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Super-Wide Angle Photos* for Large-Scale Mapping

The Wild A9 plotter using 1:10,000-scale photographs gives results that are usable for highway design in developing regions.

Abstract: *An experiment with super-wide angle photographs (3.5-inch, 120°) using the Wild A9 plotter (which requires that the photographs first be reduced to half-size diapositives) was completed with photographs at flight heights of 2,900, 4,400 and 7,200 feet taken over a test area that had previously been surveyed for cadastral purposes with a high standard of accuracy. The standard error (68%) for the A9 work with the lowest altitude was ±23 cm. (9 in.) horizontally and ±18 cm. (7 in.) vertically.*

The accuracy that is achievable with 120° photography and the Wild A9 plotter was reported briefly at the Tenth Congress (Lisbon, 1964) of the International Society for Photogrammetry. Of particular interest was the determination of what could be expected if 1:10,000-scale photography is used for a map scale of 1:2,000, reducing the original negatives to 1:20,000 for the A9 plotter, thus working with an enlargement of 10 times in the A9.

With this investigation the answer was sought as to whether the user of the A9–B9 group of instruments in developing countries would be able to produce, where necessary, engineering plans or cadastral maps at a scale of 1:2,000. Will precision and image quality of the reduced diapositive and of the plotting instrument be adequate to achieve satisfactory results?

To clear up these specific questions, an area which had recently been surveyed photogrammetrically for numerical cadastral purposes was re-signalized and photographed by the Swiss Federal Survey Directorate with the RC9 Camera (Super-Aviogon f/5.6, 120° field, $f=88$ mm., format 9×9 inches, Cronar film). Negative scales were 1:10,000, 1:15,000 and 1:25,000, and the corresponding flight heights above ground were 2,900 ft. (880 m.), 4,400 ft. (1,320 m.) and 7,200 ft. (2,200 m.), approximately. The exposures were taken with 80% overlap.

The area photographed, the administrative unit of Daegerlen in Canton Zurich, has generally a gently rolling character with fields and meadows and small woods. The preceding survey for the numerical Cadastral Register of Daegerlen had been conducted with extreme care by the Photogrammetric Dept. of Mr. K. Weissmann's Survey Office in Zurich; all measured lines were included in the adjustment. For checking the new results, it could therefore be assumed that the comparisons would be made against a survey of high overall accuracy and having good agreement locally. As control points, it was possible in all cases to use signalized triangulation and traverse stations whose positional errors are not larger than ±5 cm.

Because a 1:5,000 project was being surveyed simultaneously, it was inevitable that the adopted signal size of 65 cm.×65 cm. (26×26 inches) would be larger than desirable for the 1:2,000 compilation. The identification sketches were prepared by the Survey Dept. Some additions to the A9 equipment were found useful for the new application: a 100 cm.×100 cm. plotting table (in place of 70 cm.×70 cm.) with doubling gears; an additional down-gearing of the handwheels; a vernier for finer reading of the elevation scale;

* The paper was read at the Annual Convention of the American Society of Photogrammetry, Washington, D. C., March 1965.

TABLE 1

MAGNITUDE AND DISTRIBUTION OF ERRORS REFERRED TO THE GROUND. (1 DECIMETER ≈4 INCHES)

31 error vectors from 0 to 1 decimeters
53 error vectors from 1 to 2 decimeters
37 error vectors from 2 to 3 decimeters
18 error vectors from 3 to 4 decimeters
5 error vectors from 4 to 5 decimeters
0 error vectors from 5 to 6 decimeters
1 error vectors from 6 to 7 decimeters

and the EK5 Electric Coordinate Printer (normally used for aerial triangulation) to eliminate the tedious job of reading and recording the numerous model coordinates needed for the comparison.

Although the compilation at 1:2,000 was intended for investigation of the graphical accuracy only, the coordinates of some 150 points per model of the 1:10,000 pictures were measured and recorded because a direct numerical comparison provides a more reliable verdict on the accuracy than an indirect graphical comparison.

ONE STEREOPAIR was measured independently in two A9's three times by four operators. The comparison between the new values determined photogrammetrically and the official cadastral coordinates, gave the following standard errors (s.e.):

s.e., coordinates	$m_x \pm 16$ cm.
	$m_y \pm 17$ cm.
s.e., position	$m_p \pm 23$ cm.
s.e., elevation	$m_H \pm 18$ cm $= 0.02\%\ H$.

Referred to the image plane at the original 1:10,000 scale, this corresponds to standard errors of ± 16 and ± 17 microns for the coordinates and ± 23 microns for the point positions. The magnitude and distribution of the error vectors are shown in Table 1. The one point with a 6 to 7 decimeter error vector was difficult to set on.

The standard elevation error was determined from 24 points for which elevations were available. The greatest error was 4 decimeters, the standard elevation error was just below 2 decimeters. With these results, the mapping would thus be completely satisfactory for the planning of roads and railways in development regions.

TO TEST the suitability for a cadastral survey, the local agreement of 61 distances between neighbouring points 3.5 m. to 20 m. apart was checked with the field measurements. Only one error in a 20 m. distance was 53 cm.; all others were below 40 cm., i.e. less than 0.2 mm. at the map scale of 1:2,00. The m.s.e. of all 61 short distances was **only ± 17 cm.** This relatively small value corresponds entirely with results obtained for short distances measured from wide angle and normal angle photography. Sample measurements made on other stereopairs gave results of the same quality.

