A brief verbal description of each subsection was included in relocation study reports. To illustrate, the following is quoted from a report describing the subsection shown in Figure 9. "Two recommended bands for detail study are indicated at the Palermo cutoff. The first, labeled *B-1*, consists of a series of three widenings and one 2,500-foot cut-off located 300 feet south of the main village. This band traverses two granular soils areas which may yield suitable borrow. Band *B-2* a wide sweeping curve located 1,000 feet south of the village, would require 8,000 feet of new construction, of which 400 feet is through a shallow swamp and about 3,000 feet is over ledge terrain. The southern edge of the band skirts a very deep bog and the northern boundary is limited by a cemetery. Based on terrain considerations only, the northern portion of Band *B-2* is preferred. A wash plain containing an operable pit is located less than 2 miles from the west end of the project (Photos SHC-2, 115610 #38, 39, and 40)."

Conclusion

Airphoto interpretation techniques are especially useful for highway engineering terrain studies in wilderness areas where little or no detailed information on geology or soils is available. In Maine, time-consuming and expensive field reconnaissance surveys were reduced to a minimum by the intelligent use of aerial photography. Detailed field investigation and laboratory testing is still required to obtain information for final design purposes, especially in critical areas. The Maine State Highway Commission has successfully employed airphoto interpretation techniques for obtaining a variety of information valuable in various phases of highway engineering.

The four types of strip-studies described in this paper are only a few of many possible applications of this field. It is highly probable that more intensive and specialized photo interpretation studies will be made in the near future in Maine as well as throughout the nation.

Reconsideration of the Quadruple Camera

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ABSTRACT: *The quadruple camera, least popular of all camera aggregates, is reexamined under the new light thrown by analytical aerial triangulation, and is compared to vertical or convergent systems. The conclusion is reached that this tool may possibly offer significant advantages of economy, accuracy, or easy availability. Further investigation of the matter is suggested, particularly by camera designers and executives who have available all the elements of appreciation.*

WHAT follows refers primarily to mapping with near-vertical photography and aerial triangulation.

Two convergent aerial cameras, tandem mounted in an airplane (Figure 1) and synchronized, constitute practically the equivalent of a quadruple camera. Close tolerances in the mutual relationships of the four camera cones are quite useless. If there is a common mount, as is desirable but not indispensable, then a fore-fore-aft-aft sequence of the cones should yield a very compact setup.

The total coverage of such an aggregate, for example, can be made equal to the coverage of a standard $f=6''$-$9''\times 9''$ camera. The angular field of each component is then about 62°, as against 94° for the whole system. Longitudinal and transversal tilts of the camera axes are about 15°.

It is obvious that lens designers and camera

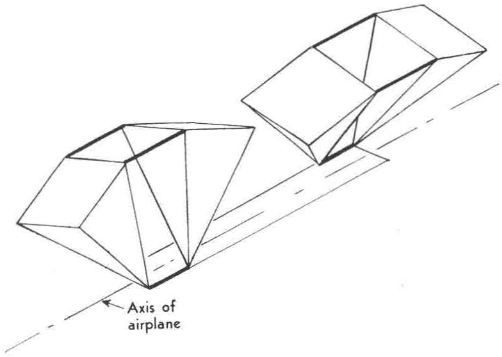

FIG. 1. Perspective view of two convergent cameras tandem mounted.

manufacturers can build f: 5.6-62° cameras having a much better angular accuracy than a f: 5.6-94° camera produced under similar conditions. It is not unreasonable to assume that it might perhaps be 1.8 times better. For instance, no 94° lens is known which secures in the real corners of the photographs such resolution and contrast as to leave emulsion granularity predominate. Considerable improvement can be expected with 62° lenses, in this respect and in others.

Assuming further 10.5″ for the focal-length of the 9″×9″, 62° cameras, this should permit flying 1.6 times higher than with the 94° camera, interpretability and local accuracy remaining practically the same in the model corners. Figure 2 illustrates at the left, the geometry with the standard camera, and at the right, the geometry with the quadruple aggregate.

As a result of the much stronger resections and intersections secured by the quadruple aggregate, about *2.5 times less ground-control* and *1.5 times less aerial triangulation hours* should be necessary.

On the other hand, a *larger camera system* would have to be carried *higher* by the airplane, and there would be about *1.5 times as much film* needed.

However, the *flying time over the area to be mapped* would be *1.6 times shorter,* and the area which could be photographed with *one load of the magazines 2.5 times larger.*

It is left to unprejudiced executives to state whether or not the savings in flying time, ground-control, and triangulation time would be outweighed by those costs which happen to be higher. Just as well, it is left to experienced lens and camera designers to say whether or not the basic assumption might be fulfilled. A partial fulfillment may already be of real interest. Other advantages than economy might be aimed at, such as *higher accuracy*

