A Cessna 185 airplane was recently purchased, and a Kargl converted K17 camera is being installed. It is expected all aerial photography in the future will be taken by and processed within the Department, thus making the Photogrammetric Division self-contained.

USE OF PHOTOGRAMMETRIC AND ELECTRONIC PROCESSES BY THE INDIANA STATE HIGHWAY COMMISSION

In November 1959, approval was given for the organization of the Bureau of Photogrammetric and Electronic Processes within the Construction Division of the State Highway Department of Indiana. An aerial photographic laboratory had already been set up in 1956. The new Bureau had as its responsiblity the performance or supervision of the following:

1. All aerial photography, either vertical or oblique, and requisite laboratory work of processing, printing, enlargement, mosaic preparation, and graphic arts reproduction associated therewith;
2. Any ground photography of a special nature requested by personnel of the Central Office, wherein the nature of the assignment justifies the services of a qualified photographer and the use of professional equipment;
3. The performance of any graphic arts, photostat or photographic copy work possible within the scope of the equipment and facilities of the photographic laboratory;
4. The preparation by photogrammetric methods of any topographic or planimetric reconnaissance or design maps using the Kelsh stereoscopic plotters;
5. Preparation, development, utilization, or modification of computer programs, and their application and processing in the IBM 650 computing equipment, for use in the design and construction of roads and bridges, traffic studies, route location, etc.
6. The maintenance of a complete file of the latest available aerial photographic coverage of the 92 counties of the State, as acquired from the Agricultural Stabilization and Conservation Service (ASCS) of the U. S. Department of Agriculture.

Equipment

The Bureau maintains a 1956 Piper Apache PA-23 (5 place, twin engine) modified for vertical camera equipment and oxygen equipped. Among the cameras are one each of a K-17C 6-in. Metrogon f/6.3; a K-17B 12-in. Aerostigmat f/5.0; a F-56 8¼-in. B&L Altimar f/4.0; a Speed Graphic 4 by 5 162-mm Optar f/4.5, 90-mm Raptar wide angle f/6.8; and Calumet view 4 by 5 135-mm Schneider Symmar f/5, 90-mm Schneider Super-Angulon f/8. Darkroom equipment includes cut-film dryers, various printers and enlargers, and a camera test bench. Sinks and tanks are, wherever possible, stainless steel to minimize corrosion. The three darkrooms are equipped with Kodak Utility Model Safelights and appropriate filters.

Laboratory Personnel

In early 1957 an engineer of Photogrammetry was engaged to direct procurement of equipment and supplies and to initiate operation of the photographic laboratory. Subsequently, four highway technicians and a photographic laboratory supervisor were hired. The maximum number of employees was reached in early 1961 when the laboratory employed a total of 13.

Outline of Procedures

1. A single strip reconnaissance flight at a 1,600 ft to 1-in. scale will give a 14,400-ft width of coverage, and 3 sidelapped flights at an 800 ft to 1-in. scale will give

a width of 18,000 ft. Considerably more work is involved in providing the latter coverage. It is, therefore, suggested that for expediency and economy the 1,600 ft to 1-in. contact scale photography be used wherever possible. Supplemental photography for mapping special areas or conditions requiring a ratio of enlargement beyond that possible at the 1,600 ft to 1-in. scale can be taken at the same time, at either 800 or 400 ft to 1-in. scale, provided such requirements are clearly stipulated at the time reconnaissance survey photography is requested. Normally, reconnaissance survey photography is not too critical with regard to foliage and vegetation, but if such is objectionable, it must be taken when foliage and vegetation are not present.

2. The Planning or Location Department should be provided with 9 by 9-in. contact stereoscopic points, a photographic index and a 24- by 36-in. uncontrolled mosaic at the scale of 800 ft to 1 in., compiled from the photography. If sufficiently current and acceptable ASCS photography is available, contact scale prints and photographic indexes can be obtained from this agency without reconnaissance flight photography. Any photography intended for eventual mapping in the Kelsh stereoplotters must be taken with one 6-in. focal length aerial camera, because the stereoplotters are equipped to handle only such photography.

