

Development of Photogrammetric Methods for Right-of-Way Operations in Texas

HUBERT A. HENRY, Supervising Designing Engineer, Texas Highway Department

THE Texas Highway Department made a number of studies prior to 1958 to ascertain the feasibility of using data photogrammetrically obtained for the development of right-of-way maps and field notes for deeds. Each time the possibility was discussed with one of the photogrammetric engineering firms they agreed it probably could be done but it would be very expensive. In some instances, it was reported that special equipment for flight altitudes for photography which were not acceptable would be required to guarantee the accuracies needed.

In the specific project studies, primarily cost estimates and comparisons were made, taking into consideration the project status with regard to the amount of survey work completed by field methods, the amount of field survey work remaining to be done, time limitations due to vegetation and weather, and the relatively high cost of the photogrammetry to be used. Determinations for the pilot project were made in the early spring of 1958 and the Dallas District decided it would be economically feasible, based on preliminary cost estimates, to use photogrammetric methods to develop a project for a section on Interstate Highway 20 in the City of Dallas, provided the accuracies required could be met.

Basically, the requirements were for maps to be compiled by photogrammetric methods at a scale of 20 ft = 1 in., with the horizontal errors not to exceed 0.5 ft and the vertical errors not to exceed 0.3 ft. The specifications were prepared by Texas Highway Department personnel and proposals were given to photogrammetric engineering firms which had been prequalified by the Texas Highway Department and had at least one of several accepted "first order" plotting instruments. It was further stipulated that any firm wishing to do the work must have a responsible representative attend a conference to review the specifications and ascertain the exact intent of each item prior to letting a contract.

At the conference, those in attendance were given the opportunity to object to any provision in the specifications considered unreasonable, and the group decided as a whole if it was necessary to make a revision. There were surprisingly few things the photogrammetric firms found impossible or unreasonable in this conference with their associates.

The proposal for the photogrammetric project consisted of the usual Texas Highway Department "Standard Specifications for Aerial Surveys and Photogrammetric Maps" containing nine items covering the method of handling the contract and prosecution of the work, and "Special Specifications" consisting of fifteen sections which detailed requirements for the specific work and materials to be furnished.

The sections of the "Special Specifications" were numbered and titled. Section 1, "Areas to be Mapped," designated five areas labeled A through E. Two of these areas were 2,000 ft wide, one area 2,400 ft wide, and two areas 1,200 ft wide. The areas 2,000 ft and 2,400 ft wide were interchange areas and were almost square. The normal width of the project was 1,200 ft which required two flight widths.

Determinations of the sizes and locations of the areas were made from a small-scale aerial photographic mosaic on which a layout of the roadway had been drawn. It was decided in the early development of the method of using data photogrammetrically obtained as field notes for property ownership deeds that it would be necessary to show all four corners of a block in a subdivision from which any property was to be obtained in order to properly complete the survey into which the individual tracts would be tied. As a result, an area 1,200 ft wide was required. Experience with the method

has since proved that this is not necessary and maps purchased for the same purpose are now being used which cover an area 760 ft wide. The reduction of the map size to provide coverage with one flight width allows substantial savings in the cost.

Section 2 of the specifications, "Maps to be Furnished," detailed which areas were to be developed as contour maps, in full or in part, and which areas were to be developed as planimetric maps only. Contours were specified for the interchange areas and spot elevations for cross-sections were specified for the remaining areas.

Section 3, "Contents of the Planimetric Maps," set out details which must be shown on the maps. An exception was allowed in this section which is not now permitted—"the planimetric features must be visible on or interpretable from the photography." It has been found from experience there should be a field edit of a project of this type and it is not an extravagant expense. Details of how the drainage, wooded areas, and coordinates were to be shown on the map were given in this section; also, the indexes for the map sheets were specified.

