Experience of Model Orientation in Wild A8 Stereo-Plotters

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ABSTRACT: *In this paper the author discusses an experimental study on the orientation of a model in several Wild A8 Stereo-plotters with several operators. The object was primarily to determine (1) the precision with which a photogrammetric model could be oriented; (2) the relative precision of orienting a model in one Wild A8 stereo-plotter with respect to other A8 stereo-plotters and (3) the economic and other factors involved in the orientation of a model, in terms of the time spent in each operation.*

INTRODUCTION

IN A job of plotting topographical maps the following major items play their roles: (1) The taking camera and the conditions under which the photographs are taken; (2) The photographic material; (3) The stereo-plotting instrument and the method of orientation; (4) The standard of precision of the control on which the absolute orientation of the model is based; and (5) The operator. It is, therefore, extremely difficult (if not almost impossible) to judge properly the influence of each item. In a regular mapping organization usually all of these items are fairly constant. However, there must always be decided the suitability of the use of the photogrammetric stereo-plotting instruments because the evaluation of the accuracy of the whole mapping system of such an organization nearly always coincides with that of the plotting instrument used.

Very often the user does not know what to expect of the plotting instrument. One is often suspicious about the accuracy data supplied by the manufacturer. During the past decade several methods and systems of testing the accuracy of stereoscopic plotting instruments have been put forward in several publications in various countries. Most of these involve measurements made from grid plates placed in the instrument instead of actual pictures. The author and some of his colleagues, not being satisfied with these existing methods, set themselves on a mission of testing the instruments' performance with actual work materials similar to those with which they are intended to be used. The details of this experimental study are given here with a view to sharing the experience with others. The author thankfully acknowledges the cooperation he received from his colleagues in Survey of India during these studies. The writing of this report has been however, somewhat delayed because of certain preoccupations of the author.

PHOTOGRAPHY AND THE PHOTOGRAPHIC CONDITIONS

The model selected for this study falls in the State of Rajasthan in the western part of India (26 degrees north latitude). The terrain is rugged, with a difference of about 2000 ft. between the highest and the lowest spots. The ground is covered with bushes and small trees of the deciduous type. Approximately fifteen per cent of the area is under cultivation.

The photographs (aerial, vertical) were taken in the month of November when the atmosphere was fairly dry with little haze. The ground temperature at the time of photography was within the range of 65 to 75 degrees Fahrenheit. The pictures were taken with a Wild RC 5a camera, focal-length 115 mm., 18 cm.×18 cm. format. The flying height of the air-craft was about 4600 m. above the average ground, thus giving an approximate photo-scale of 1:40,000.

In the present test only one pair of film diapositives were used. With a view to minimizing the effect of distortion in the film due to ageing, the diapositives were prepared and the subsequent investigations were complete within two weeks of the date of photography. The diapositives were checked for distortion after these studies. The distances between fiducial marks were in agreement with their calibrated values to within ±0.01 mm.

The Plotting Instruments

Four Wild A8 stereo-plotters were used in these investigations. The instruments were not very old. The job on each was carried out within 3 years of the initial erection of each instrument. The instruments were being regularly maintained by trained personnel and were used under normal working conditions. The instrument-rooms were temperature-controlled for a range of 70 to 75 degrees Fahrenheit and were humidity-controlled for a range of 50 to 65 per cent relative humidity

Field Control

The control was provided by a field unit and had the standard accuracy as for all topo-jobs in Survey of India, viz., m.s.e. in planimetry of less than ±2.50 m. and m.s.e. in elevation of less than ±0.60 m.

The model had five control points with their locations as indicated in Figure 1. These points were not signalized but were identified on the corresponding positive prints in the ground, where sketches were prepared to help the operator identify them while working at the instrument. Each point was a sharp detail point and was easily identifiable.