3. Planning or Location Department uses 9- by 9-in. contact scale stereoscopic coverage, 24- by 36-in. photographic mosaics, U. S. Coast and Geodetic Survey quadrangle size topographic maps, ASCS photography coverage, etc., in route location surveys. If topographic maps issued by the various Federal agencies are not available or do not particularly suit the needs for intelligent determination and comparison of route alternatives, the Planning or Location Department may have to request the preparation of topographic maps of the area involved by the photogrammetric instrument operation section. These maps could be compiled from the 1,600 ft to 1-in. scale reconnaissance photography taken with a 6-in. focal length aerial camera and using the requisite horizontal and vertical control. Such photography makes it possible to delineate contours at an interval of 10 ft at a map manuscript scale of approximately 400 ft to 1 in. If a pertinent area only need be mapped, instead of the entire photography coverage area, considerable time could be saved in the preparation of such reconnaissance-type maps. With this exception, and that of compiling topographic maps for bridge design, contours will not be delineated in any mapping accomplished by photogrammetric methods.

When the most feasible route location has been determined, the Location Department will order one of its survey parties into the field to stake the highway centerline designed on this route and to establish horizontal and vertical control for photogrammetric mapping. The survey party shall obtain all other pertinent and essential information, with the exception of measuring cross-sections and the recording of any topography that would be visible in aerial photography. At this stage the survey party may find it necessary to adjust the alignment given to them by the locating engineer. They will also note any detail of consequence required by the Design or Construction Departments that would not be visible in the aerial photography, such as pipelines, box culverts, underground drainage, utilities, property lines, and property owners. After inspection and approval by the location engineer, the complete notes of all field surveying shall be furnished to the Photogrammetry Section, along with a flight plan map or aerial photographic mosaic on which the staked alignment has been accurately plotted using plane coordinates.

4. The Kelsh stereoscopic plotter section will set targets on all horizontal control points and required centerline points that will be visible and identifiable on the large-scale photography.

5. A single low level flight will be made over staked and targeted centerline, and vertical photography will be taken at the scale of 250 ft to 1 in., providing a strip band of coverage 2,250 ft wide. Planimetric maps will be compiled at the design scale of 50 ft to 1 in. This scale, which requires considerably more photographs, photographic laboratory work, field control surveys, and stereoplotting than would a scale of 100 ft to 1 in., is justified by the increased accuracy attainable in the subsequent measuring of centerline profile and cross-sections and the stereoplotting of planimetric detail.

This aerial photography flight must be made when foliage and vegetation are not present, unless their presence is of so little significance that they would not seriously

affect accurate delineation of planimetry and measurement of the ground surface. In the latter instance, this photography flight could be made at any time the weather permits, but the locating engineer's survey party would have to provide cross-section data and topography information in areas of foliage or vegetation where such would prevent accurate use of the stereoscopic plotter. In either instance, this photography flight should be made as soon after the survey staking and ground targeting of the centerline hubs and horizontal control points as possible so that the targets will be conspicuously clean and visible on the photography.

6. The Kelsh stereoscopic plotter section must be provided with a photographic index of 9- by 9-in. contact prints and glass transparencies of the 250 ft to 1-in. scale photography.

7. The stereoscopic plotter section then obtains the minimum necessary vertical control, not to exceed six points for each stereomodel, to be used in the photogrammetric operations.

8. The stereoscopic plotter section prepares a 50 ft to 1-in. scale planimetric strip map, in 24-in. width roll form, on dimensionally stable material. The minimum width of mapping each side of the highway centerline is determined by the Location and Design Departments and such width is controlled by the right-of-way required and proximity damage or by the maximum cross-section dimensions of the roadway and roadside developments.

Planimetry on the maps will be complete in all details, indicating distances along and out from centerline of all objects such as trees, buildings and other existing structures, drainage features, fence and property lines, property owners, and any other information needed by the design engineers in designing the highway and preparing construction plan-profile sheets.

