Are Aerial Photographs Obsolete?[1]

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IN A recent thought-provoking paper* Abrams (1961) made much of the obsolescence of aerial photography. He suggested scrapping current procedures in aerial photographic operations and starting on a fresh approach combining radar, infrared, television, radio electronic computing and their allied technologies. It is difficult to believe that at this stage Abrams would completely abandon conventional aerial photography. His statements were doubtless intended to stimulate thought along avenues of research which have to date, with notable exceptions, received relatively little attention. We share his concern in this regard, but we cannot agree that research on new methods requires abandonment of techniques that have value and which in fact have not yet reached their full capability.

Obsolete implies that a second system, procedure, or machine 1) has replaced, or 2) is replacing a first. In the first context there is no argument, for aerial photographs have not been replaced. But if one takes the point of view that obsolete means "tending to become out of date" then there may be grounds for discussion with respect to conventional aerial photography. One must, however, define just what is becoming obsolete! Clearly Abrams refers to the *entire system* of procurement and processing, both physical and mental. He speaks of the gains to be made from widespread use of new sensing systems. These gains include all-weather capability and reduction in bulk of both instruments and recording media. Information content of the resulting records would be markedly increased and would be in a form suitable for automatic cataloguing, retrieval, and processing.

Goddard (this JOURNAL p. 88), however, is strongly of the opinion that a new system is not required, but that modifications of existing materials, equipment, and procedures will keep pace with the needs of changing times, although he recognizes that other sensing methods will contribute much information. In support of his views he cites the development of higher-speed materials, improvements being made in cameras, especially the panoramic cameras, improvement of stabilization, and other factors related to optical photography; he also notes some of the deficiencies of other sensing systems such as elaborate instrumentation required for certain radar operations. Thus we have opposing views, one suggesting that conventional aerial photographs are obsolete, the other stating that conventional aerial photographs are anything but obsolete. These two views are divergent because they are based on a consideration of an *entire system* for procuring and processing the photographic or sensing record. The general system is said to include the problems of weather, equipment, physical processing, and extraction of information.

We should like to examine only one part of the system of aerial photographic operations, namely the problem of information content and extraction of information. A full comparison of conventional aerial photographs with records of emission or reflection in the invisible part of the electromagnetic spectrum (in terms of information content) is unwarranted because with different energy wavelengths, different characteristics of materials (i.e., molecular makeup temperature etc.) strongly offect the record; different sensing records may result, such as the line records at short wavelengths, the continuum of tone change within the visible light range, and the broad band responses at long wavelengths. Thus, the information gathered and stored by each sensing system

* "Aerial photographs are obsolete" by Talbert Abrams, PHOTOGRAMMETRIC ENGINEERING, Vol. XXVII, no. 5, p. 691 (Dec. 1961).

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may be unique to that system or part of the spectrum, and cannot always be compared directly. Because of this, various systems should be used so as to complement and not replace each other. The information content of a high-resolution radar record, for example, may supplement that of a conventional aerial photograph, and the two records when used together may readily provide the solution to specific interpretation problems that would otherwise be difficult to resolve (see Frost, 1960, p. 787).

Yet it is felt that the conventional aerial photograph has an important contribution to make to the photo interpretation function, and we would like to examine this in a little more detail. Conventional aerial photographs, through selective-filter techniques, commonly record that part of the electromagnetic spectrum with wavelengths roughly between 500 and 650 millimicrons. This part of the spectrum includes a large part of the solar radiation, and thus conventional aerial photography makes use of a large source of natural energy, and may, under favorable weather conditions, achieve its record in the shortest possible exposure time. Hence, effects of image motion on the resultant record are minimized. Also, theoretically, the shorter the wavelength of recorded energy the greater the resolution attained. Fortunately conventional aerial photography uses the shortest wavelengths of light not significantly affected by atmospheric absorption and scattering. Thus conventional aerial photography is a superb medium for recording the shape of parts of the Earth's surface in the minimum exposure time.

Also, as Craig has so clearly shown (1961) the resolution and hence storage capability (information transfer rate) of the photographic film far exceeds that of any other form of data recording. Thus from the standpoint of data storage per unit area, as well as the production of a record of the shape of parts of the Earth's surface, conventional aerial photography remains unchallenged. Data initially recorded on conventional photography, moreover are as amenable to sophisticated techniques of storage, handling, and transmittal as data recorded by other sensing instruments. For example, photographs of the back side of the Moon were scanned, transmitted, processed, and stored by such techniques.