Section 4, "Contents of Topographic Map," required the elevation data to be shown either by contour lines on a base map which is the same as the planimetric map, or by spot elevations to be shown at designated points with errors not to exceed 0.25 ft. The grid was designated for this project to be on the State Plane Coordinate System. An index of the topographic maps was also required.

Section 5, "Drafting," Section 6, "Planimetric Maps," and Section 7, "Topographic Maps," specified requirements for drafting, sheet size, reproductions and similar details for both the planimetric and topographic maps.

Section 8, "Ground Control," and Sections 9 and 10, "Accuracy of Planimetric Maps" and "Accuracy of Topographic Maps," are probably the three most important sections of the "Special Specifications." The horizontal control was required to meet second order accuracy and the vertical control required to meet third order accuracy, tied to surveys of first or second order accuracy of the U. S. Coast and Geodetic or U. S. Geological Survey. Station markers and bench marks were monumented by concrete markers with a bronze disc properly labeled.

Field notes of the horizontal and vertical control were furnished in the original field books and on IBM cards for quick checking. Sketch maps showing the location of all monuments were also required. The specified accuracies of the maps were based on the requirements that all defined cultural features were to be mapped, in their correct horizontal grid position, with errors not to exceed 0.5 ft. Ninety percent of all elevations interpolated were to be correct with errors not to exceed 0.3 ft and the remaining 10 percent with errors not to exceed 0.5 ft.

Section 11, "Cross Sections," required 90 percent of the points shown to have a vertical accuracy of 0.2 ft and the remaining 10 percent not to exceed an error of 0.2 ft. Horizontal accuracy of the points was to conform with requirements for accuracy of planimetric maps.

Section 12, "Methods of Testing," and Section 13, "Negatives and Photographs," were of the standard type specification for these items. Section 14, "Delivery Schedule," and Section 15, "Payment," established the schedules for delivery of the photographs and maps and payment for the work and materials.

The specifications included a map of the areas designated and a "Table of Symbols".

The project was contracted for on April 16, 1958. Total price for the project was \$ 120,000 or \$ 11,760 per linear mile 1,000 ft to 1,200 ft wide, with a completion time of 200 calendar days.

The work on the project was carefully checked by the Texas Highway Department District Office personnel as rapidly as possible after it was delivered by the photogrammetric engineering firm. No major errors were found and most of the minor discrepancies were the result of the lack of a field edit, which was not required by the specifications.

As a part of the method developed to use this information in preparing right-of-way maps and deeds, the City of Dallas made available to the Department previously established survey points at or near the center of each street intersection. These points are part of a survey system established and maintained by the City of Dallas. Each point was paneled prior to taking the aerial photographs for the photogrammetric project and were shown on the completed maps.

The plats of the subdivisions through which the project was to be developed were obtained for use in checking the maps. It was found that the panel points plotted by this method and those plotted from the data furnished by the City of Dallas were in remarkably close agreement. All were well within the tolerances of a second order survey. It was also found that the plats of the subdivisions and the planimetrics of the photogrammetric maps conformed throughout the project with few or no discrepancies.

The corners of each block having been established from the panel points and the subdivision plats, the property lines of each parcel involved in the right-of-way considerations were checked according to the deeds recorded and on file. The latest records of the deeds were photostated or the deed description copied on card forms and furnished to the Department to be used for plotting the property lines in the District Office.

In order to determine the properties involved in the right-of-way considerations, the generally proposed geometric layout for the highway was plotted on the subdivision plats. A copy of this map was made available to the abstract company scheduled to handle the abstract work and title insurance for the project. The abstract company furnished, as a part of the contingencies, the deed information.

A field edit was then made by engineers of the Texas Highway Department to study the improvements included in the proposed right-of-way and to make brief notes on a work copy of the map. This information was very valuable in the final determinations of the geometrics and design with regard to the estimated cost of the real estate involved. Such things as retaining walls versus slopes had to be determined. In some cases, this meant working up cost estimates on the retaining walls and having appraisals made on the additional right-of-way required for slopes. It also meant adjusting a ramp or changing the design of a fill to avoid a major right-of-way expense.

