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# OBSERVING PLANET EARTH FROM SPACE - WHAT'S NEXT?

David S. Johnson *

During the two decades of the space age, there have been rapid developments in techniques for observing the planet Earth, its oceans, land masses, and atmosphere. The United States and Russia now operate environmental satellites in polar orbit utilized primarily for operational weather forecasting, but also providing some support for observations of the land and ocean surface. A new third generation polar orbit operational satellite has just been launched for use in the U.S. system.

The United States today operates routinely two geostationary operational environmental satellites (GOES) to provide nearly continuous observations of the Western Hemisphere. Similar satellites have now been launched by Japan and the European Space Agency, and are under construction by the USSR and planned by India. Thus, a global network of operational satellites to monitor the Earth's atmosphere operationally is now a reality.

The NASA Landsat program has demonstrated the ability to use higher resolution, multispectral images of the Earth's surface in a wide variety of applications important to humanity. With the recent launch of Seasat-1, NASA now is demonstrating the technology to monitor a number of ocean parameters by microwave techniques regardless of cloud cover. This new source of information is expected to demonstrate the potential value of a number of ocean observations which will be of importance not only to weather forecasting, but to human activities on and within the sea.

These Earth observing techniques, coupled with the advent of the Space Shuttle, the Tracking and Data Relay Satellite System and global positioning satellites, provide an array of technology to serve as building blocks for an earth observing satellite system or systems to emerge about 1985. While its exact character cannot be fully defined at this time, a number of studies now in progress give some preliminary indication of its general form and evolution.

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* *U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Rockville, Maryland 20852*

Twenty years ago, The National Aeronautics and Space Act of 1958 was passed, setting up the National Aeronautics and Space Administration. Since that time--in twenty short years--NASA has led the United States to a preeminent position in man's exploration of this challenging frontier. Within two years following passage of the Space Act, NASA launched the first TIROS weather satellite for observing the earth and its cloud cover. Thus was borne one of today's two highly successful civil, operational space applications programs. Because of its commercial success, the second of these two, space communications, has often enjoyed a higher degree of public visibility. But the world-wide system of satellites for observing the planet Earth, its oceans, land masses, and atmosphere, has had far reaching effects on the world's population through demonstrated improvements in monitoring the Earth's surface and its atmosphere on a global scale.

The global operational system now includes polar, low-earth orbiting and geostationary environmental satellites. The operational low-earth orbiting system has components operated by the Soviet Union and the United States. Although these satellites primarily are used for operational weather forecasting, they also are providing some support for observations of land and ocean surfaces. In particular, the newest U.S. operational satellite--the third generation "TIROS-N" launched last month--specifically is designed to improve our capability for monitoring sea surface temperatures.

Since 1974, the United States has operated two Geostationary Operational Environmental Satellites, called (GOES), to provide nearly continuous observations of the Western Hemisphere. In 1977, Japan and the European Space Agency launched similar geostationary satellites to monitor atmospheric phenomena over their respective portions of the globe. By the early 1980's, the USSR is planning to complete the globe-girdling network of environmental monitoring satellites by operating an additional geostationary satellite over the Indian Ocean. India is planning its own multi-purpose satellite to combine domestic communications and weather observations from a single geostationary satellite. This combined network of low-earth and geostationary orbit operational satellites will ensure timely monitoring of the great regime of atmospheric and oceanic phenomena in a way scarcely conceivable 20 years ago.

## CURRENT EXPERIMENTAL SYSTEM

In the more recent past, the NASA Landsat program has introduced a new generation of higher resolution multi-spectral earth observations which have proven to be powerful tools in analyzing natural resources, such as mineral deposits and agricultural crops, as well as providing assistance to cartographers in mapping heretofore inaccessible portions of the earth's surface.

The latest addition to mankind's arsenal of space-borne observing tools was provided by the launch of NASA's Seasat-1 last June. This

spacecraft, with its payload of microwave sensors, began to demonstrate the ability to monitor a variety of ocean parameters, even in the presence of cloud cover, before its untimely death last month. With this impressive array of technology, one hears the usual human reaction: "There's nothing more to do!" This is, of course, the assertion which has been made by countless generations, probably starting with the invention of the wheel. A more appropriate question would be: "How do we chart a prudent course to make maximum, cost-effective use of the tremendous potential which the current state of space technology offers us?" As you might expect, the quest for an answer to that question is not totally independent of budgetary and policy considerations.