Yet, while "shape" is an important interpretation criterion, others may be equally significant. Photographic tone and tone contrast, as is well known, form the fundamental basis for interpretation of conventional aerial photographs, and it is here that modification of existing data-gathering procedures and development of new interpretation methods hold a wealth of promise. Foremost among procedures that will greatly enhance the usefulness of conventional aerial photographs are microdensitometer methods, particularly when automated. Little work has been done in this field but some progress is being made. Fischer (see Ray and Fischer, 1960, p. 148) has used microdensitometer traces taken from conventional black-and-white aerial photographs to differentiate or correlate certain landform information. Color photographs have been treated in a similar manner to differentiate certain rock types (Fischer, this JOURNAL p. 133). Working along somewhat related lines, Rosenfeld, using a flying-spot scanner to measure frequency of tone contrast on conventional aerial photographs, has related resultant video traces to basic terrain types with the thought that characteristic curves representing the "texture" of terrain types might be developed. For visual interpretation of tone contrasts, electronic image-enhancement devices will permit a greater amount of information to be extracted from conventional aerial photographs (see Coleman, 1960, p. 758–760; Fischer, this JOURNAL, p. 133).

Even the interpretation criterion of "shape," which the conventional aerial photograph is so admirably designed to portray, may be amenable to rapid automated processing in the future. Murray (1961) has reported on simple tests for automatic recognition of visual patterns using the MARK I Perceptron, one of the " . . . neural net type of 'intelligent' machines. . . . " (Murray, 1961, p. 627) capable of perceiving and recognizing patterns. The automatic recognition of basic terrain types is believed by Rosenfeld (this JOURNAL, p. 115) to depend on the presence of certain geometrical figures as well as on characteristic "texture." The development of new data-handling and interpretation procedures together with refinements in existing photography that will give greater resolution, tone contrast, and sharpness (see Colwell, 1959) presage an even greater role for conventional aerial photography than heretofore. Of course we should not overlook the fact that conventional aerial photography will become considerably more useful as we learn more about the fundamental spectral reflectance characteristics of different materials.

It is equally clear, however, that other sensing systems can provide a wealth of information for the interpreter. This information, additional to that generally recorded by conventional aerial photographic procedures, is obtainable because of the fundamental differences in the manner in which materials respond to spectral energy wavelengths below and above the visible spectrum.

If a crude analogy may be permitted, the data recorded in different parts of the electromagnetic spectrum might be likened to the lines of an x-ray diffraction pattern or lines of a spectrogram. Some one or two lines of the pattern may give important information, but the entire combination of lines is commonly required to identify, recognize, or interpret a certain material. These "lines" or bits of information collected from the gamut of the electromagnetic spectrum obviously come from the visible as well as from the infrared, microwave, and other parts of the spectrum. For one interpretation problem the infrared record may provide the "strong lines" in the pattern, but for another problem these "lines" may come from conventional aerial photographs. It thus seems clear that for the photo interpretation function, conventional aerial photography is not obsolete. But it is equally clear that neither conventional aerial photography nor any other sensing record, to the exclusion of others, is necessarily the best answer to the data-gathering and interpretation procedure. On *technical grounds* conventional aerial photography remains on a firm footing for the photo interpretation as well as for the photogrammetric function. While research in new sensing systems is a natural and logical extension of photo interpretation investigations, these newer techniques cannot *solely on technical grounds* replace conventional aerial photographs. Only on *economic grounds*, when the systems approach to aerial photographic operations is considered, could conventional aerial photography become obsolete.

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Underwater Microcontouring

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Abstract: *Using vertically mounted deep-sea cameras, stereo pairs of photographs of the ocean bottom have been obtained. The camera axes were separated by a known distance sufficient to provide a three-dimensional model resulting in stereo photographs that could be used in conventional stereographic plotting instruments. A "microbathymetric chart" can thus be contoured at an interval of a few millimeters. Because the geometry of the system is known, the technique also results in an accurate determination of the height of the cameras above the bottom at the time the photographs were made. The technique holds promise as a means of quantitative evaluation of bottom roughness and as an additional parameter in bottom sediment studies.*

A new assault has been made on the unexplored regions beneath the surface of the oceans which cover two-thirds of our world.

The Coast and Geodetic Survey, using cameras developed by Edgerton, Germeshausen, and Greer, has added to its research