AERIAL CAMERA CALIBRATION FACILITIES IN AUSTRALIA

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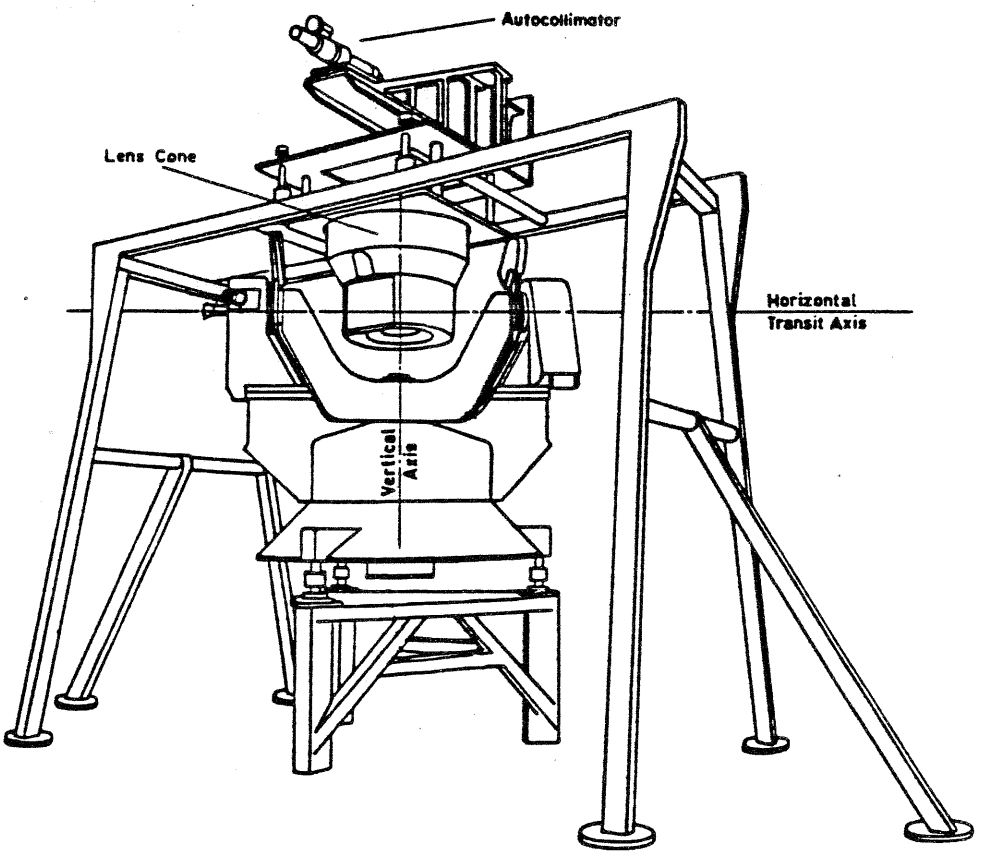
An Aerial camera calibration service for industry was established in Australia at the National Measurement Laboratory, and was described by Bell and Mayer (1956), for cameras using a register glass. During the 1960's there was a gradual introduction of vacuum frame cameras, with low distortion lenses. This made it necessary to modify the methods employed by Mayer (1957). In 1970 this facility was further upgraded with the introduction of a Hilger and Watts goniometer. New procedures were implemented and were described by Patterson (1978).

In 1982 responsibility for camera calibration was transferred from the National Measurement Laboratory to the Division of National Mapping. The new calibration laboratory was then registered with the National Association of Testing Authorities (NATA), in the field of Metrology. The camera calibration service is provided to government mapping agencies and to the commercial survey and mapping industry within Australia. This service is also offered to other countries.

The laboratory equipment consists of a Hilger and Watts goniometer, autocollimator and a series of calibration plates. The goniometer is similar to a large theodolite - a telescope supported by two trunnions, enabling rotation about a horizontal transit axis. Vertical circle readings to the nearest arc second can be made. No circle readings are available for rotation about the vertical axis.



