

The cost of this contract was \$4,909.21 and less than 2 mo were required to complete topographic mapping of a route band approximately 2.5 times as wide as would have been surveyed if the work had been done by a survey crew on the ground.

Successes achieved in aerial mapping on this project encourage serious consideration of the use of aerial surveys for measuring original ground cross-sections of the constructed highway for computation of earthwork in payment of construction contractors. If this experiment proves successful, aerial survey methods may be used for measuring cross-sections of future grading projects along the Natchez Trace Parkway.

A test survey is under way to compare costs and accuracy of ground survey and photogrammetric methods for measuring earthwork pay quantities on a 4-mi mountain grading project on the Foothills Parkway in eastern Tennessee. The original ground cross-sections were measured by conventional ground survey methods and by use of precision stereoscopic plotters. After grading is completed, the constructed highway cross-sections will be measured by both methods.

The initial aerial photography for these tests was taken after the construction contractor had completed clearing operations and before any grading was done on the project. The photography was taken by the Tennessee Valley Authority and the photogrammetric measurement of cross-sections of the cleared construction zone was done by the Aerial Surveys Branch, U. S. Bureau of Public Roads. The ground control surveys were made and field measurements of cross-sections of the same zone were accomplished by field division personnel of Region 15. After completion, all cross-section data will be sent to the Bureau's computer center for computation of earthwork volumes.

In the Washington, D. C. metropolitan area, most highway survey areas have been photographed, and small-scale topographic maps compiled from photography by photogrammetric methods are available from other Government agencies. These maps, along with contact prints of available stereoscopic coverage by aerial photography, are utilized by Region 15 in reconnaissance surveys for route determination and comparison purposes. Once the best route has been determined, large-scale photographs are taken and used in compiling topographic maps for design purposes at scales of 100 or 50 ft to 1 in., according to need, with a contour interval of 5 ft and 2 ft, respectively. It is expected that an aerial survey contract will be let for any future highway survey and design project where topographic maps of adequate scale are not available and where the area of survey is extensive enough to justify such contracting.

Region 15 also uses contact prints of aerial photography in conjunction with the available topographic maps to determine the size of drainage areas for the design of drainage structures.

USE OF AERIAL SURVEYS IN CONNECTICUT

David S. Johnson

Director of Planning and Design, Connecticut State Highway Department
Wethersfield, Connecticut

Aerial photography for highway engineering purposes was first used by the Connecticut State Highway Department in 1930 for locating, developing schematics, and preparing preliminary right-of-way acquisition maps for the Merritt Parkway through Fairfield County, a distance of approximately 38 mi. The photographs were enlarged to the scale of 200 ft to 1 in., the scale to which planimetric maps were prepared from the photography.

Using photography taken in 1934, aerial photographic mosaics were assembled of the entire State at the scale of 600 ft to 1 in. and were used for many years thereafter for planning purposes.

In 1944, the first topographic maps compiled by photogrammetric methods were

used by the Highway Department. This mapping was done at the scale of 200 ft to 1 in., with a contour interval of 5 ft, and covered a route band of topography 1 mi wide and 12.9 mi long between the cities of Hartford and New Britain. Since then, the Connecticut State Highway Department has considered photogrammetry as one of its most valuable tools and has used it constantly. The Highway Department has obtained over 800 lineal mi of topographic mapping as follows:

Length (mi)	Scale (ft to 1 in.)	Contour Interval (ft)	Width of Mapping (mi)
780	200	5	1
70	100	2	0.5
20	40	1	0.2
6	40	Location survey	-

Maps compiled photogrammetrically at the scales of 200 ft and 100 ft to 1 in. are used primarily for highway route planning (route determinations, comparison, and selection), and at the scale of 40 ft to 1 in. for the preliminary location survey and design.

As the Department has no established photogrammetric section, its aerial photography and photogrammetric work are accomplished under negotiated contract by established photogrammetric firms. The maps are reviewed before acceptance by the State, and to assure compliance with specifications, they are field checked for accuracy of location of cultural features. Also, test profiles are measured along test traverses to check the accuracy of contours.

Projects are scheduled so that the aerial photography may be taken during November and December or in the early spring. Because of the variability of the weather, the average number of days with 10 percent or less of cloud cover is only 5 or 6 a month during these periods. Also, during these same months, there are high winds and local updrafts that seriously affect flying for photography of all scales, but particularly for photography taken from low flight heights for topographic mapping at the scale of 40 ft to 1 in.