An important advantage to this method was the accurate property map developed with a speed which allowed the design engineer early consideration of all these factors, and many delays experienced in the past while waiting for information from which to make a decision were avoided.

After the geometrics had been definitely established and design features which affected right-of-way had been decided on, the exact right-of-way lines were drawn on the planimetric map.

Appraisers were then given work sheets which were prints of the area of the parcel they were to appraise. The parcel was designated by pencil shading. Copies of these sheets were also made for the property owner.

A new deed was then prepared using the deed description from the record and property survey notes scaled from the map. The new deed description was written to define clearly the property to remain and should the property owner wish to have a survey of his own made on the ground, it could affect the right-of-way line a maximum of 6 in.

The area in which this method was first used involved over 300 parcels. To date there remain less than 20 parcels to be obtained and no major problems have developed. Most of the remaining parcels are in condemnation proceedings.

The Texas Highway Department has since contracted for photogrammetric data to be developed for a project 4.3 mi long with about the same accuracy requirements, but with the width limited to 760 ft and with elevation data shown as contours only. This project was contracted for in February 1959. The per mile cost of the project was \$3,194 as compared to the original \$11,760 per mile paid for the area 1,200 ft wide. This contract is now complete, and although all phases of the project have not been developed, no major changes in the method are anticipated. The survey points established by the City of Dallas for this area were not recovered and paneled; as previously stated, these points had proved to be unnecessary.

The specifications for this second project are considered adequate as the project completed under these requirements has received warm approval from the engineers closely associated with it in the Dallas District Office. The contract price paid for the project is also considered very acceptable, and as it is the intention of the Department to use these specifications for a guide in future projects of this type, they are given in the Appendix for reference.

At the same time this method for using data photogrammetrically obtained to prepare right-of-way maps and deeds was being developed, maps were contracted for in other parts of the state to be prepared photogrammetrically with the ownership of the property in the entire map area to be plotted by the photogrammetric engineering firm. The requirements were usually for the ownership data to be prepared as an overlay to a planimetric map. The property lines were plotted in accordance with the deeds on record as of a certain date. The required accuracy of the base map was specified according to the general purpose for which the map was to be used and the ownership overlay was never required to be more accurate than the base map.

The information obtained on these overlays proved to be little more than a tabulation of the property owners which could be obtained directly from the records or from a local abstract company more economically.

The Texas Highway Department will continue working on methods and requirements of specifications for photogrammetric projects to try to reach the ultimate economic point in using data photogrammetrically obtained for the development of right-of-way maps and field notes for deeds. It was realized that one of the projects in the City of Dallas was somewhat unique in the amount of control provided by the surveys maintained by the city; however, the method is feasible for areas which require more field checking of plats and tying in previous surveys. Many of the errors of the original field surveys will become apparent on the maps and can be quickly proved in the field if necessary.

There are additional benefits from a map of the accuracy required for preparing deeds which are beginning to develop with the design studies and plan preparation of the projects. These benefits are considered by some of the design engineers using these maps as essential to the type of information they want on any future maps prepared by photogrammetric methods for their use, regardless of whether the intent is to develop right-of-way maps and field notes for deeds from the data or not. In view of the favorable price paid for the second project of this type in the City of Dallas, the additional benefits of large map scales and high orders of accuracy will be a factor to consider in determining requirements for any maps to be made of heavily developed urban areas by photogrammetric methods.

Appendix

TEXAS HIGHWAY DEPARTMENT SPECIAL SPECIFICATIONS FOR AERIAL PHOTOGRAPHS, PHOTOGRAMMETRIC MAPS, AND MOSAICS

Section 1. Area to Be Mapped

The maps and photographs to be prepared and furnished the Texas Highway Department in accordance with these specifications shall cover an area from near Loop 12 to Clarendon Drive in Dallas, Texas, as approximately outlined on the attached sketch for bidding purposes and further designated by the Texas Highway Department as Control 442, Section 2.

