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EUROPEAN ORGANISATION FOR EXPERIMENTAL PHOTOGRAMMETRIC RESEARCH

OEEPE

OFFICIAL PUBLICATION

N° 16

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Table of Contents

Preface

The period between the beginning of the Vienna test and the publication of the final report may appear to have taken longer than is usual. But regarding the multitude of the measuring data, the slow returns of results at the "Pilot Centre" and the fact that there is only one collegue to deal with all the material and to write the different reports, it is not surprising that there is a certain delay with the final report, especially since OEEPE work has often to be put into the background due to everyday work.

If an unanimous opinion on the interpretation of results is to be achieved — as it was usual with the preceding experiments of Commission C —, this may also lead to a delay of the entire experiment. Therefore, disparities of views ought not to be concealed as these can stimulate future research work of the OEEPE. Concerning the Vienna test there were different opinions on the quality of the image material used and on the resultant consequences. These circumstances led the "Swiss OEEPE-Group" to establish a supplementary report which has also been adopted into this issue of OEEPE Publications.

Meanwhile, Commission C has accomplished an experiment on "Optimal Emulsions for Large-Scale Mapping", dealing particularly with the questions of image quality and the signalization of points. A report on a special investigation in the signalized points of the Vienna test, written in German, will appear shortly.

I would like to express my thanks to both authors, Mr. *Waldhäusl* and Mr. *Kölbl*, for their industrious, dedicated but nevertheless successful and outstanding work.

November 1984

M. Jaakkola
President of Commission C

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Results of the Vienna Test of OEEPE Commission C*)

(with 4 Figures and 9 Tables)

P. Waldhäusl

SUMMARY: The OEEPE/C Vienna test comprised 7 normal angle flights at varying very large scales and with two types of illumination over an urban test field, which were repeatedly evaluated by 14 international centres. The results of these flights were compared with geodetic measurements which had also been repeatedly measured. The flights under diffuse illumination had up to 50 % larger height errors. The accuracy of the natural points decreased noticeably in comparison with the signalized points, according to the point group: mean height errors were up to 3 times, mean planimetric errors up to 6 times larger. The very large scales clearly showed the influence of interpretation uncertainties.

Unexpected faults which occured are also reported which could indicate primarily insufficient control discipline in individual photogrammetric centres.

RÉSUMÉ: Au cours de l'essai de Vienne de la Commission C de l'OEEPE ont été exécutés, au-dessus d'une zone-test urbaine et dans differents éclairages et à différentes très grandes échelles, 7 vols à chambre normal-angulaire qui ont été évalués à plusieurs reprises par 14 centres internationaux. Les résultats ont été comparés avec des mesures géodésiques ayant également subi des mesures répétées. Pour les vols effectués en lumière diffuse se sont obtenues des erreurs altimétriques plus larges de jusqu'à 50 %. La précision des points naturels est, en fonction des groupes de points, nettement inférieure à celle atteinte pour des points signalisés. Des erreurs moyennes altimétriques trois fois plus larges et des erreurs planimétriques six fois plus larges se sont manifestées. Les très grandes échelles montrent clairement l'influence des incertitudes d'interprétation.

L'auteur aborde aussi quelques défauts inattendus donnant à conclure que la discipline en matière de contrôle est pratiquée d'une manière insuffisante par certains centres photogrammétriques.

ZUSAMMENFASSUNG: Beim Versuch Wien der OEEPE/C wurden 7 Normalwinkelbildflüge in verschiedenen Größtmaßstäben und bei verschiedener Beleuchtung über einem städtischen Testfeld durch 14 Zentren international wiederholt ausgewertet. Die Ergebnisse wurden mit ebenfalls wiederholt gemessenen geodätischen Messungen verglichen. Für die Flüge bei diffusem Licht ergaben sich bis zu 50 % größere Höhenfehler. Die Genauigkeit der Naturpunkte fällt je nach Punktgruppe gegenüber der für

*) The German version of this report was first published as presented paper, Comm. IV ISPRS, Hamburg 1980, Int. Arch. Phot XXIII, pp. 747–757.

signalisierte Punkte deutlich ab: Es treten bis zu 3fache mittlere Höhenfehler und bis zu 6fache mittlere Lagefehler auf. Die Größtmaßstäbe zeigen deutlich den Einfluß der Interpretationsunsicherheiten.

Es wird auch über unerwartete Mängel berichtet, die vor allem auf fehlende Kontrolldisziplin in einzelnen photogrammetrischen Zentren schließen lassen.

1 Origin and aims of the Vienna test

A study (*van Gent* 1969) had demonstrated that the results published on photogrammetric urban surveys differed greatly at photo scales larger than 1 : 6000, that they were based on very little data material, could not be compared with each other for technical reasons and that the significance of the results was very limited (*R. Förstner* 1972).