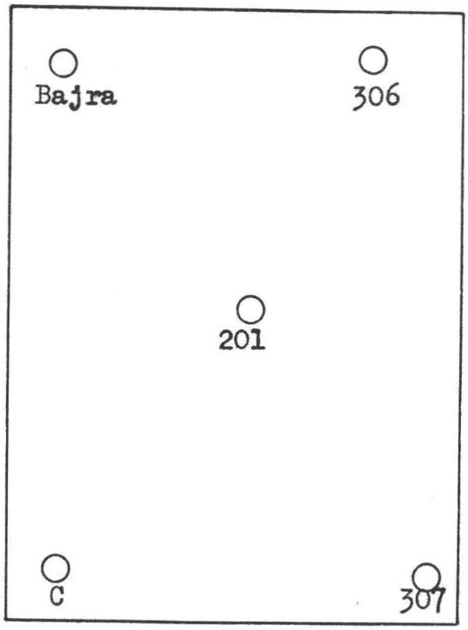

Fig. 1. Showing the relative locations of the control points in the model.

Operators

Twelve operators worked in the project. Six had an experience of three years of continuous working with stereo-plotters; the other six had similar experience of two years. Each operator was in normal health.

Setting The Model

The method of orienting the model was left to the personal liking of the individual operator. Incidentally, three used a numerical

Table I

Instrument Data of Orientation Elements, Operators

Operator	*Inst. No.*	*Values of the Elements*						*Base*	Φ
		κ'	κ''	φ'	φ''	ω'	ω''		
1	397	98.05	98.45	100.05	99.94	100.11	100.76	15.340	99.91
2	397	98.02	98.40	100.01	99.88	100.18	100.80	15.320	100.00
3	439	98.01	98.40	99.99	99.87	100.25	100.86	15.392	100.01
4	439	98.00	98.40	99.97	99.88	100.21	100.79	15.390	100.00
5	439	98.00	98.22	99.98	99.23	100.16	100.77	15.328	99.96
6	439	97.97	98.36	100.00	99.86	100.24	100.82	15.320	99.99
7	438	98.12	98.32	100.01	99.94	100.16	100.74	15.390	99.90
8	438	98.20	98.67	100.03	99.91	100.16	100.77	15.357	99.88
9	437	97.88	98.24	100.00	99.89	100.13	101.24	15.338	99.95
10	437	97.89	98.23	100.05	99.91	100.16	100.79	15.324	99.90
11	437	98.06	98.20	100.00	99.85	100.65	100.78	15.301	100.00
12	437	98.05	98.39	100.00	99.85	100.15	100.77	15.291	99.98

Note: All values are in centesimal grades excepting for base which is in centimeters.

TABLE II

A. RESIDUAL ERRORS IN ELEVATION IN FEET

Control point	*Ground elev. in ft.*	*Operators*											
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
201	2352	0	0	0	0	0	0	0	0	0	0	0	0
Bajra	2747	0	1	0	1	1	−3	−1	−5	0	−1	0	1
306	1991	2	2	−2	1	0	−1	0	3	1	0	3	4
307	2177	3	7	5	3	1	−2	1	−1	0	2	−2	3
c	2082	2	4	7	6	8	1	−2	−1	−1	2	0	0
B. RESIDUAL ERRORS IN PLANIMETRY, IN FIFTHS OF MM. IN THE PLOTTING-SCALE (1:16,666)													
201		0	0	0	0	0	0	0	0	0	0	0	0
Bajra		0	1	1	1	1	0.5	0.5	0	0	0.5	1	1
306		1	0	1	0	1	1	0.5	0.5	1	1	0	1
307		2	1	2	1	0	2	0	1	1.5	1.5	0.5	0
c		1	2	0	2	2.5	1	1.5	1.5	1.5	0.5	1.5	2.5

method of relative orientation using omega (ω) as a function of *by* (y-component of base) to be the measuring tool of Y-parallaxes. Nine of the operators used a empirical (optical-mechanical) method of relative orientation. Scaling of the model was effected by each operator graphically with the help of a plot-sheet on which the control points were plotted in the same scale as that of the model. Levelling the model was done by each of them using the trial-and-error method. The scale of the model and of the plotting was 1/16,666.

At the end of the work of each operator (i.e., after absolute orientation of the model to the satisfaction of the individual operator) all relevant instrumental data were recorded and the model was checked with respect to the coordinates at each point. The instrument data are given in Table I and the situation of the residual errors at the control points are given in Table II. The time required in each operation by each operator is given in Table III.