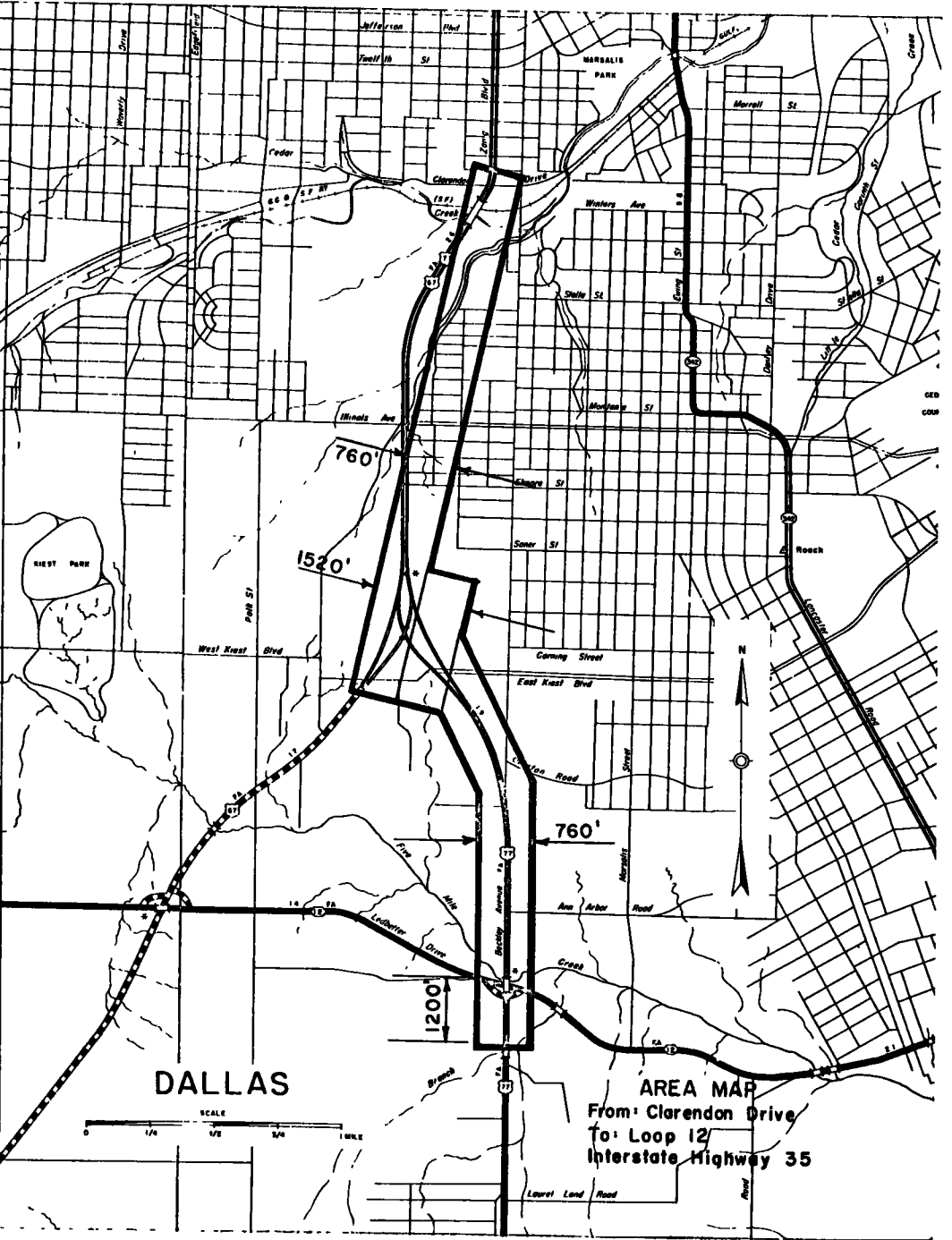
Section 2. Maps, Mosaics and Photographs to Be Furnished

(a) A topographic map manuscript and a positive copy thereof on Du Pont Matte Cronar 0.004 in. thick at a scale of 1 in. = 20 ft with a 1-ft contour interval and a planimetric map positive on Du Pont Matte Cronar (0.004 in. thick) before elevations are plotted, at a scale of 1 in. = 20 ft, are to be furnished of the area generally outlined on the attached sketch.