Hilger and Watts Vertical Goniometer

Two calibration plates are currently used. The plate for cameras with flat focal planes is glass, 260mm x 273mm x 12mm, polished flat to within two micro meters. Grid-lines are ruled at nominal intervals of 10mm along the diagonals. The distances of these lines from the centre is known to $\pm$ 2 micro meters. An aspheric profile calibration plate with a similar grid pattern, made by Wild, is used for calibrating Wild RC9 cameras.

Visual observations made along the diagonals are input to a VAX 11/750 mini computer and lens distortions calculated. Values for radial distortion (v_i) are derived by application of the method of least squares and a value of the focal length is chosen such that Σv_i^2 is a minimum across the diagonals (Patterson, 1978).

An option in the software was developed in 1983 to enable a fit of the calculated distortions to an odd powered polynomial of a specified order, before correcting for symmetry. A seven term polynomial is normally fitted where the distortion pattern of the lens type is suitable as suggested by Zeimann and El Hakim (1982).

The calibration report contains the following information:

. The coordinates of the principal point of autocollimation with respect to the fiducial centre, and their uncertainty;

. The coordinates of the fiducial marks with respect to the fiducial centre, and their uncertainty;

. The calibrated focal length, the method used to calculate it and its uncertainty.

. The coordinates of the principal point of best symmetry for the calibrated focal length;

. In tabular form, the radial distortion for the calibrated focal length, referred to the principal point of symmetry, for each diagonal observed, and the means at intervals of 10mm;

. A plot of the coordinates of the points of autocollimation and symmetry and the fiducial marks with respect to the fiducial centre;

. A plot of the symmetrical radial distortions for each diagonal and the mean.

An example of the computer generated camera calibration report is given as Annexure 'A'.

Research is currently being carried out on the development of a laboratory photographic calibration procedure using the existing equipment to determine focal length, radial and tangential distortions. This procedure will be extended to provide laboratory lens resolution tests as per the ISPRS Commission I recommended procedures (Carman 1960, Tayman and Ziemann 1982).

In Flight Calibration

Previous work on in flight calibration in Australia has been carried out on a small area test range at Willunga by the Department of Lands South Australia. This work is reported by Spencer (1980) and is focussed on

system distortions caused by usage of a glass camera port.

A larger test field is now being established in the urban area of Melbourne near the camera calibration centre, by the Division of National Mapping. The standard mapping photography used by the Division of National Mapping is superwide angle at a scale of 1:80 000.

The test range is designed to have a grid of a minimum of one hundred locations over an area of 18 x 18 kilometres. To overcome the cost of targetting this number of points, existing ground detail will be used. These targets consist of point features and the intersections of other linear or regular features. It is expected that the selection of such points will enable the area to be permanently available with minimum maintenance.

The target points are being coordinated by ground survey using existing marks in an homogeneous system based on the Australian Map Grid.

It is anticipated that once established the new test field with its permanent features can be used at any time to provide single frame partial calibrations at 1:80 000 and multi frame system calibration at larger scales.

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DIVISION OF NATIONAL MAPPING

