THE USES OF AERIAL PHOTOGRAPHS AND MAPS BY THE TEXAS HIGHWAY DEPARTMENT*

Julian Montgomery, State Highway Engineer,
Texas Highway Department

THE Texas Highway Department first fully realized the potential value of aerial photography in highway work when studying locations projected on the Tactical Maps of the U. S. Army that were compiled by a method of carefully controlled aerial photographs.

Ground surveys confirmed the accuracy of this method of mapping and it was soon found that in sections where such data were available Reconnaissance and Preliminary Surveys were no longer a prerequisite to good location; and in addition, the minute detail of actual topography afforded by the aerial photographs of these sections greatly exceeded that possible to be secured by any economical ground survey procedure.

Naturally, this lead was followed. The Department proceeded to secure aerial photographs for location purposes of a hilly and wooded section of our State through which it was desired to construct a highway. This section was sparsely populated and roads of any kind were few and far between. A photographic flight was made along the approximately fifty-mile length of the route it was desired to follow, and a "strip-map" was constructed by matching easily identified images of well-known objects, such as ranch houses, flagged water wells and well-known peaks.

From this strip-map the location was determined and, with but minor changes, was staked out and constructed along the line thus selected.

Later it became necessary to select a location connecting two large metropolitan areas and traversing a section intensively cultivated and dotted with several small towns. Again the strip-map constructed of aerial photographs was utilized, and again it was found that the approximate eighty miles of located line almost exactly coincided with that selected on the strip-map.

From that day aerial photography has made rapid strides. Today we find that many sections of our State have been photographed from the air by carefully controlled flights, and that aerial maps of such sections, in any desired scale, are commercially available.

During the past year or so, aerial photographs of 16 counties or parts of counties, involving a total area of some 6,700 square miles in Texas, have been used by the Department in studying locations of highways. For your information we are offering below a discussion outlining the reasons for purchasing some of these maps and their value to the Department in solving the problems involved.

1. Wharton County—U. S. Highway 96—in vicinity of Wharton—58.5 Sq. Miles.

Maps of this area were secured to study proper means of erosion control near the Colorado River Bridge on U. S. Highway 96 west of Wharton, and to study flood conditions north and east of Wharton in an effort to alleviate the drainage problem at Peach Creek on U. S. 96 east of Wharton. These aerial photographs were secured by special flight which was made immediately after one of the largest floods on the Colorado River. The finished photographs reflected flood damage, boundary of area inundated, and course of flood waters,

* Presented at the San Antonio Meeting.

and this information naturally increased the value of these maps in their use for studying this particular problem. The mosaic was secured on a scale of 1″=2,000′ and the enlargements of the contact prints on a scale of 1″=500′.

2. Gonzales County—Highways 29 and 112—South of Gonzales—25 Sq. Miles.

These maps were secured for the purpose of defending the State in 11 lawsuits which request payment of approximately $385,000.00 for property damages supposedly caused by the interruption of the natural flow of flood waters in the Colorado River by the construction of Highways 29 and 112 south of Gonzales. These maps were prepared from a special flight on the unusual scale of 1″=200′ for contact prints and 1″=500′ for the mosaic. These maps have been used for reference purposes in checking data secured by field surveys and in preparing and establishing accuracy of topographic maps. We are advised by the Legal Department that these aerial maps are considered of primary importance in defending the State in these damage suits.

3. Collin, Tarrant, Travis, Bastrop, San Patricio, Nueces, Orange and Jefferson Counties—6,386 Sq. Miles.

In November 1938 contract was executed for the acquisition of various types of aerial maps covering these counties. These maps were obtained by flights made between 1930 and 1938 and were secured primarily as an experiment definitely to determine the value of aerial photogrammetry to highway construction and the most logical and economical types of maps which would result in increased speed and efficiency in our engineering work. A controlled mosaic was secured for each county reflecting the county as a unit on a scale of 1″=6,000′. Controlled mosaics were secured covering sections of $3\frac{3}{4}$ minutes of latitude and longitude (quarter-grid) in each county on a scale of 1″=1,000′. These mosaics are mounted on pasteboard.