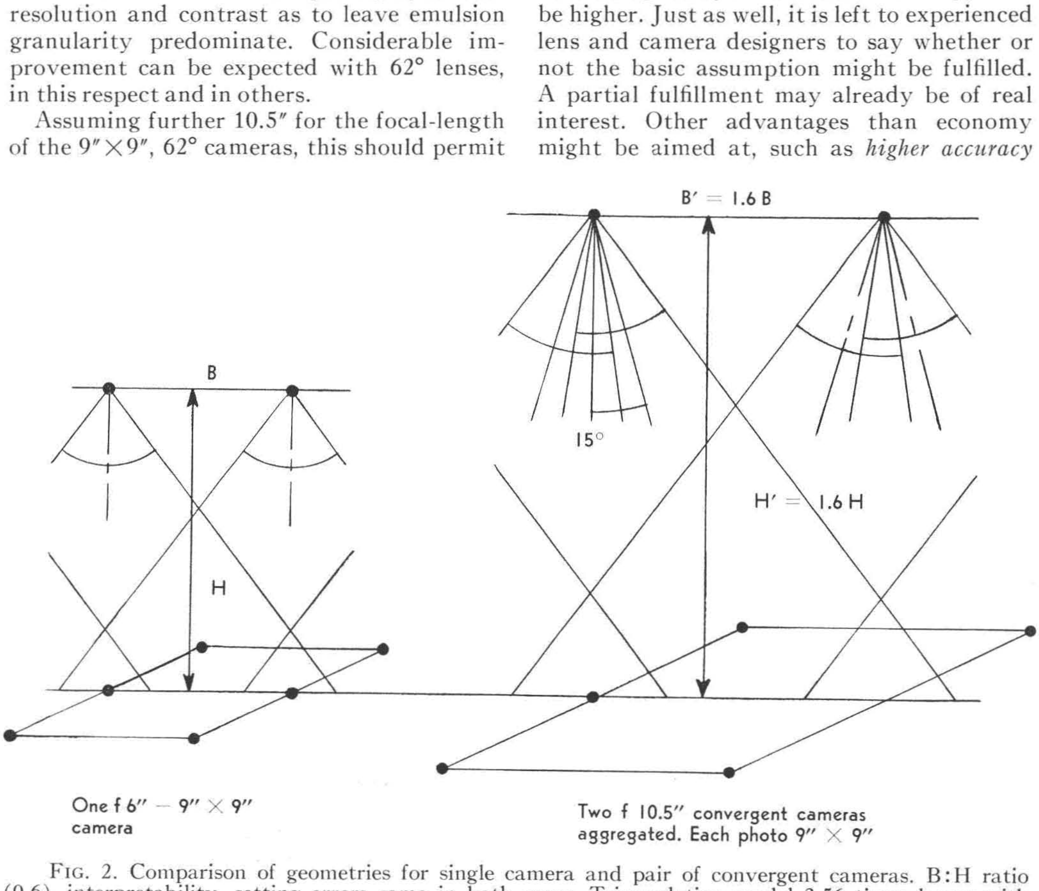

FIG. 2. Comparison of geometries for single camera and pair of convergent cameras. B:H ratio (0.6), interpretability, setting errors same in both cases. Triangulation model 2.56 times larger with aggregate, compilation model 1.28 times.

or *freedom from industrial barriers.* Varying the field-angle, aperture, focal-length, picture size and shape seems to make possible challenging combinations.

To make a long story short, two remarks only will be added:

(1) Taking as term of reference, on the left side of Figure 2, a $f=6''$-$9''\times 9''$ *convergent* camera instead of the single $f=6''$-$9''\times 9''$ camera does not change the main conclusions significantly. One has to fly so much lower in order to secure adequate stereoscopic interpretability and the accuracy of the settings in the critical model corners,* that all the advantage that better intersection angles secure over worse scale transfer angles, and weakened stereoscopic settings, is lost again.‡

(2) The traditional doubts about accuracy and cost of handling *composite* photography are no longer justified. With extensive calibration areas available, and doing aerial triangulation on stereocomparator and electronic computer, the actual (random) inner geometrical relationships of multilens aggregates can be taken into account in a matter of seconds per pass point, with extreme accuracy. A condition for this is however using a flexible and economical method of computation, like the one recently developed for the Royal McBee LGP-30 electronic computer. As for plotting when a quadruple aggregate is used, each triangulated model happens precisely to be conveniently halved.

* A map cannot be trusted better than its systematically worse sections.

‡ W. A. Brucklacher, Bildmessung & Luftbildwesen, July 1956.

A System for Projecting Prints for Controlled Mosaics on Steep Slopes[1]

CORTLAND P. LOHR,
and
WM. WADE

INTRODUCTION

SINCE many difficulties arise in the construction of mosaics, due to photographic distortion and differences in scale between the individual photos, many methods have been tried to overcome them. Even when a radial template laydown has been made and a number of control points have been obtained in correct geodetic positions and with correct scale and distances between them, there still remains the difficulty of making projection prints so that the points on these prints will exactly fit all of the control points, to say nothing of portions of the prints which may be distorted between control points. It may be said that no mosaic can be made with complete accuracy if there are many changes of elevation in the area photographed, without using an exorbitant number of control points.

A method has been developed by the U. S. Geological Survey for making prints which are free of distortion, by a series of photographic strip exposures made in conjunction with a stereoscopic plotting instrument. (See *Development of the Orthophotoscope*, PHOTOGRAMMETRIC ENGINEERING, *September 1955, Page 529.*) It is a remarkably ingenious method, but in its present state of development the cost of prints is so fantastically high that it is impractical to use the prints for the great majority of mosaics. Improvements in the future may make this method less costly. It has the advantage of rectifying all portions of a photo-model instead of only a few controlled portions.

[1] This method was developed by Cortland P. Lohr and described by Wm. Wade, both of the Cartographic Unit, Soil Conservation Service, Portland, Oregon.