photographic techniques, films, cameras, and knowledge increase, the uses of photogrammetry will increase.

USE OF PHOTOGRAMMETRY IN MONTANA

After the advent of the Interstate System in 1956, a requirement of which was an estimation of the cost of constructing the highway in each State, a State-wide aerial mapping contract was entered into by the Montana State Highway Commission for topographic mapping of the entire system. A scale of 200 ft to 1 in. with a contour interval of 5 ft was chosen for the general mapping, with some sections being mapped at a scale of 100 ft to 1 in. with a 2-ft contour interval.

On completion of the contract and after use of the mapping for several months, the great value of photogrammetric products became evident to the engineering personnel and, as a result, it was decided to enter into the photogrammetric field. A small economical print-type stereoscopic plotter was purchased, along with mirror stereoscopes and parallax bars.

Because of Montana's inclement weather and the lack of private aerial photography companies in the State, it was decided in 1957 to purchase a Cessna 180 with aerial camera. Related darkroom equipment was also purchased. Because of continued utilization of photogrammetric products and the increased work load two Kelsh stereoscopic plotters were purchased by 1959. More accurate design mapping was the constant demand of design engineers, including structural designers.

In keeping with these demands, a LogEtronic automatic dodging printer was purchased and a specialist was trained in ground control. The regular field survey crews within the State are used along with the specialist who selects the finite image points, sets the targets, and trains other personnel in these techniques. By 1960 the original camera was replaced by a Wild RC-8 aerial camera.

The Photogrammetry Section is assigned to the Interstate Department because 99 percent of its work is performed on Interstate highways. Of the aforementioned personnel, two are supervisory, one is assigned to the field, two are part-time and also do work for other departments, and four are photogrammetric instrument operators and draftsmen.

From the fall of 1958 to 1961 more than 200 sq m1 of reconnaissance topographic mapping was accomplished. More than 80 percent of this mapping 1s done at the scale of 200 ft to 1 m., with a 5-ft contour interval, and the remainder 1s done at the scale of 400 ft to 1 m., with a 10-ft interval. This work also includes approximately 50 sq m1 of design mapping at scales of 50 ft and 100 ft to 1 m., with a 1- and 2-ft contour intervals, respectively. Another 100 sq m1 of mapping 1s under way. Thus far no cross-sections have been measured photogrammetrically, other than extension of field measured cross-sections.

Other specialized work completed includes the assembly of an uncontrolled mosaic of every city, town, and hamlet in the State. These mosaics are to be incorporated into a book to complement the City Plat Book already produced by the State Highway Commission. The feasibility of furnishing the construction department monthly aerial photography of the highway construction projects to verify monthly progress reports and payments is being studied.

The Right-of-Way Department is furnished enlarged aerial photographs at a scale of 200 ft to 1 in. or larger of all Interstate projects to facilitate negotiations. This photography is acquired as near to the time of negotiation and purchase as possible to insure obtaining the most up-to-date information possible.

Research is being done on the utilization of various methods of ground control when surveying in very rugged mountainous topography for different mapping scales. This includes the use of electronic distance measuring devices alone and in conjunction with field survey crews utilizing conventional methods. Many aerial photography, photographic mosaic, and topographic map displays are made for the legal staff and have proven invaluable in condemnation suits. Such displays are also made for the Public Information Section.

CURRENT PHOTOGRAMMETRIC PRACTICES IN VIRGINIA

Fred B. Bales Virginia Department of Highways

Before photogrammetry can be utilized to its fullest extent, the user must recognize its limitations. Photogrammetry is not the highway engineering cure-all prophesied by so many during the past few years. It must be employed with discretion and with close quality control.

In Virginia, only equipment and materials known to consistently provide high quality results are used. Photography, for instance, is taken using only a stable base aerial film and an aerial camera with a distortion-free lens. Diapositives are printed only on glass plates $\frac{1}{4}$ in. thick. Map manuscripts are compiled using only a stable base drafting film on which control points are plotted by means of a precision coordinato-graph.

Ground control for mapping by aerial methods is established with Tellurometers for distance measurement and Wild T-2 theodolites for angular measurement. Two masters and two remotes of the early model MRA/1 Tellurometer and the later addition of two units of the MRA/2 model provide three complete distance measuring systems.

For quality control, a test profile is measured routinely on the ground during establishment of ground control for each stereoscopic model from which a map is to be compiled. The profile data, however, are withheld from the stereoscopic instrument operator until after each stereoscopic model has been used in compiling the maps and making other essential measurements. An independent check is then made by a supervisor to determine completeness of planimetric detail and accuracy of the contour delineations or cross-section measurements. This check is made before the setup of each successive stereoscopic model is removed from the photogrammetric instrument.

The actual utilization of photogrammetric equipment for highway engineering in the State can be placed in two distinct areas: (a) route location stages, and (b) accumulation of survey data for use in highway design. In the route location stages, topographic mapping is accomplished at a scale of 200 ft to 1 in. with a 5-ft contour interval. For highway design, the maps are compiled at a scale of 50 ft to 1 in. with a 2-ft contour interval or cross-sections are measured photogrammetrically using stereoscopic models of the same scale.

Aerial photography is taken using a State-owned Aero Commander twin engine aircraft with a Wild RC-8 aerial camera. Both pilot and photographer are former survey party personnel who have other office duties within the highway location section when not actually engaged in flying.

A complete photographic laboratory is maintained for processing the exposed aerial film and printing photographs on paper and on glass as needed. Contact printing is accomplished through the use of an automatic electronic dodging printer and enlargements are made utilizing a Zeiss SEG-V Rectifier-Enlarger. Photographic mosaics are copied using an overhead-type Robertson copy camera. This camera is used for all departmental copy work, including road and bridge plans, maps, and sketches, and further doubles as a photographic enlarger.

All ground control for the route location topographic mapping (scale of 200 ft to 1 in. with a 5-ft contour interval) is accomplished by three survey parties equipped with Tellurometers, Wild T-2 theodolites, and Zeiss automatic self-leveling levels. Horizontal control for all such mapping is based on the Virginia State plane coordinate sys-