# The coming global view of earth

**The first satellite to study the earth's resources is scheduled for launch in July. This article is the first of several on both the promise of the program and the problems and issues associated with it.**

by Everly Driscoll

*"We are dealing with a new technology that will revolutionize both human knowledge and human behavior. I do not believe any of us fully realize what ultimately will be at stake in the decisions we make, the actions we take and the policies and precedents we establish. We all can be sure, however, that a great responsibility rests upon us."*—JAMES C. FLETCHER, NASA administrator, on earth resources programs, January 1972.

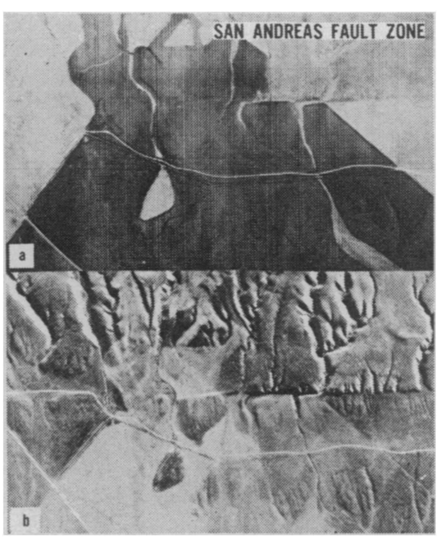
On June 1, there were 515 satellites circling the earth. With the exception of the weather and communications satellites, the man on the street probably realized little or no direct social or economic benefits from these eyes in the sky.

With the launch of the first Earth Resources Technology Satellite (ERTS A), scheduled for early July, that could change (SN: 6/19/71, p. 413). What ERTS A can do as an experimental system, what follow-on satellites could and should do, what will be done with the ERTS data, who should eventually control operational satellites (if they become a reality), and how this information about the planet will affect the lives of people on earth are questions of intense concern today to a host of governmental agencies, foreign nations and the White House Office of Management and Budget (OMB).

ERTS, as part of the national earth resources survey program (ERSP), has been a long time coming (it was first proposed in 1966). It will be the first U.S. civilian satellite flown with the prime objective to look at the surface of the earth (SN: 11/27/71, p. 362).

In February, OMB chartered an interagency coordinating committee to oversee the earth resources program. While the development of remote sensing capability from space is one job of NASA, study of the earth is not. That task somehow belongs to other Federal agencies (Agriculture, Commerce, Interior, Defense), state and local agencies, universities, private industry and foreign governments. By 1969 NASA became actively interested in earth resources. Since then it has been in an awkward position. OMB, because of the economic and political implications of surveying the earth from space, resisted by cutting, curtailing and refusing funds. But Congress, anxious to see NASA doing something that could be pointed out as a direct benefit to the average taxpayer, has been prodding NASA to move faster, chastising it when it didn't, and working to increase the funds that OMB cut. The user agencies, realizing that the jobs they are now doing will probably be altered by remote-sensing techniques, have vested interests. Each agency has different requirements and would like NASA to fly a different kind of system. Each is thinking of follow-on operational systems and is now awaiting the ERTS A data to see if it will be useful.

All in all, getting ERTS A up has been a tedious process. The whole subject has, at times, been sensitive.



NASA

*Same view with different sensors.*

"By its nature," says Allen E. Puckett, vice president of Hughes Aircraft Co., one of the contractors for ERTS, "it [ERTS] represents a great many compromises between conflicting requirements of various possible end uses."