## FACTORS INFLUENCING DECISIONS

Until now, the thrust of most earth observation satellites and their sensors has been restricted to experimental programs and funding has come from the Federal government. By contrast, direct governmental funding of communications satellites essentially ended many years ago. The reason is clear. The economic return to be gained from space communications was obvious. Industry thus could commit investment capital in the full expectation of being able to amortize that investment and earn a reasonable profit. In the case of earth observations, the situation is much less clear. A recent study purports to show that the current U.S. operational environmental satellite program pays its own way in economic benefits to its varied users. While this conclusion undoubtedly is true, it is difficult to envision a viable entrepreneurial approach to tapping the multitude of different beneficiaries of weather forecasting, ship navigation, fishing fleet direction, and so forth for the purposes of stockholder satisfaction. A related question is what functions should be performed by the Federal government, supported by general tax revenues, versus what should be supported by special interest groups or left to private enterprise.

A similar problem arises when one regards the Landsat program. The actual returns are becoming known and they appear to be large. Waiting in the wings is a still larger potential for economic benefits, if the program becomes truly operational. By "truly operational," I mean two things: first, a commitment to a long-term observational program and second, prompt availability of data to interested users. In addition to the issues I've mentioned with respect to the environmental satellite program, there is a much wider spectrum of potential users of Landsat type data, making the aggregation of requirements and support very difficult.

In the oceanic arena, Seasat-1, the first experimental satellite devoted to oceanic observations, was launched last July 26, and data processing was only just coming up to speed when the satellite failed on October 10. Thus, we don't yet have the level of use experience which exists in the environmental and Landsat programs. However, Seasat-1 produced over ninety days of data which is commanding great interest on the part of the marine scientific community. NOAA and

NASA are funding over 30 experiments, totalling about two million dollars, for research by non-governmental groups using data from Seasat-1. Many more experiments were proposed than could be funded from available resources by these two agencies. Major research and demonstration programs also are being conducted within NASA, NOAA, and the Navy. I fully expect that this program, even with the untimely demise of the spacecraft, will demonstrate that the information derived from these sensors can be of inestimable value to ocean interests from commercial fisheries to geodesists, and from merchant mariners to naval fleets. Here again, the diversity of potential users may make commercial exploitation of the new technology difficult, if not impossible. But vital national interests in the oceans, especially reflected in the marine responsibilities of NOAA and the Navy, suggest a dominant Federal role in any operational program which may evolve.

What of other factors affecting earth observations from space? Each of the current satellites was lofted into space by an expendable launch vehicle. The satellites themselves, once in orbit, are never again touched by human hands. Data gathering is done by radio links with earth-bound command and data acquisition, or CDA stations. This latter factor can be a severe limitation to acquisition of global data when considering such high data producers as the Multi-Spectral Scanner or Thematic Mapper on Landsat, or the Synthetic Aperture Radar on Seasat. The practical result is that the potential for full global coverage cannot be realized for these sensors due to the gaps between CDA's and the limited capacity of on-board storage media. Another present-day limitation is the necessity to perform significant processing on the ground to combine sensor data with attitude and orbit data in order to locate the observations with respect to the earth's surface.

The influence of these factors will be modified significantly within the next five to ten years. First and foremost, it is expected that the Space Transportation System or "Space Shuttle" will provide more cost-effective means, not only to loft spacecraft into orbit, but eventually to perform in-orbit repairs or to recover satellites from near-earth orbit. The ability to launch heavier payloads at lower cost should lead to multipurpose payloads serving interdisciplinary needs for earth observations, allowing expanded operational services at less cost than is possible with today's launch systems. Second, NASA's Tracking and Data Relay Satellite System (TDRSS) holds forth the promise of obtaining the same continuous, real-time data flow from low-earth orbiting spacecraft as is currently possible from geostationary satellites. Finally, the Department of Defense's Global Position System will provide an accurate means for earth-location of observations autonomously aboard the spacecraft without ground processing.

