

PERFORMANCE OF REDUCED AERIAL PHOTOGRAPHS IN THE MPS-2

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ABSTRACT

Aerial photographs from a Wild RC-10 camera were reduced by rephotographing the negatives using a Hassablad camera with a copying lens. The lens distortion of the final photography was examined, and the accuracy of point determination measured, and compared with results from measurements taken from the original large format photography by the same operator using a Kern PG-2 analogue stereoplotter. The results indicate that reduced aerial photography can be used for many mapping applications, provided that the photographic reduction is performed carefully using a suitable lens, and high resolution film. The subsequent measurements then have to be made with a precision analytical instrument with suitable magnification.

1.0 INTRODUCTION

The limitations inherent in mechanical analogue stereoplotters have greatly influenced the design of aerial survey cameras, and their lens systems. It is difficult to build and maintain a mechanical system to accurately transform from a perspective to an orthogonal projection since all small errors and amounts of play in the mechanical linkages tend to compound and affect the final accuracy. The problem is reduced if the scale of the photography is kept as large as possible, and hence the development of large format cameras. In addition, radial lens distortion has to be very small to reduce the difficulties in correcting this type of image displacement on mechanical equipment.

The lens designer is then faced with the difficult task of providing a lens system with a wide field of view and even light distribution over a large format image and maintain low radial distortion characteristics. The resultant lens systems tend to have a low resolving power and be of small aperture. The small aperture then influences the film and shutter speed and the final outcome is that most aerial cameras have a resolution of less than 80 line pairs per millimetre on the negatives.

If reduced diapositives are made from large format negatives using a high resolution film and a special copying lens, then very little data will be lost in the printing process and the resultant stereopair when viewed under suitable magnification should appear to the operator similar to that viewed in an analogue instrument using large format diapositives.

2.0 THE POTENTIAL FOR SMALL FORMAT DIAPOSITIVES

Aerial photography produced for mapping is used for many other purposes by people from various disciplines such as foresters, town planners, engineers, etc. Mostly the information extracted by these people is by means of approximate techniques since they seldom have access to accurate equipment nor do they have the time to become skilled at using mechanical analogue equipment. In addition it is usual for maps to be reviewed on say a ten to fifteen year cycle, but photography is to be taken on say a two to three year cycle so that the photography represents current information.

A mapping organization could cheaply produce a microfilm data base for an area in addition to their normal products. Such a data base would consist of reduced diapositives together with a diskette of orientation parameters computed from the block adjustment. In this way the the organization would be making their expertise more readily available, and users of photogrammetric data would have direct access to more accurate information.

3.0 INITIAL MEASUREMENTS

The Central Mapping Authority of New South Wales maintains a photogrammetric test range in the Bathurst Town Area. The co-ordinates of over 60 natural features have been measured by conventional surveying techniques and photography at various scales has been taken of the area. Negatives from a typical stereo-pair were selected and rephotographed using a Hassablad camera fitted with a 100 mm copying lens. The camera was mounted on a tripod, the negative on an illuminated table, and the principal axis of the camera was set normal to the negative by first pointing to a mirror placed on top of the negative. When the photographs were taken the mirror was replaced by a glass grid plate with the grid squares in contact with the emulsion of the negative.

Photography was on Kodak Technical Pan film 2415 (ESTAR-AH Base) and it was processed to achieve maximum resolution according to the manufacturers instructions.

The original photography was at a flying height of 2530 metres with an 80% overlap giving an air base of 1096 metres.

Initial measurements of the fiducial marks were made in the MPS to determine the reduction scale. This value was used to compute fiducial co-ordinates and the effective focal length of the reduced diapositives using data from the aerial camera calibration certificate.

An orientation was then performed on the MPS and after misidentified points were removed, the standard errors in x, y and z were about 0.3 metres.

The photos were then measured using the MPS in stereocomparator mode to record plate co-ordinates of 52 points as well as the camera fiducials. The camera fiducials were measured twice to check the precision of pointing and this was inside 4 microns.

4.0 ANALYSIS OF DATA

4.1 Lens Distortion

Using a space resection program, the plate co-ordinates were used to calculate the lens distortion and centering errors of the final negatives.

As a glass plate with grid lines on it had been used to hold the original negatives flat, these lines were observed using the lens distortion program in the MPS and the lens distortion characteristics of the Hassablad lens measured.

Details of the lens distortion of the original aerial camera were supplied on a calibration certificate from Wild.

Graphs of the radial distortion curves for the original lens, for the Hassablad lens and for the combined lens system are shown in Figure 1.

