selections possible before the launch of the first EOS satellite, then scheduled for late 1995. The lifetime of the first group was to extend for 4 years beyond the launch of the first satellite, or until 1999. In short, NASA intended to fund more than one group of investigators over a 10-year period (1989 to 1999). These intentions were stated within the context of expanding resources through the 1980s. Soon after, NASA's budgets stopped growing, and, as a result, the number of science teams has remained the same and their tenure has increased. At a minimum, the lifetime of the first group of investigators has been extended to 13 years (1989 to 2002), including 4 years beyond AM-1's 1998 launch date.

EOS science investigators were selected to (1) analyze and interpret data from EOS instruments in more than one earth science discipline and (2) serve as members of the Investigator Working Group, developing detailed science plans and assisting NASA in optimizing the scientific return of the EOS mission. Currently, there are 31 interdisciplinary principal investigators, 9 of whom are affiliated with foreign agencies and/or institutions. NASA is wholly or partly funding 22 investigations, and its international partners are funding 7. There are also 354 coinvestigators associated with the 29 interdisciplinary science investigations as well as 20 instrument principal investigators/team leaders and 197 other instrument team members.

In our ongoing work, we found that although NASA has not determined what size research community is sufficient to meet EOS' basic research goals, last year it recognized that more basic research teams were needed, and took a limited step to expand the community. NASA solicited proposals in September 1995 to address specific interdisciplinary science issues that are not well covered by existing NASA-funded investigations.[7] However, the announcement largely precluded investigators from analyzing data from the first EOS mission, AM-1, which is now scheduled for launch in 1998. Instead, NASA asked them to propose interdisciplinary research that primarily uses existing data sets from past satellite missions and field experiments. NASA received 134 proposals for interdisciplinary science investigations and expects to fund 20 to 25 investigators. NASA intends to solicit additional EOS science proposals in the future.

[7]The solicitation described five research areas, for example, one of which is the implications of continued global expansion of urbanization and high-input agriculture for the environment.

Reevaluating Science Investigations

The nature and membership of EOS' interdisciplinary science teams has remained largely unchanged. In 1995 and 1996, as part of its strategy to review and possibly change the current mix of the interdisciplinary science investigations, NASA and the EOS investigators' peers in the earth sciences research community started to review the scientific merit of the current investigations. This peer review is not yet finished, but it could lead to the possible deselection of some EOS interdisciplinary science teams. NASA rejected the idea that the current investigations should be evaluated as part of a new solicitation for proposals to conduct interdisciplinary science investigations.

Recruiting New Investigators

The long-term growth of the EOS research community depends, in part, on NASA's ability to recruit graduate students and newly graduated earth scientists to use remotely sensed data. NASA supports prospective researchers in the earth sciences through the graduate student Global Change Fellowship program, and it supported 112 fellowships for the 1993 to 1994 academic year. As part of the September 1995 solicitation to add investigators, NASA also established a new investigator program as part of Mission to Planet Earth and solicited proposals for interdisciplinary science investigations from recent Ph.D. recipients. NASA received 65 proposals and expects to fund 10 to 15 new investigators.

RETURN ON EOS SCIENCE INVESTMENT UNCERTAIN

NASA intends to support research stemming from the September 1995 solicitation through a "funding wedge" created over a period of several years by freezing the budgets of some EOS interdisciplinary science investigators. Although NASA intends to further expand the EOS research community, its plans depend on its ability to generate future savings in the program. It remains to be seen if this will become a major constraint on the further development of EOS-related researchers.

EOS' 29 interdisciplinary science teams needs to be put in context. Over the years, NASA has stated that about 10,000 earth scientists might use EOS-related data. Given the large size of EOS' potential research community and the nonrestrictive nature of its data policy, one might think the sufficiency of EOS researchers is the least of NASA' s problems. Actually, the fact that 10,000 earth scientists may be potential users of EOS data overlooks the requirement that scientists need to be funded to conduct basic research on global climate change. We found that for this type of work, scientists analyze data when they are paid to do so. This observation is based on our review of the authorship of 172 journal articles about 2 pre-EOS-era earth sciences missions - - the Upper Atmosphere Research Satellite (UARS) and TOPEX/Poseidon. Publicly funded investigators wrote all but 10 of the articles. If NASA were to fund even a 10th of the 10,000-scientist research community, at an average of $250,000 each, it would have to budget $250 million annually.

NASA requested $58.4 million for EOS interdisciplinary science in fiscal year 1996, and according to the fiscal year 1996 budget submission, funding for EOS interdisciplinary science is planned to increase to $73.2 million in fiscal year 2000.

