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Improving Quality of Aerial Color Prints

Their modestly higher photographic expense can be saved many times over in reduced cost of the overall project

AERIAL COLOR PHOTOGRAPHY, which was virtually unheard of ten years ago, and up to recently was still a specialized technique of interest to only a few, is now becoming more and more important in many fields of photogrammetry. The reason is simple: color can potentially present much more useful photographic information than black-and-white film. The increase in information content, in fact, is such that many photogrammetrists foresee a substantial reduction in ground surveying by field men, with cost savings far exceeding the greater expense of the film itself.

Since improved information content is the primary objective, color prints of aerial film must contain as much of the information available in the negatives as is technically possible. Just as in printing black-and-white film for interpretation, it is self-defeating to capture information in the negative and lose it on the way to the print. Electronic printers made by LogEtronics Inc., Springfield, Va. have been used for many years to enhance photographic detail in black-and-white aerial film through automatic exposure that compensates for varying density ranges in the negative. Recently, LogEtronics introduced the Mark III Color Contact Printer, which also applies incremental exposure control in making tone-matched color prints, color diapositive plates and positive color transparencies. The same scanning-beam modulation used in LogEtronics black-and-white printers automatically corrects for dense, thin or normal negatives to bring out full detail in highlight, shadow and midtone areas of color prints. The first prototype Mark III printer was installed at Color Technique in June, 1967 for field evaluation of both photographic quality and operating characteristics and has since been in almost constant use. The Mark III printer is the successor to the original LogEtronics color printer first used by the Coast and Geodetic Survey in 1965.

MAJOR APPLICATION AREAS

Forestry and geological surveying were the first users of photogrammetry to work with color prints. Several men in these fields have for some time been advocating the use of color as a means of obtaining information that could not be found in black-and-white prints. For example, study of color prints can differentiate between evergreen and deciduous trees and can detect the presence and extent of disease at the tips of branches. In geological surveys, color reveals structural strengths and weaknesses that are not visible in black-and-white prints. Often color simply permits more accurate identification of surface detail. In Pennsylvania, for example, existing survey maps based on black-and-white aerial film had always identified a cer-

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The Color Photo on the Front Cover

shows part of Glacier Park, Montana as seen from 17,000 feet. Taken with a Wild RC-8 camera by Montana State Hwy. Dept. on Aero Ektachrome Type 2448 processed to a negative and printed by Color Technique Inc. with a LogEtronics Mark III Color Printer.

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tain iregular line as a stream. A subsequent color survey showed that this line was actually an abandoned railroad track.

Aerial color prints have today become widely used in many other application areas; among these are highway planning, mineral deposits, air pollution, water pollution, bulk inventory control, urban renewal and even downtown parking studies. In water pollution control, black-and-white film reveals very little information about water. In contrast, color infrared film emphasizes the difference in color corresponding to various depths of coastal waters. This color film not only indicates the degree of pollution but helps in identifying the type of pollution and in tracing it to its source.

In bulk inventory control, iron ore and manganese appear identical in black-and-white prints but quite different in color prints. Aerial studies for urban renewal identify types of houses, drainage and condition of buildings far better in color. In parking studies, aerial photos are exposed at regular intervals during the day, both vertically and obliquely. Color prints not only indicate the color of cars, but their sizes and color of license plates for identifying states.

Problems in Conventional Color Prints

Conventional color printing methods involve two technical problems which together can handicap the value of aerial color. First, the limitations of existing anti-vignetting filters mean that vignetting must often be compensated for in the printing process. Secondly, the inherent lack of control over lighting conditions from exposure to exposure in aerial photography requires density control in printing both for tone-matching multiple exposures on a flight line and for enhancing detail in highlight and shadow areas.

Anti-vignetting filters, which are necessary on all aerial cameras because of their short focal lengths, are balanced for $f/8$ exposure. With the films used today, however, most exposures are made at $f/5.6$, in addition to the fact that vignetting usually varies with conditions along the flight line. Since it can be expected to be some time before adjustable anti-vignetting filters are available to compensate for all conditions, some dodging is needed in the printing process to balance out densities at the center and edges of the print. In addition to matching the contrast range from frame to frame, light differences between one area and another on the ground—shadow to light from valley to hilltop—indicate the need for gross contrast control within a frame in order to insure maximum photographic detail.

Conventional color printing methods are seriously limited in compensating for both gross and detail density variations. Automatic strip printers, in which a projection bulb is a constant light source, can only be used with a near-perfect anti-vignetting filter or the resulting print is virtually unusable. Hand dodging to compensate for vignetting is only partly successful in that it is virtually impossible to compensate properly for the gradual density changes.

