USE OF AERIAL SURVEYS IN REGION 8, U. S. BUREAU OF PUBLIC ROADS

George B. Forrest
Supervising Highway Design Engineer, Vancouver, Washington

By January 1962, there were approximately 320 lineal mi of topographic maps on different routes within this region. These maps vary in scale from 100 ft to 1 in., with a contour interval of 5 ft, to 400 ft to 1 in., with a contour interval of 20 ft, depending on the character of the topography surveyed.

Because of dense timber and brush cover over many sections of highway location, aerial photographs are being used to study route alternatives before sending field survey crews into the areas. The photographs are used in stereoscopic pairs and in assemblies as uncontrolled photographic mosaics to determine each route alternative, as governed by land usage, drainage areas, soil interpretation, and location and classification of surfacing material sites. The possible route alternatives are drawn on the aerial photographs in stereoscopic correspondence with the ground and used as a guide by the chief locator assigned to the survey for field review. By image identification, the locators can find and evaluate each route alternative meeting horizontal and vertical alignment standards.

Aerial vertical photographs are used to compare feasible route alternatives and to prepare a preliminary reconnaissance design for cost analysis of the route alternatives throughout any given area. On some routes, alignment and grade have been developed and grading qualities have been obtained directly from the photographs by the parallax measurement method and electronic computer offset daylight program. On one route the initial reconnaissance cost analysis indicated that the ground survey was in the wrong area. As a result of this survey and comparison, a new route was selected at substantial savings in cost and time. A highway on the new route will be opened to travel in approximately 4 yr, whereas a highway on the original route would have required 10 to 15 yr for completion with normal appropriations. Since the initial reconnaissance survey and route comparisons, a preliminary survey by aerial methods over the unfinished portion of the route and the design and construction plans have been completed, and the centerline has been staked in the field. The designed and staked location followed very closely the route location and initial design comparisons for cost estimating.

Approximately 3,000 mi of alternative route possibilities have been reviewed within this Region by direct use of aerial photographs. Vertical, horizontal, and subsidence movements along centerline on one route in Montana have been checked by re-establishing control for aerial surveys on right-of-way monuments placed before the earthquake near West Yellowstone.

Recently essential surveys were made and 123 mi of road realignment were designed for the U. S. Army Corps of Engineers within the Libby Dam area in Montana. The reconnaissance survey and route location were made by use of photogrammetrically compiled topographic maps at a scale of 1,000 ft to 1 in. with a 20-ft contour interval. These maps were enlarged 1 diam to a scale of 500 ft to 1 in. The objectives of this reconnaissance survey were to relocate existing Forest Highway and Forest Development and access roads which will be inundated, to determine the side of the reservoir for which each routing is best adapted by topography, type of materials, and design criteria, and to outline in detail the areas where additional aerial surveys should be made.

The basic control was established and targeted by the Corps of Engineers along a railroad in the bottom of a canyon at intervals of approximately 1,000 ft with vertical control points on each side of the canyon at 6-mi intervals. The routes were then photographed and mapped at scales of 200 ft to 1 in., with a 5-ft contour interval, and 400 ft to 1 in., with a 10-ft contour interval, in specified area. Mapping was accomplished with a first-order optical train photogrammetric instrument, bridging control along the route between the targeted control points. The topographic maps were enlarged to 1 diam to obtain scales of 100 ft to 1 in. or 200 ft to 1 in., as desired. The preliminary location design and construction plans were made using these enlarged topographic maps, supplemented by stereoscopic examination of the aerial photographs used to compile the maps.

Approximately two horizontal control stations per mile have been established along the proposed realignment on each side of the reservoir at points intervisible along the railroad tracks. These stations are for positioning control in staking the designed centerline along each route. They will also be used by the Corps of Engineers as reference points in right-of-way surveys and as basic control for surveys of the reservoir area. Angles and distances were measured by T-2 theodolite and Electrotape instruments to third-order accuracy.

Topography in the area of survey is rugged with sections of heavy timber and brush cover. Therefore, after the preliminary design was completed, a P-line was staked on the ground as close as possible to the designed projection of the highway centerline, using established control stations as the origin of horizontal position. The object of this traverse is to check the topographic maps. In areas where the contours check, no additional topographic measurements were made other than for structure site surveys. In areas where a discrepancy occurred between the contours and the field surveyed P-line, ground survey methods were used under the timber and through brush areas to measure cross-sections. In areas adapted to aerial surveys, the P-line was targeted to serve for basic control and another set of aerial photographs was taken at a larger scale to measure photogrammetrically cross-sections across the proposed alignment directly from the photograph.

After all essential adjustment of alignment and grade were made in the field, the corrections were noted on the plans and the centerline was staked on the ground by computed offset from the P-line. This alignment was reviewed by participating agencies. Once agreement was attained, the designed alignment was staked for highway construction.

The aerial photographs obtained are useful for outlining proposed recreational areas, noting connecting roads to timbered areas, measuring drainage areas to determine size of structures, and ascertaining preliminary classification of materials.