Our observation that the size of the EOS research community is relatively small is based on a comparison of (1) the number of science teams associated with the two pre-EOS earth observation satellite missions–UARS and TOPEX/Poseidon–to their EOS-era counterparts; and (2) the ratio of the number of science teams to the raw data acquisition rate expected from the EOS core cluster of spacecraft to the number of science teams and raw data acquisition rates of UARS and TOPEX.

UARS, launched in September 1991, consists of 10 instruments that are measuring the composition and temperature of the upper atmosphere, atmospheric winds, and energy from the sun. The UARS science teams are led by 10 "principal" and 12 "theoretical" investigators. NASA broadened the UARS science community in 1994 by selecting additional teams led by 40 "guest" investigators. NASA is also funding correlative measurement teams led by 38 investigators to develop an independent database to validate and complement measurements made by UARS' instruments.[8] In the EOS era, solar energy and atmospheric chemistry measurements will be made principally by the ACRIM, SAGE, and SOLSTICE instruments and the CHEM spacecraft.[9] Currently, only 12 instrument and interdisciplinary science teams are associated with these instruments and the CHEM spacecraft. In contrast, UARS supports research conducted by 62 instrument and science teams.

TOPEX was launched in August 1992 to study the circulation of the world's oceans. The primary instrument is an altimeter that measures the height of the satellite above the ocean, wind speed, and wave height. NASA and its French partner selected science teams led by 38 principal investigators.[10] The 38 TOPEX-related science teams have about 200 members, and NASA plans to solicit additional investigators. In the EOS era, the follow-on mission to TOPEX is Radar-ALT. An instrument team has not yet been selected, but only 7 of the 29 interdisciplinary science teams currently plan to use Radar-ALT data in their investigations.

---

[8]According to the Clinton administration's fiscal year 1996 budget submission, funding for UARS' operations and data analysis will cease in fiscal year 1998.

[9]ACRIM (1998) monitors the variability of total solar irradiance; SAGE (1998) provides profiles of aerosols, ozone, and trace gases in the atmosphere; SOLSTICE (2002) measures full disk solar ultraviolet irradiance; and instruments on the CHEM spacecraft (2002) measure, in part, tropospheric ozone. Dates are for the first flight of each instrument in the EOS era.

[10]According to the Clinton administration's fiscal year 1996 budget submission, funding for TOPEX's operations and data analysis will cease in fiscal year 1999.

There is a striking difference between the number of (1) science teams and volume of data of pre-EOS missions and (2) the current EOS science teams and the expected volume of data from EOS. Taken together, the number, but not necessarily the size, of the UARS and TOPEX science teams is a little larger than all the EOS teams, while EOS' data rate is close to 1,000 times greater than the combined data rate of UARS and TOPEX. EOS will provide 42 million bits per second of data to 49 science and instrument teams. The corresponding ratio for UARS and TOPEX is a total of 48 thousand bits per second of data to 60 teams.[11] Although we recognize that a data rate comparison is, at best, a rough gauge of the magnitude of the data-analysis opportunities facing the earth science research community, the difference is too large to ignore.

Achieving the best science return on the large investment in EOS will require a proper balancing of EOS' three elements: space systems, information systems, and researchers. It is not clear to us that NASA will achieve this balance because the science community funded to do basic research under EOS is relatively small compared to two pre-EOS era satellites. Although NASA recognizes the need to increase the number of basic researchers, we remain concerned about NASA's ability to fund more basic research through future savings that may not materialize or that may be absorbed in budget reductions.