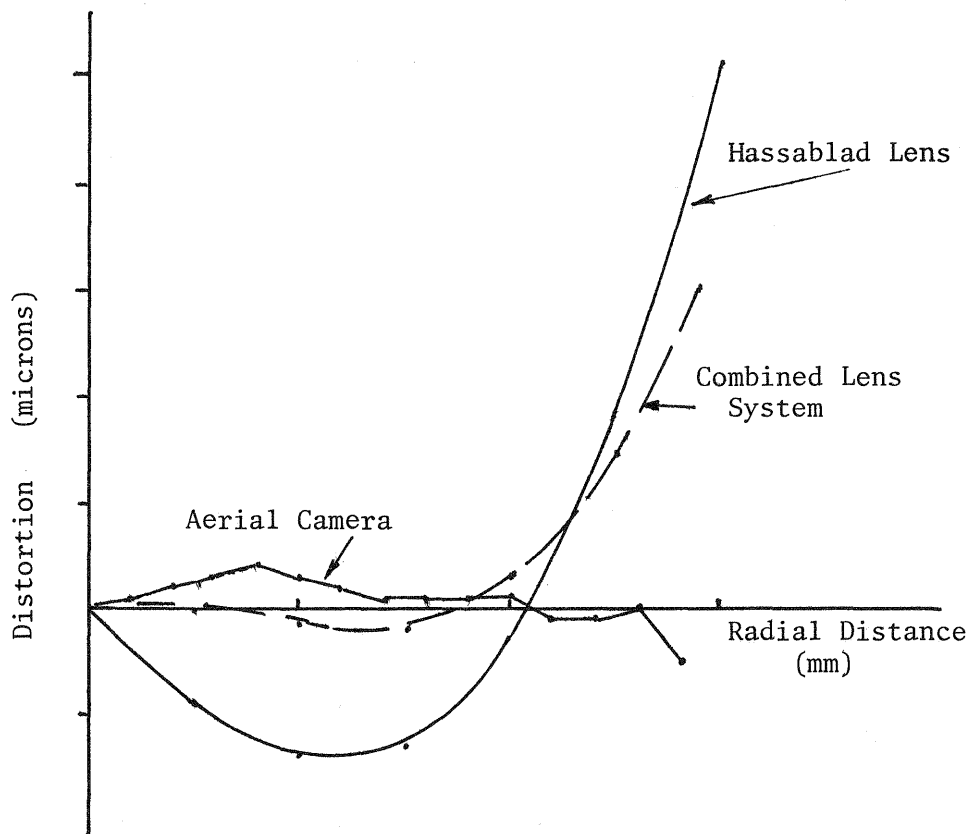


FIGURE 1: Lens Distortion Curve

It can be seen by inspection that that the results from the space resection program are close to the result from summing the lens distortion curve from the original aerial camera calibration with the computed curve from the Hassablad camera as measured by the MPS. The results deteriorate towards the edge of the photograph as there are insufficient data points in this location.

5.0 PERFORMANCE WHEN RESET

We had hoped to use the output from a block adjustment to reset the MPS and simulate the situation where an interior orientation only is performed and the absolute orientation is read in from a diskette. However, no adjustment data was available for the particular stereopair used in this test so the orientations from the space resection/intersection were used instead.

Several factors have affected the accuracy:

1. There was difficulty in indentifying the control points in certain positions. Points 31, 43 and 50 are probably blunders.
2. The floating mark was too large when the MPS was used at maximum magnification. For this type of work a smaller mark should be used.
3. There seemed to be some non linear shrinkage as indicated by the measurements on the fiducial marks. This would have a significant effect on the observations and only further measurements will settle the source of this trouble.

The biggest problem was the difficulty in finding the exact points used for control. There had been changes such as road resurfacing in the town and some points were on the ground near buildings.

TABLE 1: Times for This Exercise

Mounting diapositives	2 minutes
Interior orientation	5 minutes
Exterior orientation	Not needed
Observing data points	30 minutes

6.0 MEASUREMENT WITH ANALOGUE INSTRUMENT

The original large format diapositives were set up in a Kern PG-2 stereoplotter fitted with a tri-axis locator and digital output. Setting up was carried out by a practising photogrammetrist, using datapoints which had been checked by the previous tests. There was some difficulty in setting up the photographs due to the large overlap and for this reason a relative orientation only was performed and the model co-ordinates as measured were then transformed to make a best fit with ten selected control points.

TABLE 2: Times for This Exercise

Mounting diapositives	10 minutes
Interior orientation	80 minutes
Exterior orientation	Not performed
Observing data points	30 minutes

7.0 COMPARISON OF RESULTS

The results for the mean value for each point are tabulated below for comparison.