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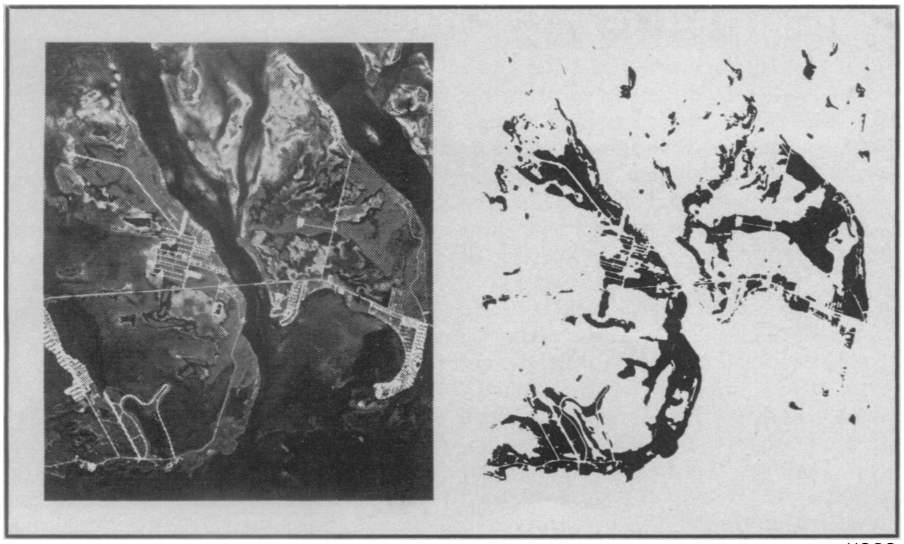
The compromises involved the sensors being flown and the resolution of the imagery to be acquired. ERTS has three systems: a return-beam-vidicon camera (television), a multispectral point scanner, and a data-collection system. The TV camera will record imagery in three spectral bands—blue, green and red—in 185-kilometer squares. (According to Arch Park of NASA, 550 such photos, each containing 16 million data bits, will be required to cover the United States.) The scanner will obtain line-scan images in 185-kilometer-wide swaths in the same color bands, plus a near infrared band. The third system is for collection and relay of data from ground stations. About 300 surface platforms have been set up in North America to send local information, such as rainfall, temperature, wind velocity and other conditions to the satellite for relay to receiving stations.

Problems with the scanner delayed the launch of ERTS from March to



USGS

*Using infrared to highlight patterns of vegetation (right) in Florida Keys.*

May. Other technicalities, including problems with a modified Delta launch vehicle, have delayed the launch from May to July. Total cost of the two satellites (the second, ERTS B, is to be launched next year), a data processing center, and funding for investigators will have cost from $152 million to $176 million. This does not include the $5 million each for the launch vehicles.

When ERTS A finally is launched from the Western Test Range, it will go into a near-polar, sun-synchronous orbit. It will cover the entire globe, except for the polar regions, from an altitude of about 917 kilometers. During the 103-minute orbit of the earth, real-time and recorded data will be sent to receiving stations in California, Alaska, Maryland (Goddard Space Flight Center) and Prince Albert, Sask., Canada.

The TV camera will not see much detail. Alden P. Colvocoresses of the U. S. Geological Survey says in the January PHOTOGRAMMETRIC ENGINEERING the ERTS camera has a low-contrast ground resolution of 180 to 275 meters. This compares with Gemini and Apollo photographic resolution of from 70 to 125 meters; Skylab's multispectral camera, 40 to 100 meters; Skylab's Earth Terrain Camera (ETC), 10 to 40 meters; high-altitude aircraft cameras, 4 to 10 meters. Military satellite cameras can obtain a resolution better than 3 meters. The ERTS camera will thus see objects the size of two to three football fields. But, says one photogrammetrist, an object will have to be about the size of a 160-acre farm before it will yield much data. One oceanographer agrees: "Looking at San Francisco Bay will be difficult."

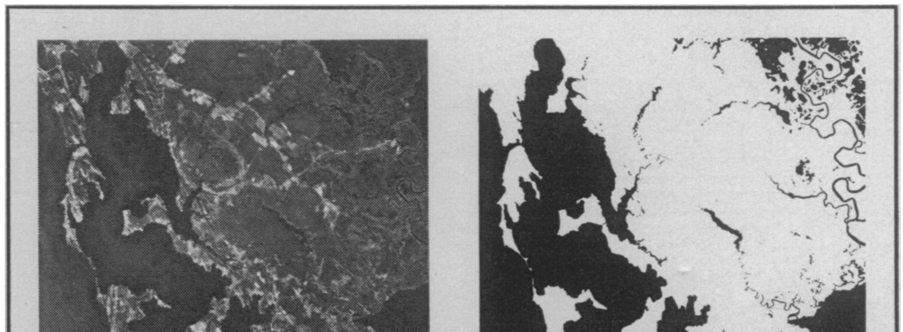
NASA has higher hopes. High-contrast ground objects, such as the difference between a field that has been plowed, and one with crops, should have about a 100-meter resolution, says John Denoyer of NASA headquarters. The whole point of ERTS, says NASA, is to provide a broad-based, repetitive coverage of the earth. "We are not sure what we will get," says Park. ERTS is to find out.