VISUAL GONIOMETER CAMERA CALIBRATION

CAMERA: NATMAP - WILD RC10 No.UAG 1031

CALIBRATION DATE 13/08/1982

FILTER ON CAMERA DURING CALIBRATION
500 PAN2X AV1.4X

COORDINATES OF PRINCIPAL POINT OF AUTOCOLLIMATION (PPA) WITH RESPECT TO FIDUCIAL CENTRE IN MILLIMETERS

X= 0.020 Y= 0.005

THE UNCERTAINTY ASSOCIATED WITH THESE VALUES DOES NOT EXCEED 0.010 MILLIMETERS

COORDINATES OF FIDUCIAL MARKS

	E	F	G	H
XMM	0.01	-149.91	-0.01	149.91
YMM	-149.90	0.00	149.92	0.00

THE UNCERTAINTY ASSOCIATED WITH THESE VALUES DOES NOT EXCEED 0.020 MILLIMETERS

CALIBRATED FOCAL LENGTH IN MM 151.55

THE UNCERTAINTY ASSOCIATED WITH THIS VALUE DOES NOT EXCEED 0.010 MILLIMETERS

THE CALIBRATED FOCAL LENGTH HAS BEEN DETERMINED SUCH THAT THE SUM OF THE SQUARES OF THE DISTORTIONS IS A MINIMUM

THE TEMPERATURE AT THE TIME OF CALIBRATION WAS APPROXIMATELY 20 DEGREES CELCIUS

COORDINATES OF PRINCIPAL POINT OF SYMMETRY (PPS)
IN MILLIMETERS, WITH RESPECT TO THE FIDUCIAL CENTRE

X = 0.032 Y = 0.000

RADIAL DISTORTION IN MILLIMETERS
REFERRED TO THE PRINCIPAL POINT OF SYMMETRY

RADIUS MM	SEMI-DIAGONAL E	F	G	H	MEAN
10	0.001	0.003	0.002	0.000	0.002
20	0.003	0.005	0.004	0.001	0.003
30	0.004	0.006	0.005	0.001	0.004
40	0.004	0.006	0.005	0.002	0.004
50	0.004	0.004	0.005	0.002	0.004
60	0.003	0.003	0.003	0.002	0.003
70	0.002	0.000	0.001	0.002	0.001
80	-0.000	-0.002	-0.001	0.000	-0.001
90	-0.002	-0.005	-0.003	-0.001	-0.003
100	-0.004	-0.006	-0.005	-0.003	-0.005
110	-0.006	-0.007	-0.006	-0.005	-0.006
120	-0.006	-0.007	-0.006	-0.005	-0.006
130	-0.002	-0.002	-0.003	0.001	-0.002
140	0.009	0.013	0.007	0.015	0.011

