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New Roles for Recce

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RECENTLY, the Subcommittee for Investigations and Oversight of the House Committee on Science and Technology issued its report, *Information Technology for Emergency Management*, culminating two years of hearings on the use of modern technology to deal with both natural and man-made disasters.

Opening the hearings, Subcommittee Chairman (now Senator) Albert Gore, Jr., said: "We are all aware of the tremendous technological advances made in the last few years. We have seen and benefited from their applications in the areas of health and medicine, the environment, and other scientific fields. But we must ensure that this technology is applied to our nation's ability to predict, prevent, and respond quickly and effectively to natural or man-made disasters."

I testified at those hearings that there was one resource not being used to its full potential. If it were properly employed it could save countless lives and billions of dollars in property damage each year. That resource is the nation's aerial reconnaissance and interpretation technology.

Few outside the military and intelligence fields are aware of this resource. Fewer still know how to interpret that technology, and even fewer know how and when to apply it. Yet it is the same technology with which the United States monitors SALT and the Middle East Truce Agreement; observes and predicts crop yields in the Soviet Union, Australia, Canada, Argentina, and India; and assesses damage caused by such catastrophes as the Italian, Guatemalan, and Alaskan earthquakes.

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Aerial reconnaissance and photographic and multisensor interpretation are sciences born of wartime necessity to obtain accurate information on the enemy rapidly. Since World War II, these sciences have been advanced and refined by the intelligence and mapping agencies until today's overhead reconnaissance systems provide more data with a greater frequency and cover larger areas than ever before. Computer and software developments make the entire information-gathering and interpretation system manageable.

Remote sensing of the earth can be done from a variety of platforms, such as low-flying helicopters, light aircraft, reconnaissance resources of the military services, the U-2 and SR-71, NASA satellites and Shuttles, and the meteorological satellites that photograph the hemispheres from 22,300 miles in space. Surveying the earth from high-flying or orbiting platforms fitted with remote sensing devices could be the most significant technological development of our time.

Looking down on our planet to observe the complex and continuously changing interrelationship of land, sea, and air has added immeasurably to our knowledge of the fragile relationship between man and his environment. The combination of an established data base, broad area coverage, and large-scale photography has created unique opportunities for interpreting both natural and technological phenomena and disasters.

Properly interpreted, the remote sensing of our environment can provide current, definitive information that should be used in the decision-making and problem-solving procedures we apply on earth. The pace of remote sensing techniques will accelerate since imagery can now be digitized. Combining imagery interpretation expertise with computer technology provides numerous innovative applications. It is now possible to analyze entire countries, regions, or continents. Remote sensing can provide data with speed and accuracy that cannot be attained from other sources.

Dimensions of the Problem

The resources of our planet are limited and in many instances are being depleted at an alarming rate. At the same time, world population is expanding geometrically. Those who interpret pertinent reconnaissance data are always impressed with the fragile web of life that is visible in the imagery. All cultural and economic activity conforms to definite, identifiable patterns. The imagery interpreter knows these patterns as "signatures." Building codes, regulations, customs, practices, and procedures govern the methods by which man farms the land, builds homes, constructs factories, and extracts resources.

Visible also in the imagery are current activities that will affect our future livelihood adversely, such as building on flood plains, stripping the earth's timber for lumber and firewood, poor agricultural practices that cause the erosion of farmlands, the misuse or contamination of water, improper and indiscriminate disposal of wastes, and the impact of weather-related disasters, earthquakes, and volcanoes.

Natural and technological disasters kill and injure thousands of people and cause property damage of astronomical proportions. The 1983 National Oceanic and Atmospheric Administration (NOAA) *Climate Impact Assessment Report* for the United States reveals more than $27 billion of property damage in the US directly attributable to weather phenomena. That year, the worst flooding in fifty years occurred in Latin America, while there were major droughts in Africa and Australia. And we have become all too familiar with such man-made disasters as chemical spills, explosions, fires, nuclear accidents, and waste and sewage problems.