The sensors will note any changes in the reflection of surface features in the four spectral bands. By flying similar sensors in aircraft, scientists have obtained a fairly good idea of what they might see: fresh versus polluted water (if the pollution causes a change in color or turbidity), sick versus healthy crops and vegetation, and geological features. On a broad scale, scientists should be able to differentiate between wheat and corn. "If geologists are able to locate petroleum and mineral deposits, it will be by inference only," says Martin W. Molloy of NASA. (This is because different rock types cannot now be detected—only land forms.) Earth scientists will be able to make gross classifications of land use—forestry versus cultivated land, for example. They will be able to locate soil and surface water resources, and determine snow and ice coverage. This latter potential is of great use, notes William O. Davis of the National Oceanic and Atmospheric Administration (NOAA). With some ground-truth data such as local temperature and weather conditions and local snow thickness and water content, scientists can look at large areas of snow and ice coverage from ERTS and predict the rate of melting and the extent of probable flooding.

"Should operational systems be controlled by the government or private enterprise? Who has proprietary use of the data?"

Another area in which ERTS should be useful is in the study of coast-line changes, says Murray Felsher of the Environmental Protection Agency (EPA). The Corps of Engineers, for example, will be able to use information showing the growth of beaches and the movements of spits (barriers), as well as the gross movements of sand and sediment to guide them in channel dredging.

But even these broad investigations will still be about 90 percent empirical. The "signatures"—what the reflected energy looks like—will have to be compared with remote-sensing imagery of the same site from aircraft. In preparation, NASA has been flying U-2's and RB 57's over specified regions. Interpretation of ERTS data will also depend on ground-truth information—someone actually going into the region to see



USGS

*Using infrared to separate patterns of land and water in Chesapeake Bay area.*

how the land there is being used.

In spite of current uncertainties about what can be gleaned from the raw data, one thing is sure. There will be lots of it. The total amount of data is mind-boggling and the situation will probably approach what some term a "data glut." The system is capable of producing 300,000 data products a week; of surveying more than 42 million square kilometers a week; and of covering the same scene 20 times a year (every 18 days). According to Daniel J. Fink, vice president of General Electric, manufacturer of ERTS, "It will produce 15 million bits of information per second, equivalent to an Encyclopaedia Britannica every couple of minutes." Another way to look at it is that the satellite will produce 188 scenes per day in 7 spectral bands, says Denoyer.

There will be no way to look at all of the data, and NASA and users admit they are "at the foot of the Rockies." Unlike other satellites, the instruments do not have a "principal investigator" (PI)—a scientist who submits the proposal for the instrument, then builds it, then is responsible for reducing the data. Depending on whether one talks to some principal investigators, or to NASA, this is either a great weakness or a strength. Says one scientist, "No one will look at all of the data for comparison and scientific investigations, thus many things will be overlooked." NASA disagrees. The data are valuable beyond what even 300 PI's can do, says Denoyer. Thus NASA, through Interior, will provide the data to anyone. In addressing the data problem, James C. Fletcher, NASA administrator, told a group of users in January: "A key element of any long-range earth survey program must be to develop machine capability that can accept raw data from a variety of sensors. . . . The level of machine capability to which I refer does not really exist today."

What does exist today to handle ERTS is people: no automatic computers to reject useless data or retrieval systems to cull out related information. Various NASA centers and universities are developing computer hardware and software. NASA built a $35 million data center at Goddard, just for ERTS. Data will be sent there from the receiving stations. Canada has its own station and data center.

The Department of Interior has the largest in-house earth resources program, called EROS (Earth Resources Observation Systems). Interior built an EROS Data Center at Sioux Falls, S.D., which is under the management of the Topographic Division of the U.S. Geological Survey. The 300 or so investigators (including 98 foreign) chosen by NASA will receive their data directly from Goddard. Much of it will be converted to 70 millimeter film. All data will be sent to both Interior's center and to a similar center of NOAA, where it will be placed in the public domain for anyone to buy. Agriculture and EPA will also receive ERTS film.

Earth resources satellites raise a host of questions. How does one assess the economic and social benefits from such a system? What, for example, a Government adviser asks, is the commercial value of being 98 percent accurate on a crop inventory as compared with 88 percent accurate? No one is sure yet, but OMB has given Interior the responsibility for establishing the methodology for such an assessment. OMB also expects some answers before more such satellites will be approved.

Other questions concern control of operational systems. Should they be controlled by the government or private enterprise, or some mixture of both? Who has proprietary use of the data? Some laws, for example, may prohibit placing in the public domain information about a given farm. What are the international sensitivities? Should U.S. businessmen be allowed to buy information about Argentina, for example, if Argentine officials haven't seen it? (With the current ERTS, NASA has sought proposals from all foreign countries.) When and if local and global models from ERS data are built showing the region-wide or nation-wide effects of a given action—say of building a dam—what can be done about it?

ERTS B is tentatively scheduled for next year. But beyond that all earth-oriented civilian satellites are only on the drawing boards until some more answers come in. □