This contract also provides for the purchase of 30′ quadrangles, strip-maps, contact prints, and enlargements covering any portion of the counties involved as the need for maps of this type arises. It is believed that the use of these maps will definitely establish the value of aerial photogrammetry to highway construction as relates to reconnaissance, actual location, drainage area surveys, regional planning, etc.

4. Medina County—U. S. Highway 90—Hondo Creek near D'Hanis—16 Sq. Miles.

A location problem was encountered on U. S. Highway 90 in Medina County at Hondo Creek, and in April 1939 we secured a strip-map and contact prints covering approximately 16 square miles in this vicinity. We are advised by the District Engineer that these maps unquestionably resulted in a savings to the Department in engineering cost as he was able to establish the most desirable stream crossing and adjacent highway location without the necessity of running several preliminary lines in this extremely rough and timbered country. These maps required special flight.

5. Zavala County—U. S. Highway 83—in vicinity of Nueces River—32 Sq. Miles.

In June 1939 we purchased copies of two quarter-grid sections and the contact prints involved for U. S. Highway 83 in the vicinity of the Nueces River in Zavala County. A quarter-grid consists of $3\frac{3}{4}$ minutes of latitude and longitude, and involves approximately 16 square miles. These maps were obtained from previous flights and were secured for use in establishing the most logical crossing

of the Nueces River and the proper location for connections to the present road. The old bridge was destroyed by flood in 1935 and a temporary low water bridge has been in use to date. Provision has not been made for the financing of a new high water structure and preliminary investigations have not sufficiently advanced to establish the value of these particular aerial maps; however, it is felt that these maps will assist in establishing the most feasible crossing and eliminate the necessity of extensive reconnaissance work.

6. Wilson County—U. S. Highway 181 and State Highway 97—In vicinity of Floresville—48 Sq. Miles.

Considerable difficulty has been encountered in an effort to secure a location for U. S. Highway 181 and State Highway 97 in the vicinity of Floresville in Wilson County which would be acceptable to all parties concerned. Copies of mosaics covering three quarter-grid sections (approximately 48 square miles) in this area were secured in July 1939 in order to permit a study of the proposed location in relation to all governing topographic features and existing improvements. These maps not only will aid the Department in arriving at the most feasible location but will also permit a graphic presentation of the proposed arrangement to local authorities in establishing its merit over such alternate routes as might appear desirable from a local viewpoint.

7. Val Verde and Edwards Counties—U. S. Highway 277—5 miles north of Del Rio to Sutton County Line—112 Sq. Miles.

The routing of U. S. Highway 277 from Del Rio north toward Sonora has represented a major location problem which has been under consideration for several years. The District Engineer advises that the area traversed had never been accurately mapped, and it was difficult to obtain access to the territory to be traversed due to lack of existing roads, locked gates on those in existence, and the heavily timbered and mountainous nature of this country. A contract was executed in August 1939 for the acquisition of a strip-map and contact prints covering approximately 56 miles measured along the proposed route. These maps required a special flight which has just been completed, and the desirable materials should be delivered at any early date.

The District Office had established what was considered as the tentative routing of this highway, and preliminary flight was made to establish the approximate boundaries of the area to be photographed. It is interesting to note that the small amount of study permitted the Department to recognize the desirability of shifting the proposed route at its northern extremity to traverse more suitable terrain.

8. Real County—U. S. Highway 83—North of Leakey—20 Sq. Miles.

The routing of U. S. Highway 83 north of Leakey has also been somewhat of a problem to the Department, and arrangements were made for the acquisition of a strip-map and contact prints in this vicinity. These maps for this small area were secured at a nominal fee in connection with the flight for U. S. 277 in Val Verde and Edwards Counties, and while delivery has not as yet been made we are confident the maps will be of material benefit to the Department in determining the proper location of this highway.

