NUMERICAL METHODS FOR RADIAL TRIANGULATION

By

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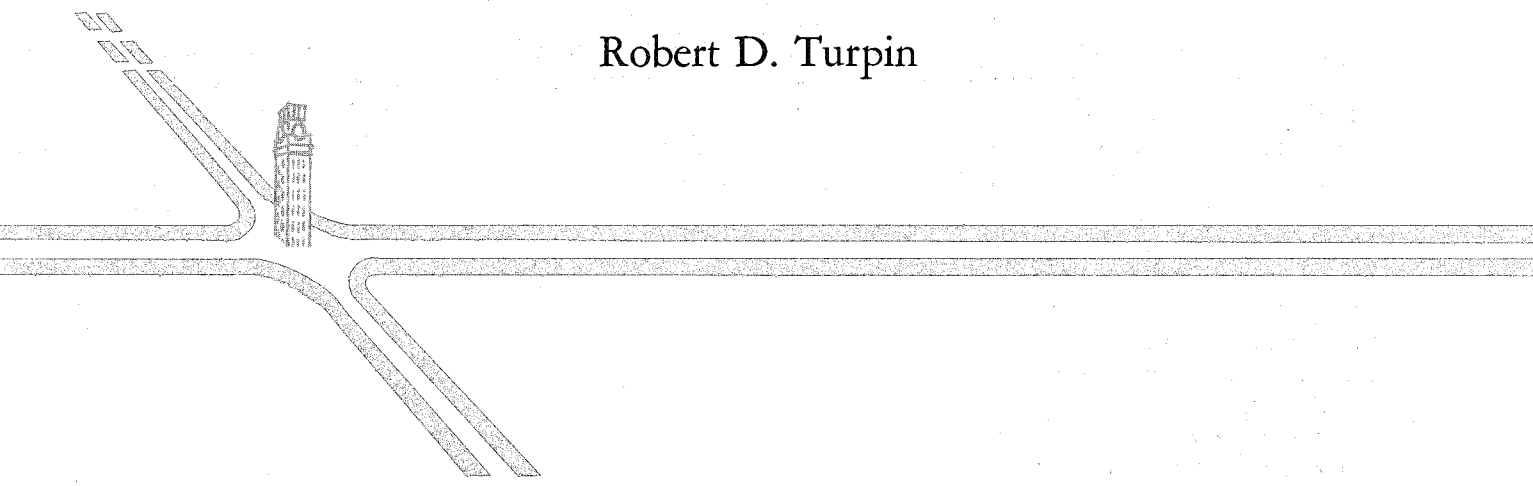

SUMMARY REPORT 79-1F(S)

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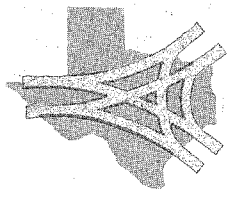

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In the use of aerial photography for the preparation of maps, some ground surveys (usually referred to as control surveys) are needed in order to determine the scale and the orientation of the photography. There are a number of satisfactory methods of obtaining the necessary ground control but these methods are usually time consuming and often prove to be quite expensive. Thus, any procedure whereby some of the ground-control surveys could be eliminated or minimized would be desirable from an economy standpoint. One means of achieving this saving is by *aerial triangulation.*

Aerial triangulation is the process for the extension of horizontal and/or vertical control whereby the measurements of angles and/or distances on overlapping photographs are related into a spatial solution using the perspective principles of the photographs. One form of aerial triangulation is termed *radial triangulation,* wherein the horizontal positions of pass points are determined by angle measurements made on the photograph with the angle vertex at the "center" of the photograph.

The photographic measurements for the radial triangulation procedure may be obtained with any of several types of instruments. Since the data as presented in the calculations are in the form of angles or directions measured at the principal point, the data can be utilized more readily if acquired directly in this form. However, since instruments for measuring angles in this manner usually are not readily available, other types of equipment which can be used to measure coordinates in an orthogonal system are quite satisfactory. The simplest method would be to use a linear measuring device (such as a finely calibrated glass scale), although more sophisticated equipment (such as the heavy plotters and monocular comparators) generally would be more desirable.

Two basic principles are involved in this radial triangulation process—resection and intersection. If three control points (with horizontal positions known) can be identified on a photograph, then the resection principle can be used to determine the position of the ground object imaged at the principal point by using the angles measured at the principal point to the three control-point images. By use of control points selected within the overlap area of two overlapping photographs, the coordinates of the principal point of each photograph can be determined from these three control points.

Once the ground coordinates of the principal points of the first and second photograph have been determined, these points become the terminals for a base line connecting these two photographs, and, if angles are measured from the principal points to other points identifiable on both photographs 1 and 2, the ground coordinates of these other points may be computed by the intersection principle.

An outline of the procedure is given below:

1. Identify and mark the principal point and at least three control points with known horizontal coordinates in photographs 1 and 2 of a flight strip.
2. Identify and mark three pass points in the overlap area between photographs 1, 2, and 3 on the first three photographs of the flight strip.
3. Measure the coordinates on each photograph of the control points and of the pass points using the principal point as the origin of the coordinates on each photograph.
4. Convert the measured coordinates into angles or directions from the principal point to each of the control points and of the pass points.
5. By the resection principle, solve for the ground coordinates of the principal point of photograph 1 and the principal point of photograph 2, using the angles at the principal points and the known horizontal dimensions for the three control points.

6. Using these computed ground coordinates for the principal points of photograph 1 and photograph 2, apply the intersection principle to determine the ground coordinates for the pass points for photographs 1, 2, and 3.
7. Using the ground coordinates for the pass points as determined in step 6, apply the resection principle to determine the ground coordinates of the principal point of photograph 3.

A computer program was developed to carry out the necessary calculations used in evaluating radial triangulation.

Four sets of photographic data, each utilizing 6 to 10 photographs in a strip, were used to test the computational procedures outlined above.

Three conclusions were developed from this research study:

1. The distribution and spacing of the control points and the pass points constitute very critical considerations in numerical radial triangulation for extending horizontal control.
2. Errors in the horizontal position of the pass points do not increase significantly as the distance is increased between the initial control points and the pass points.
3. Small amounts of tilt in the photograph (i.e., less than 1°) do not cause appreciable errors in the computed position of the pass points.