If the design engineers prefer to have map planimetry furnished at a scale of 100 ft to 1 in., particularly in rural areas, accurate laboratory reduction of the 50 ft to 1-in. scale mapping can readily be provided, or any portion may be enlarged to a scale of 25 ft to 1 in. Because of the considerable photographic laboratory work involved in this reduction or enlargement, the 50 ft to 1-in. map scale should be used wherever possible.

9. Immediately following completion of the planimetry compilation and establishment of centerline stations and plus points necessary for photogrammetric measurement of cross-section data, spot elevations along centerline and perpendicular thereto along cross-section lines will be measured directly from each stereoscopic model and recorded in such form as may be required by the Design Department and the Electronic Computation Section.

10. All data will be furnished the Design Department for use in design and preparation of construction plan-profile and cross-section sheets. The dimensional data will also be furnished to the electronic computer section for the preparation of the first group of punched cards of centerline profile and cross-sections.

11. As soon as the Design Department has established highway centerline grades on the profile, controlling elevations of the grade lines will be furnished to the Computer Section in such form as they may require for the preparation of the second set of punched cards based on the established grades, which, when processed with the first set containing existing ground data, will result in the computation of earthwork quantities. Several trial attempts may be required in this procedure before the highway gradient can be established.

12. Until such time as there is electronic plotting equipment, plotted cross-sections, if required, will have to be provided by the Design Department. Plotted cross-sections are not required for computation of earthwork quantities. If they are expected as part of the construction plans by the construction forces and by the contracting organizations, they will have to be plotted by conventional methods.

13. The same general procedures are applicable in furnishing aerial photography, in compiling topographic maps, and in electronic computing for location and design of bridges by the Bridge Design Department. The same 50 ft to 1-in. scale maps compiled from the 250 ft to 1-in. scale photography can be accurately enlarged to the 30 ft to 1-in. scale customarily employed in bridge design. To provide a plotting scale of

30 ft to 1 in. directly on map manuscripts under the stereoscopic plotter would entail use of a flight height of only 900 ft above the ground. Over exceedingly rough topography and throughout urban areas where air traffic is heavy, this flight height would impose a serious safety problem. Wherever relief within each stereoscopic model does not exceed 220 ft, the flight height must, in all cases, not be less than four times the height of relief that will appear in each successive stereoscopic model to be used in photogrammetrically compiling maps and in measuring profile and cross-sections. Location conditions will, therefore, determine the photogrammetric methods by which the 30 ft to 1-in. scale maps can be provided.

14. After construction has been completed, photogrammetry and electronic computation can again be employed in the determination of as-constructed pay quantities. Photography taken for this purpose would also provide a photographic record of the project as constructed for future reference.

15. Additional Services:

a. Electronic computation, in addition to computing earthwork quantities without the necessity of plotting cross-sections, has a limitless field of application in design and in solving construction problems, such as designing vertical and horizontal alignment, making traverse computations, determining profile grades, making ditch grade analysis, designing interchange ramp profiles, accomplishing horizontal and vertical curve computations, ascertaining bridge geometry, and completing all phases of design, making traffic analysis, computing right-of-way metes and bounds descriptions, and making bid tabulations. Actual production is now being accomplished on several of these applications.

b. On completion of right-of-way plans by the Design Department, photographic mosaics can be assembled, copied, and printed from the reconnaissance, ASCS, or special photography.

c. Special aerial photography, either vertical or oblique, can be provided for such usage as right-of-way delineation and evaluation, traffic analysis, interchange design, borrow pit quantity determinations, maintenance, soils and drainage determinations, route location determinations, preliminary survey of selected route, and illustration and public information.