THE UNCERTAINTY ASSOCIATED WITH THESE VALUES
DOES NOT EXCEED 0.005 MILLIMETERS

NATMAP - WILD RC10 No.UAG 1031

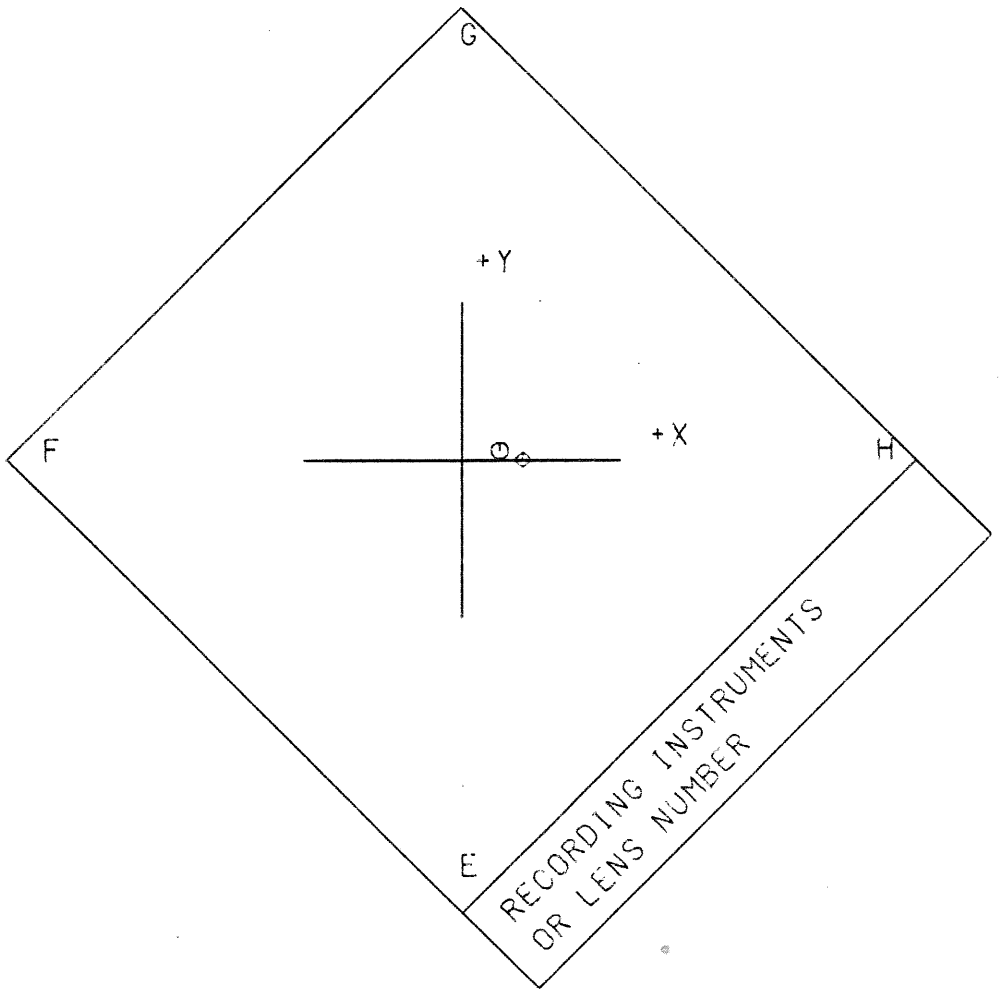
CALIBRATION DATE 13 08 82

COORDINATES OF (PPA) ⊙

XMM= 0.02 YMM=0.01

COORDINATES OF (PPS) ◈

XMM= 0.032 YMM=0.000

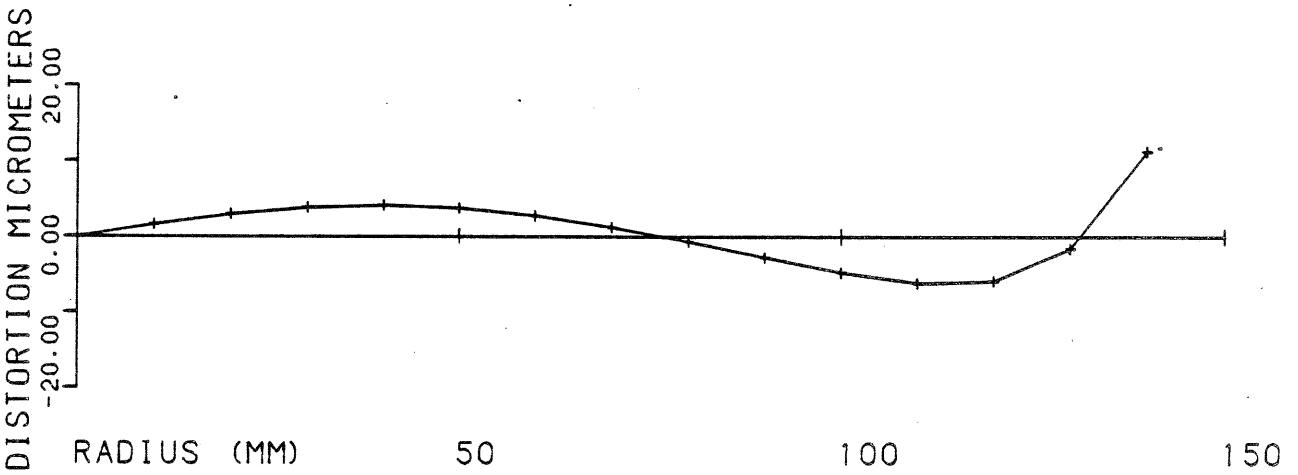


NATMAP - WILD RC10 No.UAG 1031

C.F.L. 151.55
FILTER ON CAMERA 500 PAN2X AV1.4X

CALIBRATION DATE 13 08 82

MEAN DISTORTION CURVE



SYMMETRICAL DISTORTION
ORIGIN: POINT OF SYMMETRY