Vertical photography is on file for 60 percent of the routes on which construction or route location surveys are under way. The scale of this photography ranges from 600 ft to 1 in. to 1 mi to 1 in. The contact prints of such aerial photography are used extensively by locators in making route reconnaissance surveys and soil investigations.

Contract Procedure

Aerial survey work is contracted to responsible photogrammetric engineering firms in its entirety as a proposal for engineering services. Award is not necessarily on the basis of the lowest proposal, because experience, time required to complete the work, availability of equipment and type of equipment must be considered.

Each survey area is reviewed by existing aerial photography and small-scale topographic maps compiled and published on a quadrangle basis, or by field inspection to determine scale of photography for route reconnaissance surveys and for preliminary survey mapping of selected routes by the aerial survey contractor. The scale varies from 1,000 to 2,000 ft to 1 in., for reconnaissance survey mapping photography and from 200 to 600 ft to 1 in. for preliminary survey mapping photography, depending on the type of topography within the limits of the proposed route survey area. The width of coverage on the reconnaissance photography will vary from 5 to 15 mi, depending on route possibilities and drainage areas within the area of survey.

Before the contractor places ground survey control targets, the reconnaissance survey photography is furnished on which are outlined in detail the mapping boundaries and the approximate location of the proposed survey route. A control line is flagged on the ground along or near the center of the route. The contractor establishes station markers in the ground to serve as control survey points along the flagged line at about 10 points to the mile and places a target on each point before photographing the mapping zone. Distances and angles are measured by electronic measuring devices and T-2 theodolites. Approximately five vertical control points, or pass points, are located on each stereoscopic model.

Permanent station markers are established as concrete monuments at intervals of ½ mi. Test traverses are measured along the control line by field survey parties.

Topographic maps at a scale of 100 ft to 1 in., with contours at a 4- to 10-ft interval, depending on topography, are compiled by the contractor on map manuscripts 24 in. wide and 72 in. long. The accuracy of the photogrammetrically compiled topographic maps are tested by traverses and profiles measured by field survey parties.

The designed alignment is projected on the topographic maps, and the mathematical description thereof is actually computed by plane coordinates. Topographic data and listings of grading quantities are obtained by automatic data processing. In general, the "Reference Guide Outline, Specifications for Aerial Surveys and Mapping by Photogrammetric Methods for Highways, 1958" is used in the administration of all contracts awarded for aerial photography, ground control surveying, and topographic mapping by photogrammetric methods.

USE OF AERIAL PHOTOGRAPHY IN REGION 15, U. S. BUREAU OF PUBLIC ROADS

(Eastern National Forests and Parks)

An aerial photography contractor was engaged in March 1961 for topographic mapping of a 10-mi section of the Natchez Trace Parkway in Mississippi. The preliminary P-line was staked on the ground by conventional survey methods.

To stake the right-of-way, it was first necessary to design a centerline of the highway for the projection of the right-of-way taking lines and preparation of the development plans.

The Public Roads division office set photographic targets on survey control points. The targets were cross-shaped and made of white and black cloth strips 8 in. wide and 10 ft long. All vertical and horizontal survey controls were tied to the targets, which were centered by a tack in a wooden stake driven flush with ground surface.

Under the negotiated contract, the aerial surveys contractor furnished the following:

1. A route map at a scale of 500 ft to 1 in., and two sets of contact prints, 9 by 9 in., of the 500 ft to 1 in.-scale vertical photography.
2. State plane coordinate computations for all preliminary P-line control points and for all other control points for which photographic targets were set.
3. Topographic maps extending 1,000 ft on each side of the P-line at the horizontal scale of 100 ft to 1 in. with a contour interval of 5 ft and three sets of prints of each map sheet.
4. An index map of the map sheets and a photographic index of the aerial vertical photographs.

For such work, the contractor was paid $500.00 per linear mile of highway.

The contract stipulated the contours should not be in error by more than ¼-contour interval (1.25 ft) for 90 percent of the points tested, and not more than ½-contour interval for the remaining 10 percent. Numerous checks made by the U. S. Bureau of Public Roads showed that in no case was a contour in error as much as 1.25 ft; for over 90 percent of the points tested the contour error was less than 0.5 ft. Horizontal accuracy was also very satisfactory.

The 2,000 ft width of topography mapped provided much latitude in design for centerline projection. Such width also contributed greatly to the expeditious design of drainage structures and preparation of a complete set of construction plans.

Photography flying was done on March 14, 1961, before the trees began leafing out. The airplane used was a Cessna 180; the aerial camera was a K-17 type (modified) with a 6-in. focal length Metrogon lens tested by the National Bureau of Standards. The contractor completed all photography, plane coordinate computations of control, and photogrammetric compilation of the topographic maps by the latter part of April 1961.

The cost of such topographic mapping, if done by conventional ground survey methods would have been approximately $16,000 and would have taken from 4 to 5 mo to complete