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# Are Three Pointings Necessary?

## Aerotriangulation tests showed that, using A-7 and A-8 plotters, the accuracy did not improve.

### Introduction

A physical measurement of a quantity is unable to provide a true value because it always contains errors due to the imperfection of the measuring instrument and human visual effect. However, the most probable value of that particular set of observations can be determined by the mean value of a limited number of measurements. This is the well-known Gaussian theory of errors.

Photogrammetric measurements in aerotriangulation are conducted basically to determine the spatial positions from photographs, therefore, any error in a measured coordinate directly affects the final ground coordinates. The general practice to increase the accuracy of the triangulated points at the Washington State Highways Department, as well as in many other organizations (Hallert[4], Harris[5], Karara[6]), is to make three pointings, read each time and take the average values for each measured point. Certainly some improvement in the accuracy should accrue but apparently little significant improvement occurs (Wiser[2], Gracie[3]).

In order to clarify the possibility of improving the accuracy of the triangulated points with three readings and to hold to uniform procedures in the Washington State Highways Department, it therefore seemed useful, important and advisable to complete an experimental test of several readings for each model point in aerotriangulation.

Abstract: *In order to clarify the possibility of improving the accuracy of triangulated points with several readings, an experimental test comparing a single setting with a series of three settings on each model point at the flight of 1500 feet was conducted by the Washington State Highways Department. The results have shown that the accuracies did not improve by increasing the readings.*

### Experiment Test

A test model taken at a flight height of 1500 feet with a Wild RC-8, $f=6$ inch camera was chosen. The test area is located at elevations of 90 feet to 260 feet. A total of 15 ground control points were targeted with white bars in the dark background and established by traverse and precise levels with first-order accuracy standards. The distribution of the ground control points of the test model is shown in Figure 1.

All points in the test model including six artificial points (PUG) were measured by two photogrammetrists using the Wild Autograph A-7 and A-8 plotters respectively. The coordinate measurements of the model point were first set three times and recorded automatically. After completing the main series of measurements of all points, a single reading of each point was taken. The numerical computation of the averages of the three readings of the measured coordinates, as well as the linear transformation adjustment of the model coordinates to ground coordinate systems with three control points, have been calculated by using a small computer program. The residuals and residual standard errors at the ground control points, that were not used in the adjustment and served only as check points, were computed separately with single, mean readings of the A-7 and A-8 plotters respectively, as shown in Table 1 and Figure 2.

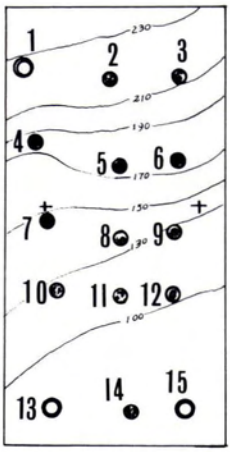


FIG. 1. Tumwater test model.

## COMPARISON OF THE RESULTS

Figure 2 shows that the accuracy does not improve with increased readings. The residuals standard errors of the coordinates in Easting, Northing and Height are ±0.05 ft., ±0.07 ft., ±0.09 ft for single reading and ±0.08 ft, ±0.06 ft, ±0.09 ft. for mean readings of A-7 plotter measurements; and ±0.07 ft., ±0.08 ft., ±0.09 ft for single reading and ±0.07 ft., ±0.05 ft., ±0.08 ft. for mean readings of A-8 plotter observations. The average standard error in E, N, H coordinates of these data is ±0.07 ft. or 6 $\mu$m on the photograph. The average standard errors of the differences between the mean and single readings of the artificial points are ±0.01 ft; ±0.03 ft, and ±0.08 ft in E, N, H coordinates respectively. The computed residuals of the check points and PUG points scarcely exceed three times the value established from the standard error, and all residual errors are distributed within this limit of interval. The residual errors of the photogrammetrically transformed coordinates depend upon numerous contributing factors. These factors are the flight height, quality of the photograph, quality of the photogrammetric processings, quality of the ground control surveys, type of targets, the large number of numerical data processing methods, and the skill and ability of personnel performing the work. If the measurement of the model points is repeated, the residual error is repeated and the effect on the final coordinates is duplicated in the same order of magnitude of the interval, thus affording no improvement in the accuracy.