Before receiving the LogEtronics contact printer, Color Technique for eight years produced paper color prints in a multiple-light printer. The technician attempted to adjust for vignetting and point-to-point contrast variation by switching light sources on and off. However, the variations in light intensity also changed the color quality, so that the dodging process was often a long, tedious task. A test print was exposed and sent to the lab for processing, with perhaps a two-hour wait to check the result before making an adjustment for the next test print. It was not unusual to make five or six test prints before finding an acceptable combination of exposing lights. It was often two or three days between receiving rolls of flight-line film and shipping color prints.

Color printing with constant light sources can also necessitate making more than one print at different exposure times in order to obtain optimum density ranges for studying different parts of the print. For example, not long ago a state highway department had to make four separate prints of a hillside in order to obtain adequate information on water flow patterns affecting landslide potential.

Since about 90 percent of aerial color prints processed at Color Technique had to be dodged, there was a clear need for an improvement in the printing process: better exposure control, reduced technician time per print, and faster delivery to customers.

The LogEtronic Color Printer

The LogEtronics Mark III Color Contact Printer (Figure 1) accepts color negative rolls or cut sheets up to 10 by 10 inches; the printing light consists of a modulated scanning beam on a special tri-color phosphor cathode-ray tube. The printing paper is automatically advanced while the printer operator positions the negatives on the feed spools. Two types of

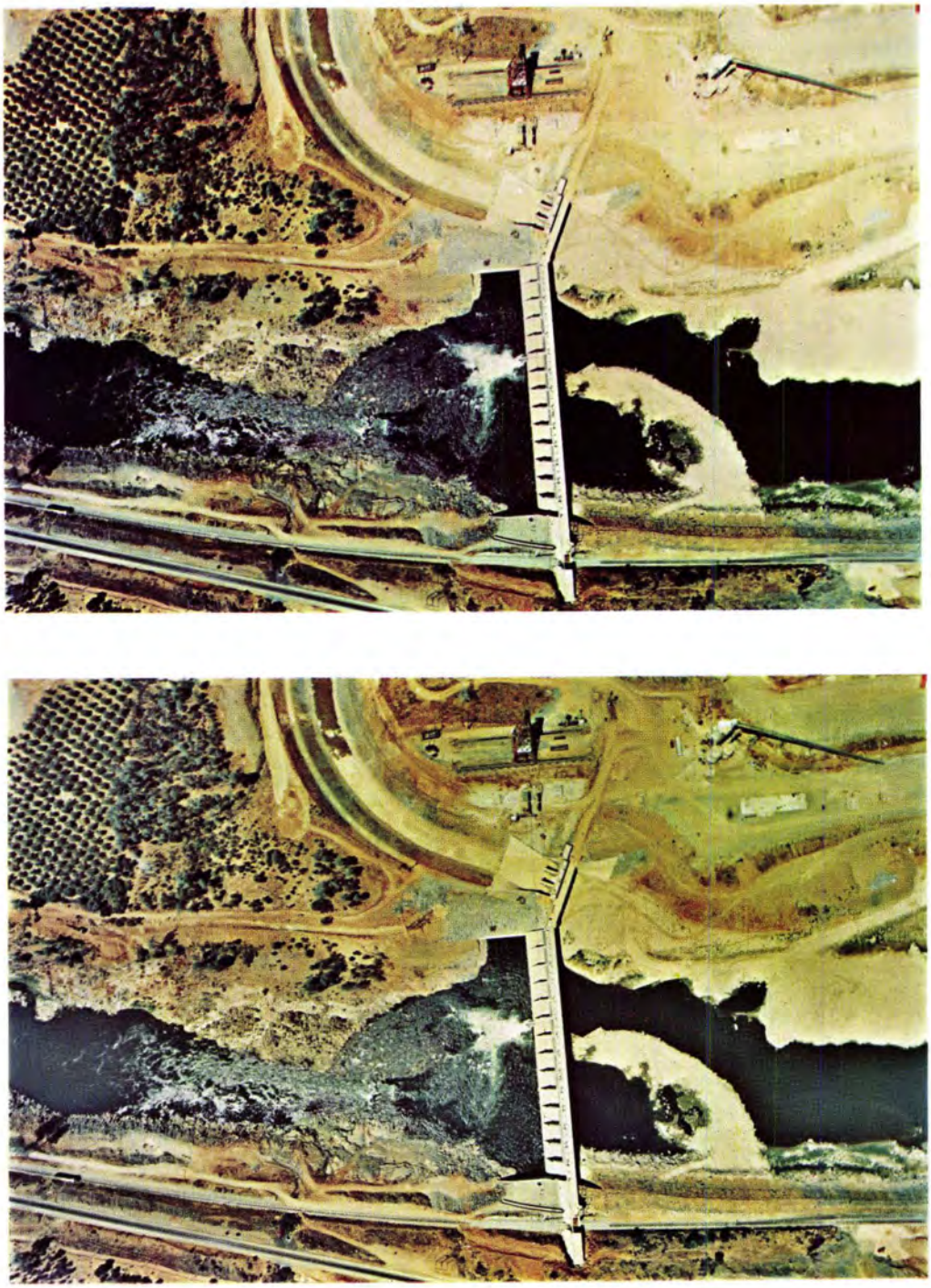

PLATE 1. The upper print was made with a constant-source light whereas the lower print was made with the LogEtronics Mark III Color Contact printer. (Courtesy U. S. Geological Survey, Menlo Park, Calif.)