The positive reproductions will under no conditions be enlargements of the map manuscript.

(b) One semi-controlled mosaic shall be furnished of the area covered by the photogrammetric maps at a scale of 1 in. = 50 ft.

(c) One set of contact prints providing full stereoscopic coverage and index maps shall be furnished of the entire designated area.



AREA MAP
From: Clarendon Drive
To: Loop 12
Interstate Highway 35

Section 3. Contents of Planimetric Maps

(a) **General.** The maps shall contain all planimetric features which are visible or identifiable on or are interpretable from the aerial photography, including land use features such as buildings, canals, ditches, reservoirs, trails, roads (highways), rail roads, quarries, borrow pits, cemeteries, orchards, boundaries of logged-off areas and wooded areas, and individual, lone large trees that can be recognized as such; and all telephone, telegraph, and electric power transmission line poles and/or tower underground cables, pipe lines and sewers, fence lines, billboards, rock and other walls, and similar details of land use. Structures such as bridges, trestles, tunnels, piers, retaining walls, dams, power plants, transformer and other substations, transportation terminals and airfields, oil, water and other storage tanks, and the like shall be shown. These shall be shown where they occur in addition to all other land use features; sidewalks, parking strips, driveways, fire hydrants, manholes, lamp posts and similar features. The backs of all curb lines shall be plotted.

Buildings and similar dimensionable objects shall be correctly outlined and oriented and shall be drawn to proper scale.

The contractor shall place on the map the names of such streams, streets, roads, towns, etc., as can be secured.

The contractor shall show by proper symbol the principal points of each model in their exact position on the map manuscript and on the positive copies thereof.

(b) **Drainage.** Drainage lines shall be shown by dash and three dot symbols for all well-defined drainage features indicated when the drainage feature is $\frac{1}{10}$ mi or more length.

All drainage lines shall be stopped at a distance of at least 40 ft from the ridge line. Streams shall be shown double line; each shore being indicated by the dash and three dot symbol. The shore line of small ponds shall also be shown by the drainage line symbol and the interior lightly hatched in ink. Where drainage is known to exist, and where depressions are noted, such culvert and bridge end walls as can be seen in the original photography, or are known to exist, shall be shown on the map.

(c) **Wooded Areas.** Woodland outlines shall be carefully and accurately delineated. The width of clearing bands along all power transmission lines shall be accurately shown. Woodland lines must be in exact position, especially where the boundary is a road, railroad or transmission line right-of-way. Free standing trees with crown diameters greater than 10 ft shall be shown by an acceptable conventional symbol.

(d) **Coordinates.** Grid lines shall be shown as grid ticks from inside border to inside border at 100-ft intervals conforming to the State Plane Coordinate System.

(e) **Indexes.** The contractor shall furnish one complete index of the area defined on the attached sketch map, of the planimetric maps on Du Pont Matte Cronaflex (0.001 in. thick) showing proper orientation of each sheet. There shall be fixed on the index map sheets a north arrow, and the approximate position of each tenth numbered coordinate grid line. The scale of this map shall enable the contractor to represent diagrammatically all map sheets on one sheet of the size stipulated for finished maps in the proposal schedule.

Section 4. Contents of Topographic Map

(a) **General.** The base map showing all cultural features and the grid coordinates will be the same as the planimetric map manuscript. Relief features will be superimposed on the base map to form the topographic map manuscript.