A number of formulas have been used in the past to determine the tolerances of the interval of the photogrammetric accuracies. Recently, discussion of these formulas as given by Hou[7] suggest that the attainable accuracy is proportional to height, i.e., the standard error of the given flight height in strip aerotriangulation would be $0.08 \times 10^{-3}$ times the flight height in feet. But it is found empirically in the present case that a single model is better expressed by:

$$S = 0.04 \times 10^{-3} h \qquad (1)$$

in which $S$ = empirical standard errors of horizontal and vertical points in feet; $h$ = flight height in feet.

## CONCLUSIONS

This research showed that the operational procedures of making three settings on each point may detect some gross errors during the

TABLE 1. THE RESULTS OF THE CHECK POINTS OF THE SINGLE AND MEAN READINGS IN AEROTRIANGULATION.

| | Residuals in Easting (ft) | | | | Residuals in Northing (ft) | | | | Residuals in Height (ft) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Single | | Mean | | Single | | Mean | | Single | | Mean | |
| Point | A7 | A8 | A7 | A8 | A7 | A8 | A7 | A8 | A7 | A8 | A7 | A8 |
| 7 | −0.03 | 0.08 | −0.02 | 0.08 | −0.03 | 0.03 | 0.03 | 0.03 | −0.12 | −0.09 | −0.02 | −0.13 |
| 8 | −0.08 | 0.05 | −0.09 | 0.03 | 0.04 | 0.13 | 0.08 | 0.08 | −0.07 | 0.13 | 0.00 | 0.00 |
| 9 | 0.00 | 0.12 | −0.10 | 0.10 | −0.04 | 0.05 | −0.09 | 0.04 | 0.10 | 0.13 | 0.01 | 0.01 |
| 6 | 0.01 | 0.09 | −0.06 | 0.10 | −0.04 | 0.07 | −0.01 | 0.06 | 0.09 | 0.09 | −0.02 | −0.05 |
| 5 | −0.01 | 0.02 | −0.10 | 0.03 | −0.01 | 0.10 | −0.02 | 0.04 | 0.04 | −0.04 | −0.04 | 0.01 |
| 4 | −0.08 | −0.03 | −0.07 | 0.00 | −0.01 | 0.09 | 0.03 | 0.07 | 0.01 | −0.02 | 0.03 | −0.07 |
| 2 | 0.00 | 0.13 | −0.03 | 0.10 | −0.08 | −0.11 | −0.09 | −0.12 | −0.06 | 0.12 | −0.13 | 0.06 |
| 3 | −0.05 | 0.01 | −0.11 | 0.00 | −0.03 | 0.02 | −0.11 | 0.01 | −0.07 | 0.04 | −0.23 | −0.10 |
| 10 | 0.04 | 0.07 | 0.00 | 0.11 | 0.13 | 0.01 | −0.03 | −0.02 | −0.19 | −0.13 | −0.12 | −0.12 |
| 11 | −0.06 | −0.02 | −0.15 | −0.02 | −0.04 | 0.06 | −0.04 | 0.00 | −0.03 | 0.09 | −0.10 | 0.01 |
| 12 | 0.00 | 0.06 | −0.05 | 0.04 | −0.15 | 0.09 | −0.07 | 0.04 | 0.08 | 0.02 | −0.02 | −0.11 |
| 14 | 0.08 | 0.01 | 0.08 | 0.03 | 0.04 | 0.11 | −0.03 | −0.02 | 0.03 | 0.00 | 0.02 | −0.11 |
| R.M.S.E. | ±0.05 | ±0.07 | ±0.08 | ±0.07 | ±0.07 | ±0.08 | ±0.06 | ±0.05 | ±0.09 | ±0.09 | ±0.09 | ±0.08 |

