Photogrammetric And Land Surveying For Cross-Country Right-Of-Way

By Herbert G. Koogle

In the mid 1960s during the formative years of our organization, we became aware of the multitude of sources for error in the conventional methods of surveying for right-of-way acquisition relative to the construction of cross-country transmission facilities. The right-of-way survey requirements for high voltage electric transmission lines and for cross-country pipelines are essentially identical, and it became our judgment that the conventional methods did not provide an adequate redundancy of information to permit the usual mathematical checks, balances and closures normal to survey data processing.

The conventional methods were to establish a project survey centerline, generally extending from one point of intersection to the next between the two ends of the line which usually are a sub-station, generating plant, or a pumping station. Property corners and cadastral corners from the Public Land Surveys are recovered adjacent to the line and measurement made by angle and distance from a point on the survey centerline to the property corner. It would be only rarely that property corners would be related to the survey centerline by a measurement from two different points, thereby providing a data redundancy for computationally proving the accuracy of the measurements.

This had another disadvantage in that the time required to make the field measurements, particularly in broken country or over terrain with moderate to heavy vegetation was time consuming and thereby less accurate and yet expensive. This situation stimulated thinking along the lines of combining the measurement technique of photogrammetry with the field land surveying to develop a unified system of surveying,utilizing the photogrammetric measurements to supplement the field surveys and provide adequate data for total right-of-way maps and descriptions suitable for the acquisition of easements or the conveyance in fee simple of right-of-way.

To those not totally familiar with the photogrammetric process, one characteristic needs to be described, which is vital to an appreciation of the accuracy and data checking characteristic which offered an improvement over the conventional procedures. A photogrammetic "model" is composed of the overlapping area of two sequential photographs which produce a stereoscopic image in the photogrammetric plotting instrument. When this model has been properly formed in the instrument, a check is provided on the field survey control. That is, should an error exist of any substantial magnitude, usually a foot or more, these discrepancies can be determined in a quantitative matter, and consequently alerts the necessity to check computations and if necessary, field survey data, to locate the source of discrepancy. Therefore, it can be seen that once the survey control is established and the photogrammetric process related accurately to the control, we then have available a system which provides the ability to derive a great quantity of survey as well as mapping information with a very high degree of accuracy and reliability.

On the first project performed by our organization using this process, the photogrammetric determination of plan information and transmission line profile was required. The photography covered a usable width on either side of the survey centerline of about 3,500 feet. Using the photogrammetric "models" sequentially along the line, the property and cadastral corners were identified and coordinate positions determined for these points. This then provided positional information related to the project centerline, which in turn is usually related to the State Plane Coordinate system for all recovered property corners and cadastral monuments within a width of about one and one half miles centered on the survey line. Utilizing a versatile coordinate geometry program on a reasonable powerful computer, it becomes a relatively easy task to compute from these positional coordinates for corners the stationing of the centerline where it intersects the property or cadastral lines, then the necessary dimensional information to indicate the property corner ties.

Following upon the implementation of this system using standard photogrammetric plotting instruments, we undertook a reasonable number of field checks and satisfied ourselves that the data derivation was not only sound, but well within the accuracy limits needed. In fact, it was our judgment that the accuracy exceeded the normal accuracy standards for chaining, unless done very carefully, and certainly that of stadia or tacheometric linear measurement techniques.

Having established the efficiency and effectiveness of the use of photogrammetric measurements to augment field survey control, there came about the implementation of analytic photogrammetry which improved the accuracy by reducing the derived standard error for positional determinations by as much as one half to one third. This is the equivalent of increasing the accuracy by a factor of between two and three times. An additional efficiency came about in the procedure for derivation of photogrammetric information, in that the information from the analytical triangulation process does not require the setting of photogrammetric "models" in the plotting instruments and therefore can be done quickly upon the completion of the data processing of survey control and the establishment of traverse information from the survey