Preliminary survey planning and the early determination and comparison of alternative highway locations are done by use of the standard topographic maps published at the scale of 2,000 ft to 1 in. as quadrangle sheets by the U. S. Geological Survey. The State of Connecticut is participating on a continuing basis with the U. S. Geological Survey in the cost of preparing these maps. When the general route zone of the highway location has been determined, topographic maps of the route are compiled at the scale of 200 ft to 1 in. from currently taken aerial photographs by precision photogrammetric methods.

The various location alternatives first developed on the small-scale topographic maps are transferred to the topographic maps compiled at the scale of 200 ft to 1 in. The larger scale maps reveal the undesirability or impracticability of part or all of various centerline locations, and the possibility or the necessity of adjusting and refining others. It is usually possible to add new location alternatives for study to replace those discarded. These alternatives can then be developed to fully engineered and scaled schematic plans for the highway. Centerlines may be shifted until the most acceptable profile is apparent, the limits of the separated roadway and divided highway sections are determined, conformity with alignment and gradient criteria are checked, interchanges are engineered to scale, and the treatment of intersected roads are shown. Comparable cost estimates of the various location alternatives are made with the aid of the photogrammetrically compiled topographic maps. After deciding which of the highway location alternatives is best, its design is further refined to provide as complete a guide as possible for its location surveying on the ground and for preparation of construction plans

at the scale of 40 ft to 1 in. The location and plane coordinates of instrument points on the proposed survey baseline are determined, based on the Connecticut State plane coordinate system.

Due to the accelerated highway program in Connecticut, it has been necessary to employ consulting engineers for survey and for design. Many of these are using photogrammetry in varying degrees for topographic map compilation at the scale of 40 ft to 1 in. as follows

1. For interchange areas it is usually more desirable to determine exact ramp locations during the latter stages of design. It is becoming increasingly more common to photograph these areas and photogrammetrically compile topographic maps with contours on a 1-ft interval, thus enabling the designer to measure cross-sections from the maps for any desired location.
2. In urban areas the base map is prepared by photogrammetric methods, supplemented by ground surveys. The cross-sections and/or spot elevations are later measured by ground surveys.
3. The use of aerial photographs, enlarged to the topographic mapping scale of 40 ft to 1 in., is increasing, particularly in cities. These enlargements are used in studying proposed highway locations on developed properties, as a means to refine the proposed baseline and as an aid in property appraisal and acquisition.
4. There have been several instances where the consulting engineers, in order to complete preliminary design, approximate grading quantities, and establish grade lines, have had topographic maps compiled photogrammetrically of highway routes with a 2-ft contour interval. The cross-sections and profiles measured from these maps are later revised in accordance with data obtained by ground surveys.

The Highway Department contemplates greater use of topographic maps compiled at the scale of 40 ft to 1 in. in the future for highway location, design, and preparation of construction plans.

USES OF PHOTOGRAMMETRY BY THE WISCONSIN STATE HIGHWAY COMMISSION

Since early in the 1950's the State Highway Commission of Wisconsin has contracted the services of a number of photogrammetric engineering firms to furnish topographic maps and allied data for the planning, location, and design of highways. By 1961, approximately 2,000 sq mi of aerial photography flying and 600 sq mi of topographic mapping were completed on highway locations within the State.

The small staff within the Design Section of the Commission is engaged principally in the administration of photogrammetric engineering contracts, construction of aerial photographic mosaics, and the training of engineers in appropriate phases of aerial surveys, including photogrammetry and photographic interpretation for highway engineering purposes.

Contract Administration

The services of photogrammetric engineering firms for taking aerial photography and compiling topographic maps have been engaged by negotiation rather than by bid, and excellent results have been attained. Specifications generally follow those prepared by the Photogrammetry for Highways Committee, jointly sponsored by the American Society of Photogrammetry and the American Congress on Surveying and Mapping, as published by the U. S. Bureau of Public Roads, with some variations brought about by local conditions of climate, topography, and land use.

Both fall and spring have been satisfactory for taking aerial photography for compilation of reconnaissance-type topographic maps to a scale of 200 ft to 1 in. with a 5-