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Determination of the Point Transfer Error

A unique and simple experiment is suggested which may be executed by mapping organizations of all sizes.

Introduction

Most mapping organizations are faced with the problem of having to transfer paneled targets from their identification photography to their mapping photography. The error associated with this operation varies according to the equipment, the quality and scale of the photography, and the skill level of the operators.

The size of the point transfer error has remained a difficult value to identify. Gauthier (1970), one of the few authors who has attempted to assess the error, estimated it to be approximately 40 μm at photoscale.

The purpose of this article is to describe a simple test for obtaining an excellent estimate of the size of the point transfer error and to report on the results of such a test performed at the Army Survey Regiment in Bendigo, Australia.

Abstract: *An experiment is described whereby a mapping organization can determine the size of the error when transferring paneled targets from their identification photography to their mapping photography. Circular errors of 12 μm (1:18,000) and 21 μm (1:80,000) were measured under the conditions found at the Army Survey Regiment, Royal Australian Survey Corps, in Bendigo, Australia.*

Method

Phase I

(1) Procure two photographs at map scale which comprise a stereopair. (Call them "A" and "B.")
(2) Make a glass diapositive (plate) of both photos.
(3) On Plate A, using a standard point marking device, drill or punch four "reference" holes approximately at the corners of a 1-cm square centered over an area where a survey target would logically be placed. The number of "squares" is optional. Certainly at least ten should be selected.
(4) Make a contact duplicate diapositive of Plate A. (Let us call it A′.)
(5) On Plate A drill or punch a hole (pseudotarget) in the confines of each 1-cm square in a location where a survey target would logically be found.
(6) Using normal point transfer procedures, transfer each pseudotarget from Plate A to B and then from B to A′.
(7) On Plates A and A′, measure the four corner reference marks and the pseudotargets with a sufficiently precise comparator. Each point should be measured at least five times.
(8) Using an appropriate transformation, fit the measured corner reference marks of Plate A′ to A.
(9) Compute the location of the pseudotarget on Plate A′ in the coordinate system of A.
(10) Compare the location of the twice transferred target to its original position. The amount of disagreement in target location is $\sqrt{2}$ times the transfer error.

Let C_D = the amount of disagreement in target location; i.e., the A → B → A′ error;
C_1 = the transfer error from A → B;
C_2 = the transfer error from B → A′; and
C = the general transfer error.

Disregarding instrument-measuring errors and realizing that C_1 must equal C_2, we have

$$C_D = (C_1^2 + C_2^2)^{\frac{1}{2}} = (2C^2)^{\frac{1}{2}} = \sqrt{2}\,C.$$

Figure 1 demonstrates the principle.

It may be argued that the above test is overly optimistic because the target or identification photography is at the same scale as the mapping photography and the point being transferred is a circular point mark instead of an actual target.

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TABLE 1. POINT TRANSFER RESULTS

Test	Phase	RMSE of Two Transfers (A→B→A′)	Measuring Plate A	Errors Plate A′	Point Transfer Error
1	I	16·0 μm	2·3 μm	2·3 μm	12 μm
2	II	18·0 μm	1·6 μm	3·1 μm	12 μm
3	I	29·2 μm	2·8 μm	2·0 μm	21 μm
4	II	27·9 μm	1·1 μm	2·2 μm	20 μm

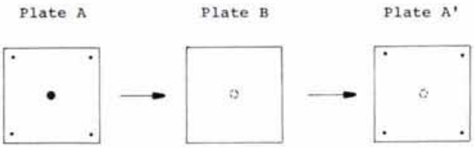

FIG. 1. The pseudotarget on Plate A was transferred to Plate B and then to Plate A′. All reference points were measured on Plates A and A′ with a comparator. The four reference points on A′ were mathematically fit to A, and the location of the twice transferred target was compared to its original position.

PHASE II

In order to dispel this argument a second phase of tests was conducted. In Phase II a three-time negative enlargement of Plate A, with its corner reference points already marked, was produced. Within each enlarged square (formerly a 1-cm square), an actual target (either a black +, T, or Y), previously placed on stripping film, was fixed to the enlarged negative. The size and shape of the targets were carefully computed so as to be (as closely as possible) identical to the survey panels normally used.

The three-time enlarged negative (Photo A) was then contacted to a positive and cut to allow it to be placed on the point tranfer device. The test was then conducted as in Phase I. However, in this case the point transfer technicians were forced to bring the "identification and mapping" photography to the same scale and were observing what appeared to be an actual survey panel. The Phase II test, while not accommodating all the differences in tone, shadow, and quality that could exist between the control and mapping photography, still provides an accurate simulation of the point transfer process and an excellent estimate of the point transfer error.