## DECISION TIME

With this new technology theoretically it would be possible, around 1985, to launch a sixteen ton spacecraft into near polar orbit and produce a continuous, real-time flow of earth-located sensor data at a rate of several megabits per second. But make no mistake about it! Even with the anticipated economies of 1980's technology, the cost of such a system would be measured in the hundreds of millions of dollars! All that before adding the cost of the ground system to process and interpret the data and deliver them to the user! Therefore, it is necessary to face and answer some major policy questions:

- Is there a need for improved operational atmospheric, land and/or ocean observations from satellites?

- If yes, what should the responsibilities of the Federal government and the private sector be in the development of such systems and their subsequent operation?

- For private sector involvement, how can a viable profit and loss structure be assured?

- With respect to government involvement, what agency will:

  - develop the system?
  - operate the system?
  - act as the interlocutor for civilian and other government users?

- To what extent do military needs and national security considerations get involved?

- What are the international ramifications of systems for which 90 percent of the potential measurements would come from outside U.S. territorial limits.

To answer these difficult questions, the President last month directed NASA to lead an interagency study to chart the future course of earth observations from space. This in-depth study will draw upon the experience gained over the last ten years in the U.S. remote sensing program. By any measure, the United States today holds a commanding lead in both the space technology for remote sensing and in data processing techniques for exploiting these measurements. The new study, to be completed next year, will provide a comprehensive plan covering expected technical, programmatic, private sector, and institutional arrangements for remote sensing of the planet Earth. The interagency task force will examine options for integrating current and future potential systems into an integrated national system. Emphasis will be placed on defining and meeting user requirements for land, sea, and atmospheric data.

In the current operational environmental satellite area, the DOD and the National Oceanic and Atmospheric Administration (NOAA) have operated separate meteorological/environmental satellite systems. During the next six months NOAA, DOD and NASA will take a fresh look at the operational requirements and constraints which have up to now precluded a totally common system for the two agencies to determine to what extent separate programs supporting specialized defense needs should be maintained. The same three agencies also are examining the possibility of an integrated approach to ocean observations from space.

Even though the results of these studies will not be known for some time, it is clear that the questions posed a few minutes ago are being addressed.

## WHAT'S NEXT?

Resources permitting, it is possible to envision a remote sensing program for the late 1980's which will provide atmospheric, land, and ocean observations over the entire globe in a timely manner to the whole spectrum of governmental (both U.S. civil and military, and foreign) and private sector users. Details of the specific sensors that will be flown in that time frame--and thus the total scope of services that can be rendered--will be determined by the budget process in fiscal years 1980 and 1981. Clearly, the Shuttle and TDRSS will play key roles in the Earth observing system. Their use may permit, by the end of the next decade, integrated spacecraft which will observe the land, oceans and atmosphere in a synergistic way. The orbit of each platform would be determined by its sensor and data requirements rather then by each discipline community being served.

These operational platforms also would support the flight of developmental sensors whose orbit requirements are similar to the operational mission. This approach already is planned for the early 1980's. For example, the NASA Search and Rescue experiment will be flown on the NOAA operational satellites in polar orbit and the VISSR Atmospheric Sounder will be carried on our Geostationary Operational Environmental Satellite.

An integrated space approach to Earth observations, combined with the use of the Tracking and Data Relay Satellite System for central data acquisition, offers the possibility of establishing a central satellite data base. It would contain observations and analyses of the planet Earth which could be tapped by a wide variety of users needing information in many geophysical disciplines. Large users with real time data needs would acquire the data they need from the central point via a communications satellite link. Private enterprise might make extensive use of the data base to produce a variety of information products of a specialized nature.

As for the needed resources, the government does not intend to keep space-based Earth observation systems an exclusively government "club." On the contrary, the private sector will be encouraged, consistent with U.S. policies and responsibilities, to participate as a full partner in any phase of the program in which there is a viable commercial opportunity.

The National Aeronautics and Space Act of 1958 proclaimed that it is the policy of the United States to exploit the potential of space for the benefit of all mankind. Clearly, the President's new space policy reiterates this commitment, builds on our twenty years of space experience, and emphasizes applications that will bring important benefits through increased knowledge of earth resources, climate, weather, pollution and agriculture.

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