FIG. 1. The LogEtronics Mark III Color Contact Printer contains a printing light consisting of a modulated scanning beam on a special tri-color phosphor cathode-ray tube.

film are used: Aero Ektachrome Type 2448 processed to a negative and Aero Infrared Ektachrome Type 8443 for such applications as water pollution control, forestry, and plant studies. Standard printing paper is Ektacolor or Ektachrome Professional Paper.

The printing procedure with the new LogEtronics color printer begins with making test prints with a basic filter pack, consisting of an 80 magenta filter and a 70 yellow filter. One test print out of a group of four or five $9\frac{1}{2}$ by $9\frac{1}{2}$-inch exposures is adequate; for a flight-line roll of perhaps 125 exposures, a test print might be made of every fifth negative.

The color technician then looks for a neutral color point in the test prints as a reference for color balancing. Usual procedure is to use an asphalt or a cement highway as reference, if available, although reflection from a blue sky or the green of forestry and surrounding terrain must often be considered. After jotting down the necessary filter changes from the basic pack, (say, +30 yellow and −10 magenta), the operator adjusts the filters and runs a second series of prints of the same negatives. After he himself approves the second set of test prints (with a carefully trained operator, virtually always on the first try), the technician obtains his supervisor's approval before running the final prints. The supervisor's approval has been found useful because he knows best the specific requirements of the particular user, and these requirements can vary widely among the many branches of science which make use of photogrammetry. Thus, while the technician may find the test prints photographically acceptable, it is possible that they may not be acceptable for the user's special information needs.

Exposure time on the LogEtronics printer varies from 12 to 30 seconds on paper, although glass diapositives for stereo plotting take somewhat longer. Once the scanning density (number of scans per inch) and photomultiplier tube setting on the printer have been established, there are no changes that have to be made between series of aerial exposures except for the filters. Since there is rarely any need to go beyond the second set of test prints, the run on final color prints usually begins on the same day the negatives are developed.

Automatic exposure control in the printer and elimination of repeated test prints after the second permit the color technician to produce three to four times as many exposure-controlled prints as he was able to do with multiple-light contact printers. At the same time, of course, the laboratory is able to provide substantially faster service to its clients.

COMPARISON OF INFORMATION DETAIL

The difference in information detail between constant-source color prints and LogEtronics color prints can be seen in Plate 1 (of course, within the limitations in detail reproduction of color printing itself). The constant-source print at top provides acceptable detail reproduction in the midtone areas, but considerable loss in detail is evident in the shadow areas. The pale, fogged appearance of the edges due to vignetting has substantially reduced the value of these parts of the print.

In the LogEtronics print below, on the other hand, point-to-point exposure control has provided more light exposure of the print in the shadow areas and, in addition, has virtually eliminated the vignetting effect. Comparison of the LogEtronic print with a print produced in a multiple-light printer would indicate a somewhat less dramatic difference in photographic detail, but there would still be considerably more information in the LogEtronic print and it would have been obtained with a far smaller investment of the technician's time. (See also photo on front cover).

Economics of High-Quality Color Prints

There is no question that color prints at first appear to be substantially more expensive than equivalent black-and-white prints. Potential users of color prints, however, must evaluate their economics in terms of the overall project cost, rather than the photographic budget alone. The film itself costs about four times as much, the processing about five times as much ($75 versus $15 for 25 feet of film), and the color prints cost about twice as much. The difference in costs of color prints and black-and-white prints is actually a very small portion of the full cost of maintaining the aircraft and crew required to acquire the picture. Furthermore, if a color print reveals critical detail information that otherwise would have had to be obtained by field men on the ground, then the resulting saving in the time of ground personnel must also be accounted for in comparing the real values of black-and-white and color aerial prints.

In the author's experience, many professional and scientific groups that are using photogrammetry are gradually becoming convinced that the higher photographic expense of high-quality color prints can be saved many times over in reduced cost of the overall project. In addition, any shift in the information gathering function from ground inspection to the aerial camera can substantially increase the pace of the project itself.