New Research and Development Activities in Photography and Navigation

by J. M. Dowdy and C. Shirley

WITHIN RECENT YEARS the term "Remote Sensing" has become the popular way to refer to the acquisition of information about an object or phenomenon which is not in immediate contact with the information-gathering device. The uses and applications for remotely sensed data are as varied as our ideas concerning methods for increasing our knowledge of our world. For example, information gathered in this way is used for military intelligence, engineering surveys, measuring gravitational variations (geodesy), land use studies (geography), mineral and oil exploration (geology), soil moisture pattern studies (hydrology), sea state identification (oceanography), forest and timber management (forestry), soils and crops analysis (agronomy), and weather forecasting (meteorology).

The better known instruments for this purpose are image-forming sensors such as cameras, radars, and infrared detectors although more exotic systems may include radio-frequency receivers, seismometers, scintillation counters, magnetometers, gravity meters, or sonar. Military requirements have encouraged the development of such equipments and consequently the performance characteristics of certain specific items are of necessity classified. However, the fundamental principles of sensor operation are understood by many scientists so that technical specialists, including photogrammetrists, are showing much enthusiasm at the data collection potential envisioned by exploiting techniques of remote sensing. Multi-sensor collection systems are being developed so that a wide variety of sensitized detectors can be used to sample at selected portions of the electromagnetic spectrum to capitalize on object/scene characteristics while minimizing the adverse effects of energy losses due to scattering, absorption, and reflection.

The desire of every photogrammetrist is to have a wealth of information about his sensor to be able to recover all geometric elements necessary to perform his mensuration tasks. In addition to this geometric fidelity, high image quality is also desired so that interpretation can be readily accomplished. The KC-6A camera (Fairchild) is expected to be an outstanding mapping data collection instrument because much effort is going into providing recoverable image geometry without undue sacrifice of image quality. Another desirable feature for mapping cameras is a large field of view. A response to this condition is the ultra-wide angle lens most notable of which is the Wild Super-Aviogon. The general requirements for a research camera particularly useful for analytical photogrammetric work are being worked out by people at U. S. Army Engineer GIMRADA.

The military is working with multi-sensor collection systems for reconnaissance and surveillance. Two such systems include the Navy RA-5C (North American Aviation) and the Air Force RF-4C (McDonnell). For military mapping data collection, there is the much publicized Air Force AN-USQ-28 System (Kollsman).

Camera systems sensing in the visible part of the spectrum are those which are most familiar to us. There are the well known frame and strip cameras for mapping and reconnaissance with the panoramic camera receiving ever increasing attention. In addition to the normal grey scale continuous tone film, color film emulsions are being used for various applications. Normal color response films are used to give a more natural rendition of the scene, while "false" color emulsions are used to enhance image contrast for such applications as camouflage detection and plant identification. Some experimenters are achieving this "false" color product by special photographic printing of synchronously matched cameras exposing conventional panchromatic and infrared emulsions. Color photography has been of particular interest to the ASP during the past few years and a special technical committee is functioning to report activities and recommendations relative to color photography. Organizations working with color photography include U. S. Geological Survey, U. S. Coast and Geodetic Survey, U. S. Air Force, U. S. Forest Service, and National Bureau of Standards.

A very recent announcement from Aeroflex Laboratories has to do with a new approach to photographic recording called Multiplex-Recording Photography. A single unit of film

(one negative) is used to record useable multiple distinct images by separate scene exposures. The technique is said to be applicable to black and white as well as color emulsions with their usual photo processing procedures. Special film viewing equipment is used for image interpretation and analysis.

Multiband spectral photography is the technique of isolating and imaging objects in separate bands of the *photographic* spectrum by selecting matching film/filter combinations. Organizations doing work in multiband spectral reconnaissance include National Aeronautic and Space Administration, U. S. Air Force, U. S. Department of Agriculture, University of Michigan, University of California, Itek Corporation, and North American Aviation, Inc. (Columbus Division).

Texas Instruments is working on spectrophotometric techniques for the higher frequency gamma-ray region to study composition and moisture content of terrain materials.

Those working on ultra-violet sensing include University of Michigan, Texas Instruments, Barringer Research Ltd. of Canada, and Perkin Elmer.

Infrared sensing work is being done by Texas Instruments, HRB Singer, U. S. Geological Survey, U. S. Forest Service, and U. S. Coast and Geodetic Survey.

Experimental work is being done in passive microwave radiometry by North American Aviation, Inc. (Columbus Division), Sperry, Airborne Instruments Laboratory, Space General, and Even Knight.

Those working with image forming radar include Goodyear, Westinghouse, Raytheon, U. S. Army Engineer Waterways Experiment Station, U. S. Army Engineer GIMRADA, and University of Kansas.

Low light level television image intensification systems are being worked on by RCA, Baird Atomic, and Macklin.

In addition to these image-forming sensors, other airborne force-field sensors are used to collect more exploration data. Two such instruments are the magnetometer and the gravity meter. The airborne magnetometer has been used successfully for several years with the most recent development here being the alkali vapor magnetometer. Air Force Cambridge Research Laboratories has been working on the airborne gravity meter. The U. S. Geological Survey has performed geophysical studies using gravity measurements along with data from the airborne magnetometer.

The search continues for more accurate information about the location and orientation of the sensor at the time of data recording to facilitate data correlation and information extraction. Precision navigators are being developed along with altimeters and stabilized mounts. Inertial platforms are now being used to provide sensor location data while also serving as a verticality reference to yield useful camera attitude information. Fairchild Space and Defense Systems Division has announced their development of a unique autocollimator-verticality device for their new KC-6A mapping camera which works with Bell's inertial navigator in the AN/USQ-28 airborne collection system. Cubic Corp. has reported on their development work with SHIRAN airborne positioning equipment which is also a part of the AN/USQ-28 system. Concerning altimeters, DeHavilland of Canada continues to improve their airborne terrain profile recorder, and Aero Service has released encouraging information on the potential of their laser altimeter.

To make these auxiliary data have greater utility during data processing, encoding and recording techniques are being developed to image this data on the film together with the basic imagery. North American Aviation, Inc. Columbus, is doing important work in the areas of binary recording and automatic reading of this coded auxiliary flight data. Fairchild is also active in this field. The AN/USQ-28 system records auxiliary flight and correlation data on airborne magnetic tape.

Much really exciting work now is concerned with sensing from spacecraft. NASA has unmanned and manned exploration programs involving earth orbital missions, lunar survey, and planetary expeditions. These scientific missions are planned for implementation over the next 10 years and represent the future activity of many of this country's best technical minds. To develop systems which will operate and perform reliably in the harsh environment of space beyond the earth's atmosphere, is indeed a formidable challenge.

Though space sensing is receiving much publicity and attention, equally challenging work is being done to understand better the vast ocean areas of earth. The U. S. Navy and the Coast and Geodetic Survey are exploiting today's technology to help solve the varied and complex problems in oceanography. In addition to photography, perhaps the technical area of most unique benefit to the underwater world is sonar. The imaginative use of sound wave propagation through water has yielded much under sea knowledge and promises still more in the future.