(b) **Relief.** Elevations shall be based on United States Coast and Geodetic Survey datum and relief shall be shown by 1-ft contour lines. All contours shall be drawn clear and sharp with a continuous solid line except through buildings or drainage structures. Each 5-ft contour shall be accentuated and numbered. Contour numbers shall be shown at intervals not to exceed 10 in. measured along the contour line. Elevation of all road intersections, roads and railroad intersections, saddles, summits, depressions, the water level on the shore lines of all streams, drainage canals, lakes, reservoirs, ponds, etc., and the centerline of each bridge end and like structures of importance in highway engineering, shall be shown accurately within 0.25 ft of the correct elevations.

Section 5. Drafting

All drafting on the map manuscript will be of the highest standard of workmanship. The manuscript shall be scribed. All lettering shall be mechanical, neat and legible with the style in accordance with standard map practice and with weight and size relative to the importance of the physical features. The general appearance of the maps and the quality of the drafting shall be consistent from sheet to sheet. Standard symbols and line weights will be in accordance with Table "A" of these Special Specifications, or as directed by the engineer.

Section 6. Positive Reproductions

The positive reproductions of the manuscript furnished for the topographic and planimetric maps shall be on sheets with a maximum size of 40 in. wide and 96 in. long. Detail sheet sizes will be as directed by the engineer. Where sheets join there shall be a minimum lap of 2 in. and there shall be match marks within the areas of the lap on each positive reproduction. There shall be in the lower right-hand corner of each sheet a title block, the size and information contained as directed by the engineer. The Du Pont Matte Cronar positives shall show all the details of the manuscript and shall be clear of blemishes, discoloration, scratches or marks that might in any way reduce usefulness during reproduction processes.

Section 7. Ground Control Surveys

It will be the contractor's responsibility to establish second order horizontal ground control and third order vertical control as required. The survey shall be tied to the State Plane Coordinate System and monumented at not greater than $\frac{1}{2}$ -mi intervals, such as monuments as may be required shall be so located that each consecutive monument shall be intervisible.

(a) Description. Ground control shall consist of determining the ground position of pertinent data on existing triangulation and traverse station monuments and bench marks, known as the basic control, the making of surveys to determine the position of all station markers and the elevation of all bench marks set on the project and the making of essential ground control surveys for the establishment of horizontal and vertical control for the stereophotogrammetric mapping which the contractor shall do by the use of aerial photography.

(b) Requirements.

1. **Origin of Basic Control:** Primary ground control surveys shall be based on and adjusted to the basic control specified. Such basic control will consist of first or second order work of the U. S. Coast and Geodetic Survey, the U. S. Geological Survey or other competent agencies or parties who engage in making basic control surveys. The Texas Highway Department makes no guarantee of either the accuracy of the position, elevations or the physical existence of the basic control monuments and bench marks. All information available about the existing basic control shall be made known to the contractor, but the responsibility shall be his to obtain and use this information.

2. **Horizontal and Vertical Control:** Standard ground survey methods necessary to obtain the accuracies specified shall be used; these may include triangulation and traverse for horizontal control, the spirit levels and precise vertical triangulation for vertical control.

All control surveys shall originate and end on the basic control for which closures are known and available or shall be run to make a closed circuit.

All station markers and bench marks set for this project shall be included in and tied to the control survey. Horizontal and vertical control stations and all points needed by the Department prior to flying shall be accurately shown and identified on the photogrammetric maps. Station markers and bench marks shall be concrete having dimensions of not less than 6 in. in width and 3 ft in the ground with bronze markers. Bronze markers are to be supplied by the Texas Highway Department. Monuments shall be placed at points as directed by the engineer.

The contractor may use whatever methods are feasible and practicable to establish the supplemental horizontal and vertical control needed for scale adjustment and orientation of the aerial photographs in the stereophotogrammetric mapping operations; such methods, however, shall be precise enough to establish control commensurate with map accuracies required.

3. Accuracy: For the purpose of these Special Specifications the order of accuracy shall be as listed below. Maximum error of closure for this project, before adjustments are made, shall be wherein N is the number of angles between tangents of the traverse and M is the length of the level circuit in miles.