In further implementation of the system, we have designed two levels of redundacy. The survey centerline takes the form of a traverse which is initiated and terminated as often as possible on geodetic control points established by either the National Geodetic Survey or the U.S. Geological Survey for the most part. These traverses are based upon the State Plane Coordinate System, which is uniquely adaptable for the maintenance of mathematical integrity for traverses running for long distances, in some instances up to 25 to 30 miles between controlling points. The traverses are closed to the published government control and are run with one second theodites and utilize laser carrier electronic distance measuring equipment. Generally, the closures are quite good and provide a solid foundation upon which to base a photogrammetric measurement for the derivation of right-of-way information. The analytical triangulation process in itself will bring to light any significant defect in the survey that would somehow or another not be apparent after the perfection of the mathematical closures, namely the possibility of compensating errors. Having established the aero-triangulation, which is known in the profession as "Bridging," the positions of identified property and cadastral corners are then derived not only with accuracy, but with complete confidence that the coordinate information conforms to a very high standard of reliability.

It would be of interest to note that the term "bridging" has to do with the fact that the analytical triangulation process mathematically ties together a series of overlapping stereoscopic aerial photographs and positions this series of photographs to a minimum number of ground control points. These points are at the beginning and ending of the flight series with a few selected points in the middle. Therefore, it becomes similar to establishing the floor of a "bridge" upon abutments, which are formed by the survey control. Having built the "bridge" in this manner, it is then possible to derive coordinate information from any image points which are established on the "bridge," and because of this integrated system the high standard of reliability is obtained.

It should be noted that to improve upon the accuracy of the system, most traverse points, both points of intersection (P.I.'s) and points on tangents (P.O.T.'s), are premarked on the ground with a white plastic material so as to make them positively identifiable in the aerial photography. The panel material provides a discrete image point which under magnification allows a technician to make a positive identification of the point, and to perform measurements of the point with a high degree of precision. The recovered property and cadastral corners are also panelled on the ground so as to make their image positions in the aerial photography positively identifiable, and the measurements made to these points carry the same degree of photogrammetric precision as to the basic control traverse.

Data derived from the photogrammetric measurements for property and cadastral corners are then compared to record information from the title research and from the Government Land Survey plats and field notes. In almost every instance, a full correlation is possible. With regard to older public land survey systems, it is possible to establish a systematic "scaling factor" of the old surveys. For example, if a survey has been performed with a chain that was slightly out of calibration by making several position determinations within a township, the extent of this error in calibration of the chain can be closely approximated, and a high degree of correlation obtained. This information is then used as input data for a very comprehensive coordinate geometry program in a PDP-1134 computer which provides the necessary information for establishing "tie" information to cadastral corners by computing P.I.'s of property and cadastral lines with the survey centerline, and all other survey information required for a complete right-of-way map and the preparation of property descriptions.

While the system may sound at first somewhat complicated, the basic principles are straight forward and we have found it to be an efficient and accurate method of delineating right-of-way. The system is efficient in obtaining the necessary and increasing amount of land survey information in a time when property values are rising at a rapid rate and accurate right-of-way descriptions are becoming more critical to a successful project.

Association Calendar

Liaison Committee/TRB	Jan. 13–14	Washington, D.C.
Membership & P.R. Committee	Jan. 21–22	Phoenix, AZ
Environment Committee	Jan. 21–23	Phoenix, AZ
Executive Committee	Jan. 22–23	Phoenix, AZ
Region 2 Forum	Jan. 30	Irving, TX
Highways/Mass Transit Subcommittee	Feb. 4–6	Washington, D.C.
Utilities Committee	March 11–12	New Orleans, LA
Region 1 Forum	March 12–13	San Luis Obispo, CA
Property Management Committee	March 15	Austin, TX
Education/Professional Development Committees	March 16–21	Nashville, TN
North American Conference of Appraisal Organizations	March 26–27	Chicago, IL
Region 7 Forum/Seminar	March 26–27	Boise, ID
Nominations & Elections Committee	April 13	Toronto, ONT
Executive Committee	April 21–24	Charlotte, NC
Pipeline Committee	April 23	Tulsa, OK
Region 5 Forum	April 23–24	Wheeling, WV