Potential Applications of Reconnaissance

Aerial photography and multisensor imagery can have three important applications in relation to natural and technological disasters. First, they are a valuable *historical* record; second, they could become the most important means for *predicting disasters;* third, this imagery is an unparalleled source of quick and accurate *damage assessment*. These are not discrete functions, of course. In actual use, there often would be considerable overlap. And they are by no means the only applications of overhead imagery.

Several years ago, Arthur C. Lundahl, Director of the National Photographic Interpretation Center from 1956 to 1973, discussed with the Director of Central Intelligence and the President's Science Advisor the wisdom of sharing these resources with civilian agencies. In 1967, as a result of a formal study recommending sharing, the Director of Central Intelligence entered into agreements with a number of federal agencies, giving them access to classified overhead photography. Subsequently, the National Photographic Interpretation Center was directed to use aerial photography for such projects as assessing natural and man-made disasters, conducting route surveys for the Alaska pipeline, compiling national forest inventories, determining the extent of snow cover in the Sierras to forecast runoff, and detecting crop blight in the Plains states.

In 1975, the Rockefeller Commission reviewed the concept of sharing classified data and concluded: "The Commission can find no impropriety in permitting civilian use of aerial photographic systems. The economy of operating a single aerial photographic program dictates the use of these photographs for appropriate civilian purposes."

Nevertheless, for a variety of reasons, aerial photography and multisensor imagery are hardly being used in emergency management. The most familiar reason heard in Washington is that "it's not in our budget (or our charter)." Elsewhere, regional experts concerned with emergency management know little or nothing about these capabilities. Congressman Gore noted "the inertia on the part of emergency agencies that leads to a failure to use the data."

Images of History

Consider the three key civilian applications of this little-used imag-

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ery. As a *historical record*, aerial photography has few equals. The United States has an enormous data base of aerial photography and multisensor imagery gathered over the past sixty years. For example, the Departments of Interior and Agriculture have more than 25,000,000 prints of the United States. In addition, there are hundreds of other repositories holding photos taken by private citizens and local, state, military, and federal agencies. The steadily increasing volume of imagery collection may prove useful in ways that we can hardly even imagine today.

During the 1930s, for example, farmers were paid by the federal government to plow under part of their crops. To prove there was compliance with agreements, photographic missions were flown over farm areas. Most of that film found its way into the National Archives. Forty years later, when the Environmental Protection Agency was charged with locating old toxic chemical dumps, they found that these pictures provided the most reliable data on the existence of the waste sites used decades before and then abandoned and forgotten, but in most cases still hazardous.

Every day, the two Landsat satellites now aloft collect more than 1,100 images worldwide. Each image covers about 100 square miles and is an irreplaceable record of a moment in time. Each establishes a baseline that is of critical importance in recognizing changes that may occur in the future.

An Ounce of Prevention

Landsat photography, supplemented by other sources of imagery, has a vast and largely unused potential for the second important civilian application—*predicting disasters*. After studying Landsat photographs, I testified in congressional hearings that the federal government has the technology, methodology, data, and expertise to have prevented, or at least greatly mitigated, the massive flooding in the west caused by snow melt in the spring of 1983. The Landsat photographs were clear, detailed, and encompassed the area of snow-melt concern.

Additional data could have been collected by SR-71 reconnaissance aircraft capable of covering the 1,450-mile length of the Colorado River in less than forty-five minutes and by U-2 aircraft equipped with a variety of sensors. These missions could have been flown as part of the routine pilot-training programs.

The US Geological Survey had maps of sufficient detail and in scales appropriate for snow-melt measurement and analysis. The Defense Mapping Agency, the US Geological Survey, and the CIA have excellent photogrammetric capabilities that could have been used to measure accurately the amount of snow and compute runoff from the snow pack. With the flow computed, dams and reservoirs could have been drawn down enough to control flooding.

Property damage from the snow melt was estimated at more than $1 billion. No monetary value can be placed on the 156 lives that were lost in the flooding. The only warning many people had was when water and mud crashed through their homes. Had federal and regional task forces been established, most of the flood damage and loss of life could have been prevented. The cost of implementing such a program would have been only about $5 million, compared to the more than $1 billion of property damage that occurred.