TABLE 3:

Point No.	Original Values			MPS-2			Kern PG-2		
	X	Y	Z	dX	dY	dZ	dX	dY	dZ
2	7509.66	8462.07	693.78	0.54	0.65	0.59			
3	7681.70	8260.86	706.76	0.54	0.61	0.78			
4	7783.86	8125.28	720.58	0.54	-0.22	0.67			
7	7578.64	8792.55	682.50	-0.61	-0.56	-0.40	.57	-.49	-.85
8	7720.92	8595.15	697.91	0.96	-0.04	-0.24			
10	7991.80	8247.07	695.20	-1.03	-0.55	0.48			
12	8266.04	7882.98	679.43	-0.45	-0.53	-0.74			
13	7724.71	8929.53	679.57	-0.48	0.45	-0.31			
14	7899.80	8743.95	691.90	0.14	-0.57	-0.40			
15	8017.54	8551.73	687.67	0.16	-0.47	-0.17	.90	-.16	.67
16	8169.84	8351.76	684.22	-0.19	-0.42	-0.31	1.15	.02	-.38
17	8291.44	8190.68	679.46				-1.00	-.11	1.22
20	8081.68	8880.09	682.39	-0.22	0.26	-0.59			
21	8208.86	8720.90	679.29	0.04	-0.26	-0.44			
22	8336.06	8515.91	673.61				.14	-.36	-.11
23	8491.26	8358.02	670.68	-0.21	-0.51	-0.31	-.57	.90	-.42
26	8244.30	9009.36	675.21	0.83	0.32	-0.65	.00	.17	.14
27	8396.19	8834.97	674.74	-0.68	0.61	-0.65	.23	-.27	-.22
28	8534.00	8640.92	671.03	0.14	0.01	0.17	.26	-.11	-.25
29	8675.97	8475.00	665.56				-1.16	.26	-.34
30	8799.96	8293.41	661.22	0.21	0.17	-0.25			
31	8268.44	9358.59	668.69	0.29	-1.48	0.80			
32	8433.24	9148.87	672.28				-.32	-.08	-.40
33	8551.43	8989.19	672.16	0.96	-1.00	-0.36	-.59	-.82	.66
34	8697.56	8803.97	667.43	0.28	-1.30	-0.27			
35	8869.25	8627.39	660.54	0.16	-0.67	-0.67	.06	.15	-.37
36	8992.82	8448.35	658.69	-0.37	-0.75	-0.38			
38	8609.91	9296.97	669.28	0.27	-0.36	-0.18	-.15	.66	.10
39	8750.98	9113.64	668.83				-.05	.27	.42
40	8895.25	8970.93	661.15				.01	-.76	.25
41	9038.91	8745.98	654.36	0.32	0.16	-0.77	1.14	.18	-.45
42	9163.41	8585.00	654.48	0.69	-0.27	-0.82			
44	8792.69	9442.32	667.28				.08	.55	.54
45	8948.31	9266.33	663.64	0.17	-0.57	0.09	-.17	-.86	.89
46	9065.71	9098.15	657.86	0.10	-0.57	0.62	.13	-.64	.32
47	9228.28	8892.72	652.36	-0.22	0.36	-0.20	-.20	.15	-.24
48	9353.59	8734.27	653.02	0.04	-0.20	-0.72			
49	8854.46	9793.69	657.89	-0.48	-0.04	0.17	.20	1.29	-.89
50	8993.64	9630.27	661.79	-0.35	-1.07	1.08	.14	.30	.38
51	9095.68	9415.89	659.78	0.07	0.64	-0.08	-.10	.48	.62
52	9240.78	9236.92	653.84				.29	-.73	-1.32
53	9409.53	9056.30	652.26	0.81	-0.74	0.18			
57	9291.16	9557.84	660.24	-0.10	0.39	-0.41			
60	9739.95	9016.48	653.32	0.48	0.37	-0.98			
	Standard deviations			0.5	0.6	0.5	.50	.55	.60

8.0 SUMMARY

It can be seen that the MPS using reduced aerial photography can produce results similar to that of a production mapping analogue instrument using large format photography. However the MPS can be operated by people with little photogrammetric training, is a relatively low cost photogrammetric instrument, and it is very portable. The possibility now exists for up to date photogrammetric data in "Microfilm" form to become generally available to a large body of users.

Some work needs to be carried out to refine the photo-reduction process to maintain high quality reduced diapositives and the MPS should be fitted with a 10 micron floating mark for this type of work. If this work is carried out and the combined lens distortion of the final diapositive carefully determined, the results can be significantly improved.