HORIZONTAL ANGLES TRIANGLE CLOSURE

Horizontal Distance	Traverse Lines	Average	Maximum	Vertical Distance
1:10,000	$(10 \text{ sec})\sqrt{N}$	3 sec	5 sec	$(0.050 \text{ ft.})\sqrt{M}$

4. Field Notes: The field notes of the horizontal and vertical control surveys shall be kept in a clear legible manner in bound engineer's field notebooks of standard manufacture. The contractor will also furnish horizontal and vertical control surveys on data processing cards (IBM) which have been punched and verified for the herein specified control survey. The data processing cards (IBM) are to be punched and verified for the herein specified surveys in accordance to instructions as outlined by D-21 of the Texas Highway Department. It will be the contractor's responsibility to contact the Texas Highway Department, D-21 in Austin directly to obtain these instructions and IBM cards which will be furnished by the state. Horizontal and vertical control information, and the data processing cards (IBM) shall be delivered at the same time the contact photographic prints, photo indexes and mosaics are delivered.

5. Records: The contractor shall provide the engineer with a written description and sketches of all azimuth marks, station markers and their references, and all bench marks. He shall also prepare a line diagram sketch map, at an appropriate scale not smaller than 1,000 ft = 1 in., of the network of horizontal control surveys completed for the project. On this map he shall designate by appropriate symbols (See Table "A") representing each kind and their respective orders of accuracy, the existing survey monuments and bench marks, the triangulation network and traverses and station markers and bench marks set on the project. This sketch map shall be appropriately titled and shall contain a graphic scale bar, directional north arrow, and applicable bearing and plane coordinate notations.

6. Materials: All materials and equipment essential for the satisfactory completion of this item shall be selected and furnished by the contractor.

7. Prior Requirements: The state highway department requires that the contractor contact the district engineer's office, Dallas, Texas, before doing any work on this contract. The amount of control, work progress outline of work to be performed and acceptability of weather conditions for the photography of this project will be subject to the approval of the district engineer. If it is determined necessary to delay the photography, such delays will be made and proper credit will be given the allowed contract time.

Section 8. Accuracy of the Planimetric Maps

All defined features checked must fall in their correct horizontal grid position within $\frac{1}{2}$ of 1 ft (0.5 ft).

Section 9. Accuracy of the Topographic Maps and Cross Section Data

(a) Cultural Features. All defined features checked must fall in their correct horizontal grid position within $\frac{1}{2}$ of 1 ft (0.5 ft).

(b) Contours. Ninety percent of all elevations interpolated shall be correct within three-tenths of the contour interval (0.3 ft) and the remaining 10 percent shall not be

an error by more than one-half contour interval (0.5 ft). Where ground is obscured by heavy cover of trees or high grass contours shall be shown as broken or dashed lines.

Section 10. Method of Testing and Inspection

The Texas Highway Department will field inspect and test the sheets as rapidly as possible after receipt from the contractor. The completeness of the cultural and topographic detail will be determined by a thorough inspection in the field. Accuracy tests will be made by the "test profile" method—that is, by running a profile over any section of the map and then comparing the elevations of test points and the horizontal positions of the cultural features indicated on the profiles with those shown on the map sheet when converted to grid position. If the section is rejected, the contractor will be required to bring it to proper accuracy at his own expense within 20 days after notification of rejection. In all cases, the highway department reserves the right to select the areas to be tested.

The highway department shall be allowed 30 days after receipt of each map for acceptance or rejection. The contractor shall be notified of acceptance or rejection within this period. This period is not included in the contract time.

In addition to field inspection and testing, the highway department reserves the right to inspect any and all phases of the work at any time.

Section 11. Photographic Mosaic

The contractor shall furnish one copy of a semi-controlled mosaic for the full coverage of the contact prints at a scale of 1 in. = 50 ft, using all of the contact prints.