A Lost Opportunity

Here's another example of a lost opportunity to prevent disaster. It took television crews to awaken the conscience of the world to the thousands dying from starvation or starvation-induced diseases in Africa. If existing multisensor imagery had been analyzed, the plight of 150,000,000 people in Ethiopia and other African countries not only could have been predicted, but action might have been taken before disaster struck. Evidence of the natural phenomena that caused crop failure occurs gradually over large areas and can be recorded through aerial photography or by multisensor imagery. Detailed analysis of large-area coverage over a period of time can identify drought or desert encroachment.

The science of determining crop conditions was developed after the USSR, experiencing a disastrous drought, secretly purchased millions of tons of US grain at bargain prices. When that became known, President Nixon called together those involved and issued an ultimatum that neither he nor any other President of the United States should ever again be caught short in similar circumstances.

Those familiar with reconnaissance and interpretation agreed that Landsat imagery could be used to monitor the distribution and vigor of crop growth and that such data, combined with other information, could produce a quantitative analysis of future yields. Analysis of the near-infrared spectrum can determine the degree of biomass, or the greenness of the crops. The more abundant and healthy the vegetation, the greater the yield. This method of determining crop yields resulted from the Large Area Crop Inventory Experiment (LACIE) in 1973 and from the later Agriculture and Resource Inventory Through Aerospace Remote Sensing (AGRISTARS) program.

A comparison of the greenness in the African drought area in 1982 and 1983 indicated that there was considerably less vegetation in 1983 than there had been the year before. This was true not only of the crop-growing areas but in pastures as well. In other words, the area was experiencing a devastating drought. Technology exists not only to estimate the magnitude of the drought but also to predict potential food shortages.

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[redacted]xample: Ash clouds [redacted]eruptions can create a [redacted]f particular interest to[redacted]an be given warning[redacted]ducts of aerial and [redacted]sance. Jet engines can [redacted]amaged by ingesting volcani[redacted]Following the eruption of Moun[redacted]int Helens on May 18, 1980, meteorological satellites photographed the ash cloud as it moved eastward, and warnings were issued to aircraft flying in or near the cloud.

Two years later, two Boeing 747s flying in the Indian Ocean area were not so fortunate. On June 24 and July 13, 1982, these aircraft experienced severe engine problems resulting in shutdowns, caused by ingesting volcanic ash from eruptions of Mount Galunggung in Indonesia. Both aircraft were forced to make emergency landings at Djakarta. The loss of an airliner with all passengers would be a calamitous event, and that sobering fact prompted a series of investigations. It was found that sulfur dioxide in the volcanic eruption plumes is detectable from space. The Nimbus 7 Total Ozone Mapping Spectrometer (TOMS), which produces daily global images that measure how much sunlight in the ultraviolet spectral region is absorbed by ozone in the atmosphere, is also capable of determining the size and the shape of volcanic ash clouds. Another experiment revealed that the Geostationary Operational Environmental Satellite (GOES) and the NOAA polar-orbiting meteorological and environmental satellites—because of their multispectral capabilities, especially in the infrared range—have a strong potential for distinguishing and tracking ash clouds.

Infrared sensors in polar-orbiting satellites have many other warning applications. The dread of foresters is fire in inaccessible areas. Recent experiments with thermal infrared sensors aboard NOAA polar-orbiting satellites have shown the usefulness of these sensors as effective and economical means of detecting and monitoring forest, tundra, and open-range fires.

Using the 3.8-micron channel, the NOAA satellites "paint" a 2,600-kilometer longitudinal swath [redacted] with a [redacted] fifteen degr[redacted] example, can be [redacted] frame, and forest or [redacted] one square mile can be de[redacted]

Reporting the Bad News

Finally, photographic and multisensor imagery has a potential for *damage assessment* that has not been fully exploited. Whenever a natural disaster strikes, there is an attendant breakdown in transportation, communications, public safety, and health care. The need for timely and accurate information on the scope and magnitude of the disaster becomes paramount for emergency management efforts. Aerial photography is unequaled in providing the data needed.

