CARETS: Remote sensing for environmental studies

Four sites will be monitored in pilot application of space observations to down-to-earth problems

Some environmentalists reject all of modern technology and call for a return to a simple, pastoral life free of fumes, artificial chemicals and any noise but the chirping of birds and the croaking of frogs. Their nostalgic yearning is not hard to understand, especially in the stink, clamor and congestion of a modern city. But it may be they have misapprehended their enemy—which may not be technology, *per se*, but, rather, technology too narrowly applied, with too little concern for the largest number of people affected. Specialization, both economic and technical, has allowed the specialists to proceed with their pet projects as if nothing else existed—and the rest of humanity be damned.

One target of environmentalists has been aerospace projects. Why send men to the moon, they ask, when the earth is in desperate need of repair. Now, however, aerospace endeavors suddenly promise to give environmentalists one of the most powerful tools—and one of those most invulnerable to special interests—they could imagine.

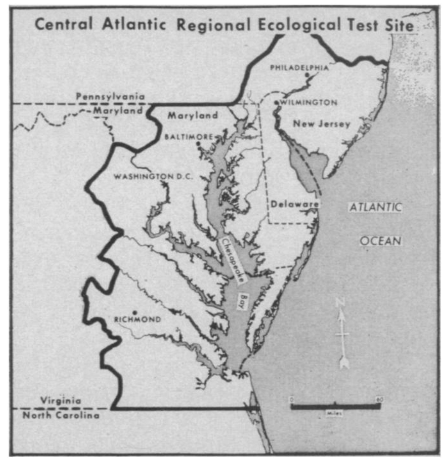
Last week, the Interior Department and the National Aeronautics and Space Administration brought together state, local and Federal officials from a 30,000-square-mile area including Washington, D.C., and portions of Pennsylvania, New Jersey, Delaware, Maryland and Virginia, called the Central Atlantic Regional Ecological Test Site (CARETS). The purpose was to explain NASA's U.S. Earth Resources Survey Program (ERSP) and Interior's companion Earth Resources Observation System (EROS). The programs will use high-flying aircraft, spacecraft and satellites to monitor precisely what is happening on the surface of the earth (as well as in part of the air envelope) in the CARETS area.

Actually, the program is not so new as it may seem. Man has looked at the surface of the earth from aircraft for years, and the techniques have steadily grown more sophisticated. NASA as early as 1964 began developing remote sensing for earth monitoring. Interior's U.S. Geological Survey has had an even greater interest because of its special role, and, after considerable early conflict between USGS and NASA, it began early to work with NASA. Now there is little doubt the first Earth Resources Technology Satellite (ERTS A) will go up next spring and ERTS B in 1973; the manned Skylab will also participate when it goes up in 1973.

Already RB-57 aircraft have overflown CARETS, and U-2's will begin flights over the region in July. Other regions—including the Phoenix-Tucson arid lands area, California's Feather River watershed and the San Francisco-Los Angeles area—will be studied in programs similar to CARETS. In addition, there have been numerous specialized overflights—a fresh-water survey of Jamaica for that island's government, for instance, and an inventory of the severity of corn blight in the Midwest—as well as many studies of urban areas in the United States. Apollo astronauts observed and photographed pollution and earth resources in orbit.

ERSP relies on the simple principle that all objects either emit or reflect characteristic electromagnetic radiation. Research and development has focused on identification of radiation patterns—called the "signature" of the object or feature—and upon accurate sensing of the radiations. Sensor verification is through "ground truth" techniques—actual examination of the features on the ground. Now available is a broad range of sensors with numerous applications:

- Ultraviolet sensors show luminescence—absorption and reemission. UV can be used mainly to detect certain rocks and minerals and roads and buildings. Oil slicks also show up sharply.
- Infrared and near infrared, either emitted or reflected, has three main applications, sensing of heat (such as thermal pollution of waterways), classifying soil and detecting vegetation and determining the condition it is in.



USGS

CARETS: 30,000 square miles.

NASA

Emphasis on ecological observation.

- Visual bands have many applications. Green is good for water penetration, for instance.
- Microwave or radio frequencies. Passive microwave frequencies—those emitted from the object—have diverse applications, such as measurement of water content of snowpack. Active microwaves—those emitted from the aircraft or satellite and bounced back—provide an image of terrain, even when cloud cover prevents visible wavelengths from getting through.
- Radiometers and spectrometers. Radiometers provide measurement of radiation in selected discrete bands. Spectrometers define the range and type of frequencies emitted.

Sensors used include regular film cameras, television systems, multispectral scanners, thermal mapping scanners, and the imaging radar systems and microwave radiometers. Sophisticated capabilities for information processing and communication will be included. For instance, in the corn blight work, the sensor and its related equipment distinguished between five categories of corn condition ranging from healthy to severely blighted, and digitized the information. (Scientists still do not know for certain why healthy and unhealthy vegetation reflect IR differently. One theory is it relates to chlorophyll; another is that water in plants is reflective and that unhealthy plant cells contain less water.)