RESULTS

A close study of Table I provides an indication of the precision with which the elements in an average Wild A8 may be restituted. The following mean square values are obtained (assuming the all-over average to be the most probable value of each element):

For Left Camera:
κ'.. $\pm 9^c$; ϕ'.. $\pm 3^c$; ω'.. $\pm 17^c$
For Right Camera:
κ''.. $\pm 13^c$; ϕ''.. $\pm 16^c$; ω''.. $\pm 13^c$
For the instrument:
Base.. ± 0.035 cm,
Φ (common phi).. $\pm 5^c$

From Table II was obtained the following mean square values: $m_{\text{planimetry}} = \pm 0.211$ mm.

TABLE III

TIME DATA, IN MINUTES

Item	*Operators*											
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Study of control data	15	13	12	15	16	18	15	13	14	15	13	15
Setting diapositives on carrier	11	12	10	13	12	10	11	10	9	10	9	9
Orientation	90	180	185	105	120	80	120	135	75	68	75	70
Total	116	205	207	133	148	108	146	158	98	93	97	94

Averages:	For studying control	14.5 mins
	For setting of diapositives	10.5 mins
	For orientation	109.0 mins
	For all the operations	134.0 mins

Note: The time taken in relative and absolute orientations were not separated.

in scale 1/16,666 i.e., ± 3.52 m. in ground; $m_{elevation} = \pm 2.55$ ft. $= \pm 0.78$ m. These reveal the total effect of everything involved in the entire process and will give a general indication as to how precisely a model could be set in a Wild A8 instrument. However, these mean square values do not convey anything more than this.

The total evaluation of a particular type of instrument is a complex problem and can not be solved with simply three tables of figures as obtained in this case from one set of study observations. However, the values arrived at will indicate the order of precision that could be expected under the conditions and circumstances as stated, generally.

*Airborne Electronic Survey Data in Cartography at the Army Map Service**

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ABSTRACT: *The inception of the use of SHORAN and APR data at the Army Map Service is presented within a briefly outlined time frame. Standard procedures in the planning and procurement of the data and special procedures in the photogrammetric instrumentation stages of map production are discussed. In addition, contrasts between time and cost factors in electronic and conventional survey and interesting aspects of the newer art, as experienced in its application to over a million square miles of defense priority mapping, are mentioned.*

IN THE pursuit of its cartographic mission the Army Map Service has utilized a large quantity of SHORAN control data, a relatively modest quantity of Airborne Profile Recorder control and, thus far, only a token quantity of HIRAN data.

SHORAN had been widely used with spectacular success prior to 1953 by both the U. S. Air Force and by the Geodetic Survey of Canada in the accomplishment of geodetic missions.[1] This was followed by the application of SHORAN to cartographic requirements in northern Canada.[2] Shortly thereafter the Army Map Service began its SHORAN procurement.

Faced with the task of expeditiously mapping vast areas of charted and uncharted lands, it was decided that considerable momentum could be imparted to the mapping programs through use of the new technology. Its employment would in a sense provide for giant steps to be used where theretofore only modest strides had been taken. To promote timely execution of mapping agreements, the reduction of total elapsed program time was attempted, by trying to utilize onrushing periods of favorable weather for airborne operations. This attempt was hampered in cases by the lack of suitable maps and meteorological data with which to adequately locate SHORAN ground stations and to provide for their establishment in advance of the start of flying operations. A solution was effected, however, by close coordination between the AMS planning element and the contractor's reconnaissance and ground station installation personnel, whose superb efforts in the field served to overcome deficiencies caused by inadequate planning data.

Regions in which operations were conducted varied from the vast desert wastes and formidably mountainous territory of the mideast to regions of culture and, conversely, of rain forest in southeast Asia. However, in no case was the initiation of airborne operations appreciably delayed by non-availability of ground stations for control coverage.

In certain areas the decision to employ SHORAN was based on the lack of basic geodetic data suitable for the immediate launching of extensive mapping programs employing conventional methods of control procurement. One of the advantages of the newer control method lay in its being applied to the establishment or extension of a geodetic net through trilateration, simultaneously

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