The mosaic shall be an assembly of scale ratioed aerial photographs matched and mounted to form a photographic mosaic, a copy photographic print thereof and negatives of the photographic prints. The photographic prints shall be on single weight, semi-matte photographic paper and linen backed. The negatives will have a 1:1 scale with the prints. Linen backing shall be of durable grade sufficient to withstand considerable handling of the mosaics. The linen backing shall be Commodore Blue Print Cloth, E-D White, as manufactured by Special Fabrics, Inc., Saylesville, Rhode Island, or equivalent. The edges of the mosaics shall be bound with edge binding plastic tape.

All photographs used in the assembly of the mosaics shall be of such quality that the finished mosaic shall have fine grain quality, normal uniform density, and such color tone and degree of contrast that all photographic details show clearly. Color shall be uniform from one photograph to another. Abrupt changes in color will not be permissible and lines shall not show where the photographic images of the separate photographs join each other. Variation from scale shall be equivalent to, or better than, one part in five hundred (1:500). Prints shall not be more than three diameters larger than the negatives of the original photographs made for the project. Any two adjacent prints of the mosaic shall not be mismatched by more than $\frac{1}{20}$ of an inch.

All prints shall be clear and free from chemicals, stains, blemishes, uneven spots, ripples, light fog or streaks, creases, scratches and other defects which would interfere with their use or in any way decrease their usefulness.

The contractor shall place on the mosaic north arrows, title blocks and the names of the major streams, streets, roads, highways, towns, etc. The length of the mosaic sheets shall be a maximum 5 ft in length with 12-in. overlap on each sheet as designated by the engineer.

Section 12. Negatives and Photographs to Be Furnished

All photographs furnished the Texas Highway Department in accordance with this proposal shall be made from a new flight subsequent to the date of contract.

The contractor shall identify all negatives with the date of photography, code letters identify project, film roll and negative number, and shall place on the film strip the time of day exposed. The negatives will be labeled in either a northerly or easterly direction.

The contractor shall furnish one complete set of photographic contact prints on semi-matte double weight paper. The prints shall be sufficiently overlapped to permit stereoscopic study of the entire area.

The contractor shall furnish two copies of a photographic index map at a scale of 1 in. = 40 ft to readily permit the selection of prints covering any part of the project on semi-matte double weight paper. Photographic index maps should show street names at maximum 9-in. spacing to aid in orientation.

All photographs shall be clear, sharp, free of blemishes, discoloration, chemicals fog or uneven spots, light streaks, creases, scratches and other defects which would in any way reduce their usefulness.

On the back of each photographic print delivered and in the same corner as the photographic number appears on the image side, there shall be stamped: Property of the Texas Highway Department, the name and address of the contractor, the focal length in millimeters of the aerial camera and the shutter opening used. Prints of vertical photography shall also be stamped with their approximate scale.

Section 13. Delivery Schedule

Contact photographs, photo indexes and mosaics shall be delivered to the Texas Highway Department, at the address specified, within 70 days after completion of flying.

The cronar positives of the map manuscript shall be delivered as rapidly as they are completed.

The contractor will deliver all materials under this contract to Mr. Frank W. Cawthon, District Engineer, P.O. Box 3067, Dallas, Texas, within 180 days after the work order is issued.

Section 14. Payment

Partial payments not to exceed one payment per calendar month, may be made on the following basis as the work progresses:

(a) Twenty percent of the contract bid price will be paid on delivery and acceptance of the contact prints, photo indexes, mosaics and control data with punched IBM cards.

(b) Seventy percent of the contract bid price will be paid on delivery and acceptance of the planimetric and topographic maps. In the case of progressive shipments the payment for each shipment will be made on the ratio of the number delivered and accepted as to the number required. It is not required that the manuscript be delivered at this time.

(c) The remaining 10 percent will be paid on delivery and acceptance of the map manuscripts and acceptance of all work; the delivery and approval of all material required under these specifications and bid proposal.