Apr 24th, 2:00 PM - 5:00 PM

Paper Session I-B - Earth Observing System

Stanley Wilson
EOS Program Scientist, Earth Science and Applications Division, NASA Headquarters

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**EARTH OBSERVING SYSTEM**

**W. Stanley Wilson**  
EOS Program Scientist

**Introduction.** To understand global change and the increasing demands of human activity, it is essential that we document and comprehend how the Earth works as a system. The international scientific community is organizing research efforts to advance our knowledge of both natural and human-induced global change. The U.S. Global Change Research Program, a consensus interagency plan, defines the U.S. element of those efforts.

Mission to Planet Earth, the central NASA contribution to the U.S. Global Change Research Program, includes two proposed initiatives in the FY 1991 Federal budget: 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 and Japanese platforms, as well as the continuing operational environmental satellites.

EOS will continue and integrate the measurements now being taken by short-term research missions. It will provide the first coordinated simultaneous measurements of the interactions of the atmosphere, oceans, solid earth, and hydrologic and biogeochemical cycles.

Earth Probes will provide a focus on observing specific Earth processes where smaller platforms and/or different orbits from EOS are required. In addition to complementing EOS, Earth Probes will provide critical near-term observations.

**Earth System Science.** Understanding global environmental change requires knowledge of the entire Earth system. A new concept, Earth System Science, has developed to describe how its components and their interactions have evolved, how they function, and how they may be expected to continue to evolve.

The ultimate goal of Earth System Science is to develop the capability to predict environmental changes, both natural and human-induced, that will occur in the future. Meeting this challenge for the next decade to century requires the integration of knowledge from the traditional disciplines and information from many different sources into a coherent view of the Earth system.

Earth remote sensing has matured as a result of technology development and utility demonstrations. But even as this has occurred, Earth science has continued to be organized along traditional disciplinary lines. With the understanding and experience which has grown within these disciplines, with new technology, and with the challenge of understanding Earth as a system, we are now ready to pursue Earth System Science.

We can now shift our focus from traditional disciplines toward interdisciplinary components of the Earth system, such as: the influence of clouds and radiation balance, role of oceans and atmosphere in heat transport, hydrologic and carbon cycles, changing composition of the atmosphere, and geological and geophysical processes.

EOS has been designed to meet observational needs of Earth System Science. It will operate for 15 years, a time period which encompasses a large span of major environmental change, ranging from several atmospheric biennial oscillations, three to five El Niños, and an entire solar cycle. It will provide a sufficiently large platform to accommodate appropriate suites of sensors so that multiple views of the same location on Earth at the same time will avoid atmospheric-induced uncertainties. It will provide broad and high-resolution spectral and spatial coverage. It will feature a fixed payload for the duration, so that it can provide a consistent set of observations.
One particular strength of EOS is that it will provide, for the first time, a long-term, simultaneous set of observations of the same phenomena on ever-increasing spatial scales (local, regional, global) that can be used to integrate and extrapolate our understanding of ecological and hydrological processes.

**EOS Space Segment.** NASA began conceptual studies for EOS in 1982; coordination with the European Space Agency (ESA), Japan, and Canada was initiated in 1986. Present plans call for two series of polar-orbiting platforms: EOS-A and EOS-B. The 15-year observational period will be achieved using three identical satellites per series, each with a five-year design lifetime.

ESA is planning two series of polar platforms with a climatological and terrestrial focus, respectively, and Japan is planning one polar platform. Both NASA and NOAA sensors are planned for inclusion on these platforms. Additionally, NASA is planning to provide sensors as attached payloads for the Space Station.

A group of 41 sensors from the U.S., Canada, Japan, and Europe has been selected as candidates for flight on EOS. The EOS-A series is tentatively planned to focus on atmospheric sounding and surface imaging; selection of specific sensors will be in October 1990. The EOS-B series is planned to include sensors capable of extending observations made by the UARS and TOPEX/Poseidon missions; sensor selection for EOS-B will occur one year later.