RESULTS

The results are shown in Table 1. The photographs for tests 1 and 2 were at a scale of 1:18,000; for tests 3 and 4, at 1:80,000. In tests 1 and 2, the corner reference marks were actually reseau crosses. Reseau photography could obviously be used; however, point-marked reference points offer additional placement flexibility and are somewhat easier to measure. Tests 2 and 4 were conducted using Phase II techniques; i.e., Plate A was enlarged and small targets were placed on the negatives.

The RMSE's in Table 1 were computed from the equation

$$\text{RMSE} = \sqrt{\frac{\sum V^2}{n-1}}$$

where

$$V = \sqrt{\Delta X^2 + \Delta Y^2}$$

The values ΔX and ΔY represent the X and Y differences between the mean of the five comparator measurements of the target on Plate A compared to the mathematically transformed measurements (again the mean of five) on Plate A′.

Although they had virtually no effect (because of the large difference in magnitudes), the comparator measuring errors were removed. The RMSE's, as a result of measuring each of the four corner reference points for both Plates A and A′, were subtracted from the total transfer error according to the following equation:

$$\sqrt{2}\begin{pmatrix}\text{transfer}\\ \text{error}\end{pmatrix} = \left[\begin{pmatrix}\text{A}\rightarrow\text{B}\rightarrow\text{A}'\\ \text{error}\end{pmatrix}^2 - \begin{pmatrix}\text{A}\\ \text{meas error}\end{pmatrix}^2 - \begin{pmatrix}\text{A}'\\ \text{meas error}\end{pmatrix}^2\right]^{\frac{1}{2}}$$

CONCLUSIONS

The results of these tests indicate that the best estimate for the point transfer error at the Army Survey Regiment, Royal Australian Survey Corps, is 12 μm at 1:18,000 and 21 μm at 1:80,000. This conclusion reflects the skill level, equipment (Wild Pug IV), and quality of photography of this unit.

It is apparent that the considerable additional effort required to accomplish the

Phase II tests is not justified. The relatively simple method as described in Phase I may be relied upon to supply an excellent estimate of an organization's point transfer error.

REFERENCE

Gauthier, J., 1970. "Mapping with Super-Wide Angle Photography: Some Observations on the Cost Advantage, the Accuracy, and the Photographic Problem." Paper presented at the 36th Meeting of the American Society of Photogrammetry, March.

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BOOK REVIEWS

Nature to Be Commanded . . ., Edited by G. D. Robinson and Andrew M. Spieker. U.S. Geological Survey, U.S. Government Printing Office, Washington, D.C., 95 pages, more than 175 illustrations, soft cover oversize, 1978, $6.25.

"*Nature to Be Commanded . . .*" is a very different Geological Survey Professional Paper. It is oversized, multicolored, highly visual, and filled with a combination of artistically displayed photographs and block drawings. At first glance it looks like a brochure advertising maps and photos rather than a Professional Paper of the U.S. Geological Survey. On an inset on a purple page, William A. Radlinski explains that this is indeed a Professional Paper "different not only in appearance but also in style and content . . . designed for a new audience." This is a Professional Paper written by experts, not for them. It expresses an "expanded commitment by the Survey 'to serve' anyone interested in the well-being of cities, and especially those involved in urban planning . . ."

Contents of the text include a carefully selected series of case studies, each pointing to the kind of Earth Science data needed for intelligent decision making in selected areas of the United States. Groundwater problems of quantity are considered in arid regions of Tucson, Arizona and diminishing quality of groundwater is investigated in Nassau County, Long Island. Problems of planning in the Atlantic and Pacific Coastal regions, the arid environment, and New England are treated.

"*Nature to Be Commanded . . .*" does what it is intended to do—it sells us on the need for Earth Science data in planning and it reminds us that to be commanded Nature must be obeyed. A knowledge of natural processes is useful, not only to the Earth scientist, but also to everyone involved with the modification of Earth processes or function. The use of "single factor" maps is emphasized as a decision making base, and the planning process in East Granby, Connecticut is used as an example. Land-use controls are portrayed simply as three steps: (1) recognition of the geologic processes operating, (2) setting public policy with respect to it, and (3) development of a public ordinance to control the use in an example from San Mateo County. Fault damage, flooding, erosion, and subsidence are considered.

The graphics are clear and the photographs are well chosen so as to add to the written text rather than simply document it. In a sense the data comprise an atlas and the text is an explanation of their use. The broad variety of data used in the evaluation of problems gives the reader a feeling of confidence that with those data at hand, planning would be simplified. Despite more than 30 photos of structural failures or acute environmental problems, the reader feels encouraged upon reading the Paper. It seems clear that, with the Earth Science data presented, those disasters pictured will be avoided in the future.

The Paper is rich in implications and successfully encourages those involved in land-use planning to seek out applicable base data. It must be emphasized, however, that the treatment is *not* directed to the professional geologist or planner. Professional Paper 950 is strongly recommended to anyone who is involved with planning and is well designed to meet that need.

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