Both ERTS satellites (A & B) will orbit at 920 kilometers in sun-synchronous orbit. They will pass over any given point every 18 days, and the sun angle at any point will always be roughly the same for each flyover.

The CARETS information will be communicated to various locations for eventual processing at a data center in Washington, D.C. Models will be constructed of the CARETS region as enough data become available. There are problems, of course. Processing the data, such as from the corn blight studies, has posed some difficult problems. And, although Interior officials will not comment, there have been rumblings that a disproportionately small amount of money is being spent on data processing and user services as contrasted with amounts for NASA's space hardware. NASA needs the hardware money; but Interior could use more than the $1.9 million budgeted for fiscal 1971 or the $5.2 million asked for 1972.

The CARETS emphasis is primarily ecological (as opposed, for instance, to geological) and the models will include inventories of vegetation, soil, water, cultural features, land use distribution, land forms and continental shelf data.

The possibilities for use of the data and model are endless. For example, the "urban heat island effect," is well-known; urban areas have higher temperatures than surrounding suburban and rural areas. The model may allow researchers to predict the exact thermal effects of a proposed new artifact, such as a freeway. Socioeconomic, demographic and other census-type data can be correlated with ecological data; the effects of a new suburban subdivision on a total urban region in terms of urban sprawl, congestion in the central city, vegetation, effect on downtown businesses and numerous other factors can be predicted with more precision.

And no longer will environmentalists have to wheedle local, state and Federal governments for a share of scarce R&D funds for studies of the kinds EROS does better. To produce an urban heat island profile of a city by other means would require thousands of ground and near-surface measurements and might be prohibitively costly. Now such a profile may become available at a small fee for anyone interested enough to go to USGS offices in Washington to get it.

The power this will give to environmentalists in their arguments before city councils, county commissions, state legislatures and Federal agencies will be immense. Says one USGS official: the data will be so indisputably objective there will be no room for debate.

CARETS and the California and Arizona studies are essentially pilot projects. If they work out—and every indication is they will—remote monitoring likely will become nationwide and worldwide. Already 20 foreign countries have asked for ERSP data. □

SLAC PROPOSAL

Loops in the linear

High-energy accelerators for electrons have to be built in straight lines. The reason for this is the phenomenon called synchrotron radiation. Charged particles whose direction is being changed by a magnetic field—as is always the case in circular accelerators—radiate part of the energy they receive.

Both protons and electrons are subject to this synchrotron radiation, but it affects electrons more severely because they are lighter and therefore go faster at a given energy. Above a few billion electron-volts electrons tend to radiate as much energy as they gain from a circular accelerator.

The way around the synchrotron-radiation problem is to build linear accelerators, but there is a practical limit to how big they can get. The 20-GeV machine of the Stanford Linear Accelerator Center is two miles long. To double that energy would require four miles of accelerator or running the electrons through the two miles twice. The latter is what the SLAC management now proposes to do.

SLAC

Proposed loops would double energy.

Doubling the energy in this way is one of the items in a five-year plan to start in fiscal year 1973 that the SLAC management has proposed to the Atomic Energy Commission. The installation would consist of reversing loops and drift tubes that would take the electrons from the accelerators and run them back and forth more than a hundred times until the accelerator can take them for the second acceleration. The accelerator requires 2.8 milliseconds cooling time between pulses, but the electrons traverse the two miles in about 0.025 milliseconds.

In going around the loops, the electrons would be subject to synchrotron radiation. The plan includes a booster section to give back the lost energy. Superconducting waveguides may be used for the radio frequency waves that accelerate the particles in this section if superconducting technology is deemed reliable enough when construction starts. If not, says a SLAC representative, there are other more conventional options at the same cost.

The drift tubes can be laid in the existing tunnel alongside the present accelerator, obviating any need for new tunneling. The total cost of the new work is estimated at $16 million. The existing SLAC cost $114 million.

Already planned improvements to the existing accelerator will raise its energy to 25 GeV so the double run would actually produce electrons around 50 GeV. There is no possibility of going to multiple runs, because the synchrotron-radiation loss in the loops would become prohibitive at higher energies.

Physicists would like to have the 50-GeV electrons so they can further explore promising lines of work opened by the existing accelerator, especially the study of partons. Two years ago SLAC physicists announced that experiments had shown that the proton is composed of discrete subparticles; they called them partons. Electrons—and the particles that can be made by striking electrons on targets, gamma rays and various mesons—are very useful in probing the structure of larger particles. Higher energy electron probes may help discover the nature of the partons and how they are put together to form protons and neutrons.

The reversing loops could also possibly be used to provide colliding-beam experiments between two beams of 20-GeV electrons, suggests Dr. S. S. Brodsky of SLAC.

The proposal is submitted at this time because the AEC is beginning work on its budget for 1973, in which, the SLAC people hope, the first funds will be included. AEC professionals tend to favor the idea; but no one is guessing whether it can be sold to others who have a say about the budget. As one AEC physicist put it: "What goes in at the beginning of the budget cycle doesn't always come out the other end." □