Platform size for EOS has been chosen to accommodate atmospheric sounding and surface imaging sensors, a grouping which maximizes the synergistic use of coincident observations, as well as minimizes atmospheric induced uncertainties. The satellites will be launched into polar orbit from Vandenberg Air Force Base on Titan-IV rockets.

An EOS platform will accommodate a payload up to 3500 kilograms and can supply up to 3.2 kilowatts of power to the payload. This platform is twice the size of the Upper Atmosphere Research Satellite (UARS), and can supply about four times the power; it will accommodate two to four instruments more than the 10 aboard UARS. Because of the wider spectral range of the instruments, its data system will manage more than 10,000 times the data of UARS.

The need for global coverage every one to three days dictates an sun-synchronous orbit with a quasi-two-day repeat; a 705-kilometer altitude, 98.2-degree inclination orbit meets this need. It will have a 1:30 p.m. local equatorial-crossing time.

The Synthetic Aperture Radar (SAR), not able to be efficiently accommodated on the EOS series of platforms, is planned for flight on a dedicated satellite in 1999. Its orbit will have a 620-kilometer altitude and similar equatorial crossing time; this will provide frequent opportunities for coincident observation of the same locations as sensors on EOS platforms.

**EOS Data and Information System.** The EOS Program has put a major emphasis on the Data and Information System (EOSDIS). EOSDIS is planned to acquire a comprehensive, global, 15-year data set; to maximize the utility of this data set for scientific purposes; and to facilitate its easy access by the research community. In addition to data processing, archival, and distribution facilities, EOSDIS includes the necessary capabilities for command and control of the spacecraft.

The development of EOSDIS will be initiated immediately by building on the existing infrastructure within the research community, implementing an architecture which is open and distributed, so that it can evolve with advances in computing and networking technology. The near-term objectives are to support the research and analysis of data which both exist and will come from the near-term pre-EOS missions. In this way, the research community can gain valuable early experience in preparation for the future large EOS data volume.

Archived data sets, in addition to those from the EOS satellites, will include complementary in situ and satellite data. EOSDIS will also involve the U.S. Geological Survey, National Oceanic and Atmospheric Administration, National Science Foundation, and other agencies.

There will be two types of data products: standard and specialized. Standard products will be generated and archived at Active Archive Centers; the target time for the availability of engineering-lever products is within 48 hours of collection; the target for derived geophysical products is within 96 hours. Specialized
products will be generated by individual investigators and made available to EOSDIS for archiving and distribution, as appropriate.

The EOSDIS policy specifies that all data and derived products be available to all users, with no preference given to EOS investigators. Research users in the U.S. and participating countries will pay only the nominal cost of data reproduction and delivery; they will be required to agree to publish their results and to make available supporting information, including methods for analyzing data. Research users in other countries may propose cooperative projects and associated "in kind" contributions (i.e., provide similar access to appropriate satellite, aircraft, and surface-based data) in exchange for access to EOS data on similar terms. Access to the raw data stream will be provided to operational agencies for forecasting purposes. NASA will provide for the commercial distribution of data on a non-discriminatory basis to all other users.

**Summary.** Our planet is experiencing profound environmental changes; the economic and social consequences of global change have received attention at the highest governmental levels. To document, understand, and predict global change is a major scientific challenge; but up to now we have lacked the ability to provide the necessary comprehensive information for key policy decisions. Modern technology and new insights offer hope for early warning of change and accurate predictions of future change, and thus major societal benefits.

Mission to Planet Earth, building on precursor research missions and encompassing the proposed Earth Probes and the Earth Observing System, is a major NASA contribution to the U.S. Global Change Research Program. It will provide the necessary comprehensive global observations of Earth which will reveal how the processes that govern global change interact as part of the Earth System. This understanding is critical to the development of models for predicting future environmental change. With a continuing, comprehensive data set from EOS, it will be possible to update and enhance the models so that they can provide the vital information needed about environmental change on local, regional, and global scales.