Right-of-Way Photographic Mosaic Requirements

For each right-of-way project, one set of photographic film reproduction negatives, 24 by 36 in. each, of an aerial uncontrolled photographic mosaic is required at a scale of 400 ft to 1-in. in rural areas and at a scale of 100 ft to 1-in. in urban areas. Said negatives shall be prepared on a continuous tone or lithographic emulsion coated polyester film base material, shall be direct reading with the emulsion side down, and shall have a matte or other surface on the top or direct reading side on which black opaque ink may be readily applied and retained without chipping or flaking under continued use. The acceptance by the State of this material, such as DuPont Cronaflex, shall be conditioned by the ability of the engineer to provide, to the satisfaction of the State, a rendition of tonal gradation on such material which will produce quality blue prints from the negative.

The mosaics specified may be prepared from either (a) the latest currently available ASCS aerial photography, (b) other existing aerial photography produced by a qualified aerial survey organization within the past 3 yr, or (c) new photography taken by or on the order of the engineer specifically to obtain the coverage required. Any such photography especially that of urban areas, shall depict acceptably current conditions of civic and personal property or other improvements within the area involved, and shall have the photographic image quality essential for satisfactorily fulfilling all needs of the State. The engineer shall submit his request for the proposed photography for approval by the State before preparation of the photographic mosaics.

In no event shall the ground area coverage of the reproduction negatives, in the 24-in. dimension, be less than 9,600 ft wide at the 400 ft to 1-in. scale, nor less than 2,400 ft wide at the 100 ft to 1-in. scale.

The reproduction negatives of the photographic mosaic shall be sufficiently image matched and end lapped between successive sheets to provide a matched continuous strip of each right-of-way project when blue-printed, trimmed, and spliced together.

The reproduction negatives shall have the following information indicated:

1. The centerline of the selected and surveyed route, positioned approximately in the center of the 24-in. dimension, with notations as to centerline stationing, degree of curvature on portions of centerline on curve, and a north point;
2. A dotted line indication of the entire property ownership both sides of centerline, and of all property adjacent to or bisected by the centerline;
3. The right-of-way line, as established, both sides of centerline,
4. The name of each property owner, or owners involved,
5. The specific acreage involved in the right-of-way taking, the separation, and the residue;
6. Any adjacent land survey section corners falling within the coverage specified, both sides of centerline, with all four sections indicated in a small circle;
7. Appropriate designation of all county lines, and all State and county roads, streams, and ditches; and
8. An appropriate title designation on each reproduction.

Summary

Photogrammetry has been employed on five road projects in which all planimetry and spot measured cross-section position and elevation points have been furnished to design squads. None of these jobs has yet progressed to the point of being placed under contract. Other stereoscopic instrument measurement work has been performed on borrow pits, for interchanges, and for a small amount of route location survey and design work.

The major portion of the aerial work, however, leads to preparation of photographic mosaics for route location by the Planning and Location Departments. Photographic indexes and stereoscopic print coverage are always provided. Oblique, public interest photography is also taken as required for the public relations department.

FUNCTION AND TECHNIQUES OF THE PHOTOGRAMMETRY SECTION, KANSAS STATE HIGHWAY COMMISSION

In 1957, a committee of five engineers was formed by the State Highway Engineer of Kansas and given the responsibility of reviewing reports of visitations made to States having organizations utilizing photogrammetric equipment, making inquiry and investigations, and finally submitting a report suggesting steps to be taken by the Highway Commission of Kansas with regard to the use of such equipment within its organization. The results of this action found the first section of the Department of Electronic Computer, Aerial Surveys and Photogrammetry organized in late 1957 with the training of personnel taken from the various existing departments in a special programing school. Electronic data processing equipment was ordered. Late in 1958, the second section was started. Again personnel were taken from existing departments for training in photogrammetry and its allied functions.

Since this time considerable growth has occurred. An organization chart of the department is shown in Figure 4. It should be noted that dual roles are being assumed by several individuals. The assistant to the head of the Photogrammetry Section (Supervisor of Aerial Surveys and Photogrammetry) is also the pilot of the plane. The Supervisor of the Photogrammetry Laboratory is the aerial cameraman. Until recently, the head of the Computer Section was also listed as a pilot and both photographers in the Photogrammetry Laboratory are alternate aerial cameramen. The system of dual roles has proven very effective in the organization of the department.