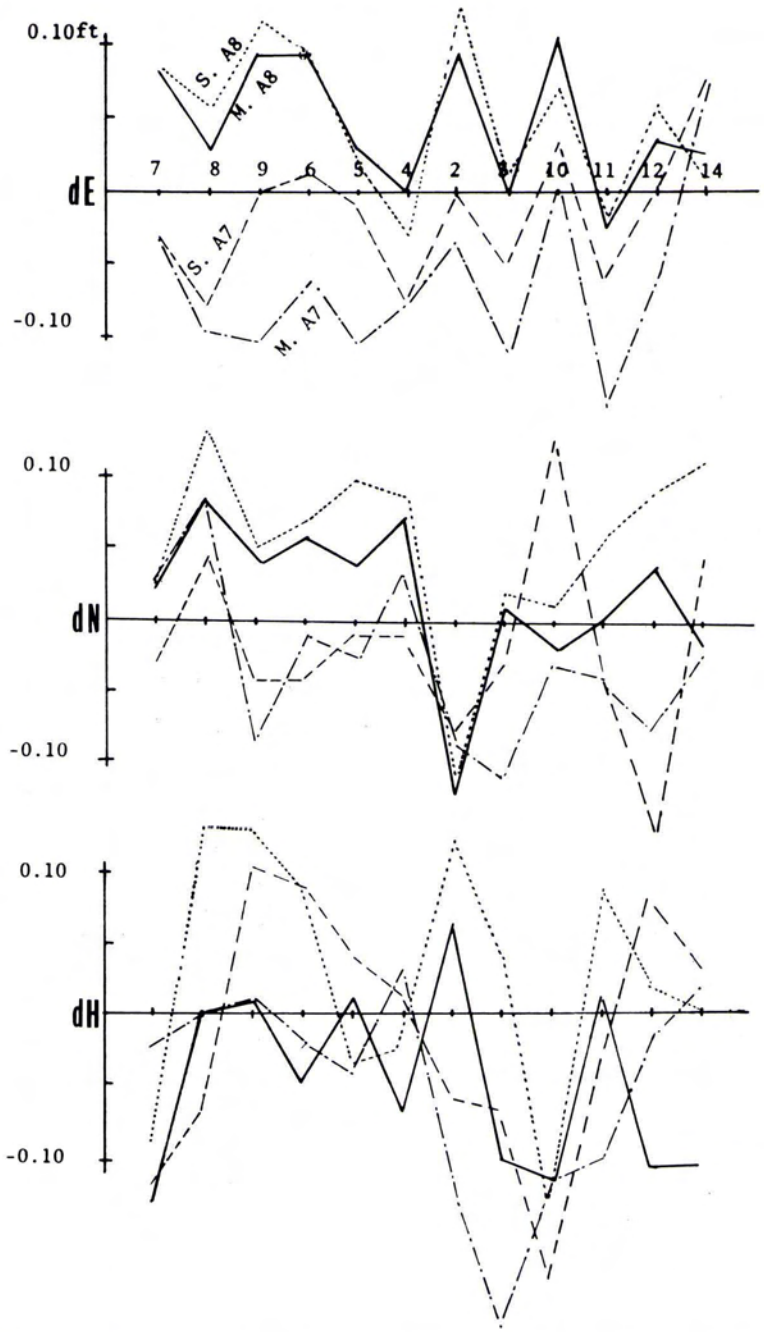


FIG. 2. Comparison of the simple and mean readings in aerotriangulation.

reading, recording and registration. However, the accuracies did not improve with increasing readings. The residual standard error depends mainly on the flight height. The magnitude of the limit of interval of the standard errors of transformed points in a single model may be estimated as three times 0.00004 times flight heights in feet using a 6-inch focal length wide angle camera and Wild A-7 and A-8 plotters.

ACKNOWLEDGMENT

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# 35th Photogrammetric Week
# Stuttgart, September 8-13, 1975

The Photogrammetric Weeks have long held a firm place in the photogrammetric community as a technical seminar for professional photogrammetrists and as an international forum for the exchange of ideas. Because of the great success of the 34th Photogrammetric Week — held for the first time in Stuttgart in 1973 — that city will again be the host for the 35th Photogrammetric Week, scheduled for the week of September 8 to 13, 1975.

The seminar will be under the scientific direction of Prof. Dr.-Ing. F. Ackermann, Stuttgart, and Dr.-Ing. H.-K. Meier, Oberkochen. It will include a review of the present status of photogrammetric techniques followed by an overview of the most important trends in development. Some 18 lectures by an international group of experts will be devoted to

- The status of photogrammetry and remote sensing
- Image acquisition and processing
- Computer-supported stereoplotting

The opening sessions will include papers on new photogrammetric instruments. Simultaneous translations of the lectures in German, English, French, and Spanish will be provided. Demonstrations of and exercises on photogrammetric instruments are scheduled for three afternoons during the seminar.

Additional information may be obtained from

Universität Stuttgart
Institut für Photogrammetrie
D-7000 Stuttgart 1, Postfach 560
West Germany

or

Carl Zeiss
Surveying and Photogrammetry Division
D-7082 Oberkochen/Württ., Postfach 1369/1380
West Germany

The closing date for applications is July 15, 1975.