9. Dallas County—U. S. Highway 77—Beckley Avenue South of Dallas—2 Sq. Miles.

The District Engineer is now preparing plans for the construction of U. S. Highway 77 in Dallas County following Beckley Avenue South of Dallas. It is

proposed to separate the grades between Beckley Avenue and the County Belt Line Road which will require a relocation of the county road. The topography in this vicinity is very rough and in August 1939 we secured an enlargement (scale 1″=660′) of one contact print covering this particular area. This print should enable the District Engineer to secure the most logical arrangement at this point with a minimum amount of field investigation.

It has been found that for our purposes the following procedure in aerial photographic mapping enables us to conduct the necessary study of those areas through which is proposed a location or relocation:

Contact Prints: Developed from the original negative that is secured from the photographic flight. The scale is controlled by the focal length of the camera lens and the altitude of the flight, and is preferred to be 1″=1,500′. These prints should overlap about 60% in the line of flight, and about 30% laterally when more than one line of flight is required. These prints should be numbered and the number so placed as not to be covered by the overlap.

Mosaics: A mosaic is made by the mounting of the contact prints in proper juxtaposition, and the assembly then photographed so as to secure a composite picture of the whole, the result being a polyconic projection of the surface of the area photographed.

Mosaics can be secured on any desired scale, and are divided into two classifications, to wit: "Controlled" and "Uncontrolled":

(a) Controlled mosaics are those that are accurately "tied" into previously established points on the ground, such as triangulation stations of the U. S. G. S. and the C. & G. Survey, the control points of the Army Grid Systems and also well defined objects that can be located easily on the ground. The controlled mosaics are very accurate and distance scaled thereon will check surprisingly close to the distances actually measured on the ground.

(b) Uncontrolled mosaics are those that are not "tied" to established points on the ground and, although lacking the accuracy of the controlled mosaic, they are especially useful in the study of those sections where proper location is controlled by topography. They may be constructed around a single photograph of a geographically known point, or expanded laterally from a single photographic-flight as a base line, with the contact prints fitted together by matching images.

Mosaics are secured either as a county unit or a 30-minute quadrangle (about 1,024 square miles) at a scale of 1″=6,000′ for a general study, or as a $3\frac{3}{4}$-minute section (about 16 square miles) at a scale of 1″=1,000′ for a topographic study. The latter, when mounted together, form the strip-map, and represent a strip 4 miles in width for any desired length.

The $3\frac{3}{4}$-minute sections of controlled mosaics require a special index map in order to establish the quadrant number and the identity of each individual section. These sections are obtained by dividing each degree of latitude and longitude into quadrants of 30-minutes each, and these quadrants are identified by consecutive numbers from 1 through 336; then each of these quadrants is subdivided into $7\frac{1}{2}$-minute sections which are identified by reference to the quadrant subdivisions; then each of these $7\frac{1}{2}$-minute sections is subdivided into quadrants of $3\frac{3}{4}$-minute sections, which are in turn identified by numbering from 1 through 4.

The costs of any of the above mosaics are as follows: (1) $5.00 per square mile for any area where photographic flights are required. (2) $2.00 per square mile for those areas where negatives are available from previous photographic flights.

At the above prices we are furnished an index map properly identifying the contact prints, and a correctly matched mosaic of the area photographed. Additional copies if desired are secured at $7.50 each for county units or 30-minute quadrangles, contact prints at twenty-five cents (25¢) each, and strip-maps at twenty-five cents (25¢) per mile.

In conclusion, we have found aerial photography to be an economical method of procedure in the certain phases of highway work mentioned below:

1. As a reliable and rapid method of reconnaissance in rough and inaccessible sections, which in many instances will entirely eliminate the necessity for preliminary surveys.

2. As an effective means of determining proper location in the metropolitan areas.

3. As offering the facilities for a careful study of all drainage areas, thus materially assisting in determining proper sites for drainage structures and the avoidance of overflow sections.

4. As an accurate means of readily determining the ground usage of the section traversed.