These first investigations into the use of the super wide angle system for large scales showed that 1:10,000 photography is indeed suitable for the production of 1:2,000 maps for important development projects. The results are thus very satisfactory, but beyond the results themselves we were also interested in the causes for the errors. We found what portion of the error is contributed by the reduction of the original 9×9-inch negative to the $4\frac{1}{2}\times4\frac{1}{2}$-inch glass diapositives, and what portion is to be attributed to the A9.

To determine these proportions, we proceeded as follows:

First (Operation I) two original 9×9-inch negatives of a model were contact printed on glass plates. 15 points were selected in this model and measured in a Wild STK1 Stereocomparator.

Then (Operation II) the pictures were reduced to half-size (1:20,000) with a Wild U3A Diapositive Printer, without correcting for earth curvature or residual distortion, and the same 15 points measured both in the comparator and in the A9. In the A9, coordinates were read at model scale 1:10,000. For the comparator measurements, a Helmert transformation was carried out onto the fiducial marks of the original photographs, thus referring the error figures to the original scale of 1:10,000 as shown in Table 2.

In the spatial model, the standard errors for Operation I were

TABLE 2

ERROR COMPARISON BETWEEN COMPARATOR AND A9 MEASUREMENTS

I. Comparison between reduced picture and original. Comparator measurements and transformation to 1:10,000	
Plate No. 50	*Plate No. 52*
$m_x = \pm\ 6$ microns	± 8 microns
$m_y = \pm\ 8$ microns	± 5 microns
$m_p = \pm 10$ microns (18 max.)	± 9 microns (17 max.)
II. A9 measurements—coordinate readings to 0.01 millimeters at 1:10,000 model scale	
Plate No. 50	*Plate No. 52*
$m_x = \pm 9$ microns	± 14 microns
$m_y = \pm 12$ microns	± 14 microns
$m_p = \pm 15$ microns (29 max.)	± 20 microns (32 max.)

$m_x = \pm$ 7 microns

$m_y = \pm$ 7 microns

$m_p = \pm$ 10 microns.

For Operation II the errors were

$m_x = \pm$ 12 microns

$m_y = \pm$ 13 microns

$m_p = \pm$ 18 microns.

Table 3 shows the error growth. It can be seen from the standard coordinate errors that there is no significant asymmetry. The point position errors permit an approximate separation of the error influences. The errors shown for Operations I and II represent deviations from the point positions in the original negatives measured in the Wild STK1 Stereocomparator. The errors shown for Operation III refer to ground coordinates and are derived from the A9 measurements mentioned earlier.

TABLE 3

ERROR GROWTH UNDER DIFFERENT MODES OF OPERATION

I *Reduction without correction*	II *A9 measurements without correction*	III *A9 measurements with correction during printing*
$m_x = \pm$ 7 microns	$\pm$12 microns	$\pm$16 microns
$m_y = \pm$ 7 microns	$\pm$13 microns	$\pm$17 microns
$m_p = \pm$10 microns	$\pm$18 microns	$\pm$23 microns

THE STANDARD residual error due to distortion, earth curvature and the photographic process is held to within $\pm$14 microns, the reduction process accounts for a standard error of $\pm$10 microns in the position of points, the A9 is responsible for $\pm$15 microns. For the individual picture coordinate, the individual error influences can be expected to be proportionally distributed corresponding to $\pm$10 microns, $\pm$7 microns and $\pm$11 microns respectively. For the map scale of 1:2,000, these influences are insignificant, since they fall within the graphical accuracy of 0.1 millimeter.

From the x-parallaxes, standard elevation errors can be computed: I, $m_H = \pm 10$ cm; II, $\pm$16 cm.; III, $\pm$18 cm. From these errors, the influences of distortion and of errors due to the photographic process can be estimated to amount to approximately $\pm$8 centimeters, while the A9 contributes some $\pm$12 centimeters and the process of reduction about $\pm$10 centimeters.

VAST UNDERSEA VALLEY DISCOVERED BENEATH INDIAN OCEAN

A vast undersea valley, 600 miles long, 25 miles wide, and surrounded by towering mountain peaks, has been discovered by American scientists beneath the Andaman Sea in the Indian Ocean. It lies buried one to three miles under the sea.

The valley, far larger in places than the Grand Canyon of the Colorado, extends from the northern tip of Sumatra in the Indonesian Archipelago to Narcondam Island, about 250 miles southwest of Rangoon, Burma.

The discovery was made by oceanographers of the Coast and Geodetic Survey, U. S. Department of Commerce, during a voyage last year by the C&GS Ship PIONEER while participating in the International Indian Ocean Expedition. The cooperative international expedition was under the sponsorship of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). Today's announcement followed a detailed and painstaking analysis of the data assembled during the trip.

Based on the soundings taken from aboard the ship, the Coast and Geodetic Survey scientists who conducted the study—marine geologist L. Austin Weeks, of Willemstadt, Curacao; marine geologist Reginald N. Harbison, of Hebbronville, Tex.; and geophysicist George Peter, of Budapest, Hungary—located the valley as lying east and parallel to the Nicobar and Andaman Islands, which connect Sumatra and Burma.