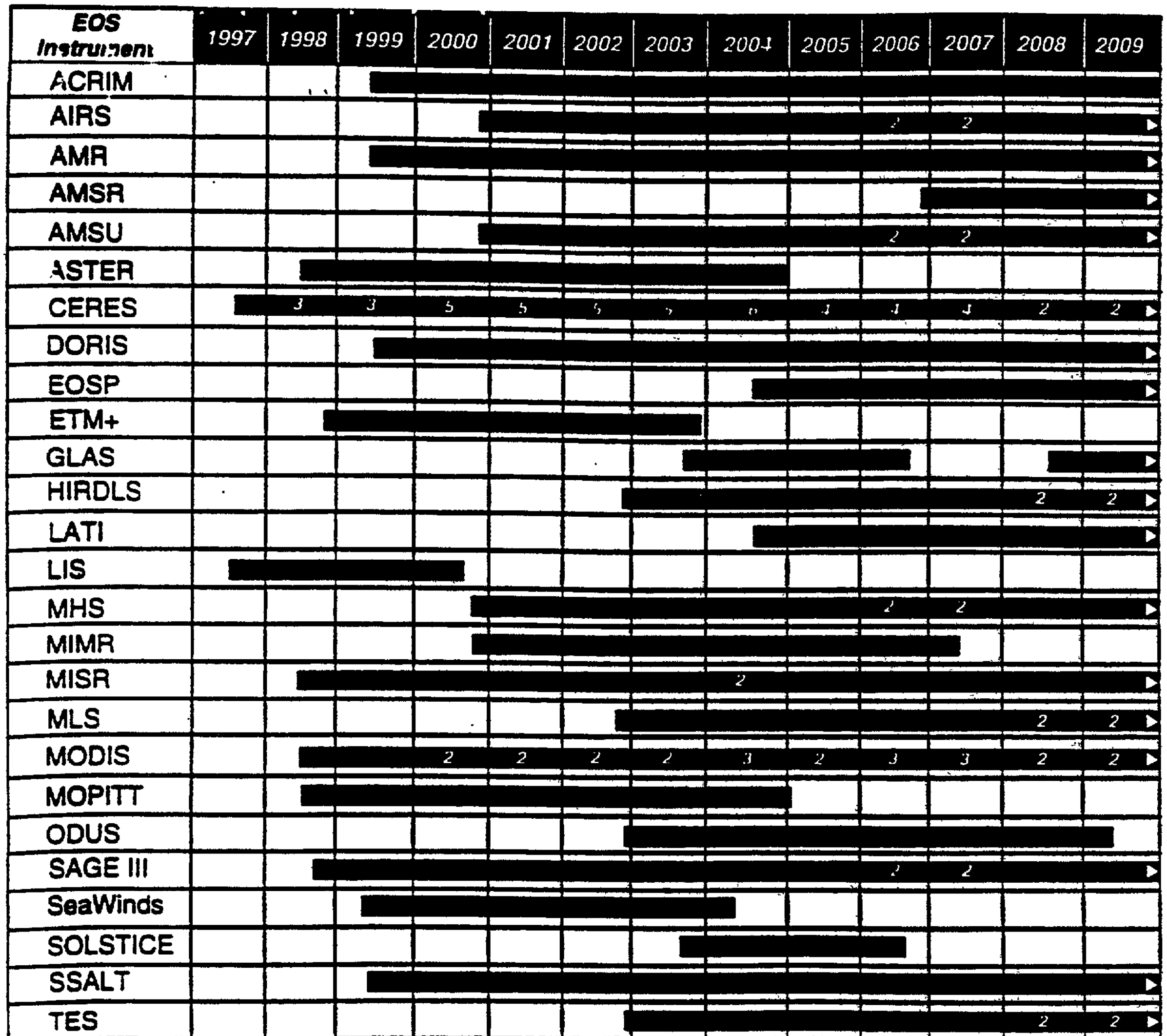
\- - - - -

Mr. Chairman, this concludes my prepared statement. I will be pleased to answer any questions you or the members of the Committee may have.

(709188)

[11]Includes 22 investigators for UARS and 38 for TOPEX.

EOS Instrument Flight Schedule



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Instruments In Flight	2	10	15	21	21	25	27	30	24	28	28	24	24
Average Data Rate (Megabits per second)	0.016	30.5	30.8	38.1	38.1	41.4	41.6	46.4	28.8	36.2	36.2	32.2	32.2

- Numbers in timeline bars indicate copies in orbit once the instruments have commenced routine operations.
- The "Instruments in Flight" entry is the maximum number of instruments operating at the same time during the year. For example, there will be 6 CERES instruments operating during the last half of 2004 when the following missions overlap (there is a 6-month period of overlapping operation to permit instrument intercalibration): AM-1(2 CERES), Flight of opportunity - not yet identified (1 CERES), PM-1 (2 CERES), and AM-2 (1 CERES).
- This schedule is currently under revision.

Source: NASA

Ordering Information

The first copy of each GAO report and testimony is free. Additional copies are $2 each. Orders should be sent to the following address, accompanied by a check or money order made out to the Supenintendent of Documents, when necessary. Visa and Mastercard credit cards are accepted, also. Orders for 100 or more copies to be mailed to a single address are discounted 25 percent.

Orders by mail:

U.S. General Accounting Office
P.O. Box 6015
Gaithersburg, MD 20884-6015

or visit:

Room 1100
700 4th St. NW (corner of 4th and G Sts. NW)
U.S. General Accounting Office
Washington, DC

Orders may also be placed by calling (202) 512-6000
or by using FAX number (202) 512-6000, or TDD (301) 413-0006.

Each day, GAO issues a list of newly available reports and testimony. To receive facsimile copies of the daily list or any list from the past 30 days, please call (301) 258-4097 using a touchtone phone. A recorded menu will provide information on

how to obtain these lists.
For information on how to access GAO reports on the INTERNET,

send an e-mail message with "info" in the body to:
info@www.gao.gov

United States
General Accounting Office
Washington, D.C. 20548-0001

Official Business
Penalty for Private Use $300

Address Correction Requested

Bulk Rate
Postage & Fees Paid
GAO
Permit No. G100