U-2s have been used to collect data essential in assessing the damage caused by earthquakes, hurricanes, floods, tornadoes, and oil spills. Both the U-2 and the SR-71 were employed during the eruption of Mount Saint Helens, gathering photographs and multisensor imagery for a quick assessment of the immediate dangers posed by the eruption.

Pre- and posteruption multisensor images provide a dramatic view of the destruction caused by that event. Almost a cubic mile of the crown of Mount Saint Helens was blown away. Trees as far as twenty-eight kilometers (more than seventeen miles) from the mountain were toppled like matchsticks, and timber was scorched for some distance beyond that. Sediment and debris filled Swift Reservoir and Spirit Lake. The massive flow of debris that swept down the North Toutle Valley raised its floor more than 600 feet, damming tributary rivers and creating new lakes and ponds.

The formation of these lakes posed a serious problem, since the dams created by the eruption might erode swiftly and release a deluge of water and mud down adjacent valleys. Evidence of volcanic ash carried into neighboring states by high-altitude winds could be seen clearly on aerial photos. Those photos were used for devising methods of alleviating problems created by swollen lakes and ponds. Foresters also used the images to search for ways to retrieve the blown-down and damaged timber.

New and Future Developments

It is generally agreed by emergency preparedness officials that a thirty- to forty-minute warning is adequate to prepare for most disasters. Warning of disasters that could occur at night is especially important. Satellites have a vital role to play in achieving this goal. In my testimony before Congress, I stated: "Although there is some collaboration among people on the ground and the aerial collector, in the future, sensors on the ground will be read by collectors in space."

An emplaced sensor that sends its data to a satellite or that can be interrogated from space has many advantages. It can be set to any desired specification, it operates twenty-four hours a day, and it can be implanted in remote locations where conditions make it impossible for man to survive. A variety of gauges and sensors that will uplink data to satellites for warning purposes is now being implanted. The US Army Corps of Engineers and the Tennessee Valley Authority are placing in remote areas hundreds of gauges that will transmit data to the Geostationary Operational Environmental Satellite (GOES) for flood warnings.

Other sensors are being implanted in earthen dams to give warning of potential trouble. The Bureau of Reclamation is using gauges and sensors to monitor snowfall and snow melt in order to alleviate potential flooding problems. In the Pacific, tidal gauges and sensors have been located on the coast to transmit tsunami (tidal wave) warnings via GOES satellites. In hurricane-prone areas, gauges and sensors are being emplaced along streams susceptible to flash flooding, with the warning data flashed to GOES satellites. Scientists have also determined that sudden surges of hydrogen have often preceded volcanic and earthquake activity. Sensors are being emplaced along major earthquake zones in California and around volcanoes in Hawaii and at Mount

Saint Helens to record hydrogen activity. Here again, data is sent via GOES to a US Geological Survey data center, where it is compared with other scientific data.

We are entering a new era of reconnaissance in which satellites will be able to collect data or interrogate sensors on earth, analyze gases in space, digest data, photograph areas of concern, and send warnings to emergency centers.

At the Subcommittee hearings, it was obvious that most of the state, county, and city emergency officials knew little or nothing about the aerial reconnaissance and multisensor imagery capabilities that could be applied to their work. It would be a valuable contribution to domestic security if the Department of Defense, the military services (including their Reserve Forces intelligence organizations), other federal agencies, and the intelligence community shared their knowledge of reconnaissance and multisensor imagery with local and regional disaster management officials.

We have invested heavily in science and technology to protect this nation from external threats. Now we must apply appropriate elements of that science and technology to mitigate or prevent natural and technological disasters. I know of no endeavor where the funds and effort expended offer so bountiful a return. ■

Dino Brugioni writes regularly for AIR FORCE Magazine. His by-line last appeared in the March '84 issue with the article "The Tyuratam Enigma." During World War II, he flew sixty-six bombing missions and a number of reconnaissance missions over North Africa, Italy, France, Germany, and Yugoslavia. After the war, he received a B.A. and an M.A. in foreign affairs from The George Washington University. He joined the CIA in 1948, becoming a senior official and a reconnaissance and photo-interpretation expert for the agency before his retirement.