Basic investigations into the measurability of differing urban detail objects did not exist at all. At large photo scales, interpretability and point definition are of great importance whereby the theoretically justified assumption that photogrammetric accuracy performance increases in proportion with the photo scale seems less tenable. Therefore, in 1970 Commission C decided to extend its earlier investigations systematically towards larger scales. Extremely large-scale air photo restitutions almost always cover urban areas. Hence, a new test area would also have to cover an urban area and normal angle chambers would have to be used which give the relatively best possible view of the ground of streets.

The task was divided into the 2 large tests of Dordrecht (*J. Timmerman* 1976) and Vienna (*P. Waldhäusl* 1978). Now the results of the Vienna test are available, to which the following tasks had been assigned:

1. The accuracy of photogrammetrically restituted points as a function of photo scale was to be tested further: the scale sequence of the Reichenbach test (*R. Förstner* 1969) (1 : 12 000 and 1 : 8000) was therefore to be extended to the utmost limit for fixed-wing aircraft (1 : 4000, 1 : 2500 and 1 : 1500).
2. The Swiss group of Commission C requested a comparison of restitution results obtained from comparable flights (1 : 4000) using an old and a new normal angle lens.
3. A comparison was to be made between terrestrically measured and photogrammetrically restituted signalized points for which a test field with exactly defined and signalized points of superior accuracy was to be established.
4. Since cast-shadows are particularly disturbing for photogrammetric urban surveys, it is wide-spread practice to conduct flights over urban areas under diffuse illumination. Therefore, flights in sunshine and under a solid blanket of clouds were to make possible accuracy comparisons.
5. However, the main aim was still a comparison between terrestrial and photogrammetric survey of varyingly accurately defined detail point groups (table 2.1).

Table 2.1 — Compilation of the detail point groups for the Vienna urban survey test

Group No.	Type of "typical urban detail points"	No. of points
1	Corners of buildings and walls	303
2	House joints, adjoining boundaries	170
3	Building entrances, windows (axes)	316
4	Edging stone points (straight lines and curves) *	628
5	Rail points (straight lines and curves) *	600
6	Fence corners	275
7	Masts, lanterns, road signs	139
8	Installations, i. e. man hole covers, covers of water or gas, sluice valves, etc.	250
9	Hydrants, bollards, trees	137
* Straight lines (consisting of 2—3 points): 223 Curves (consisting of 3—5 points): 93		Total 2818

2 Arrangement of the Vienna test field

In the Reichenbach test 80 points had to lie in each model in order to ensure a statistically representative amount of data. Equal point density in the photo would have required one point every 20 m for the photo scale 1 : 1500. Compromises were needed from the start because of buildings, etc. Finally, the Bundesamt für Eich- und Vermessungswesen, Vienna, determined 249 points, signalized 12 cm x 12 cm in white, with an average mean error of ±1 cm (*P. Hörmannsdorfer* 1973). Furthermore, the 2818 urban detail points (further characterized in table 2.1) were surveyed independently of each other by means of 2 measuring groups, i. e. they were surveyed twice. The second group had simply the field sketches of the first group at their disposal. Both worked on the basis of the 249 signalized points. The first measuring group used T1A and DI3 with rod-reflector, the second T1A, RDS and steel measuring tape for the polar surveys. A mean coordinate error of ± 2 cm was estimated from control distances. Heights were mostly levelled.

3 Photographic flights and their possible comparison

The photographic flights were conducted by the Bundesamt für Eich- und Vermessungswesen on 28 April and 3 May, 1973. The daylight illumination of the strips flown in sunlight varied only inconsiderably (13—15 hrs.). The cameras used were a WILD RC10 with the 30 At II lens no. 4003, calibrated on 12 April 1973, and a WILD RC5a with the 21 At lens no. 7, last calibrated in 1969. Table 3.1 gives a review of the photo flights and the test tasks pertaining to them.

Table 3.1 — The photo flights and their possible comparisons. The flight number is obtained from the flight horizon and the illumination number

flight horizon (number)	focal length c (photo format)	photo scale 1 :	number of models sunny (8) illumination (III)	diffuse (9) (III)
1.	30 cm (23x23 cm)	(I) 1500 (IV)	6	6
2.	30 cm (23x23 cm)	(I) 2500 (IV)	4	4
3.	30 cm (23x23 cm)	(I) (II) 4000 (IV)	2	cancelled
4.	21 cm (18x18 cm)	(II) 4000 (IV)	2	2

Comparison	
(1) I	Continuation of the Reichenbach test (only signalized points)
(2) II	Progress through new lenses (all points)
(3) III	Influence of illumination (all points)
(4) IV	Accuracy investigation on urban detail (only detail points)

4 Photogrammetric measurements

The plotting instruments were examined before and after restitutions in accordance with the recommendations of the working group "Standard Test" of the ISP. These measurements took less time than feared and the result was increased trust in the good adjustment condition of the plotting instruments. Not even one restitution centre used or considered further in any form the results of the standard tests. Major adjustment errors were not made known.

In accordance with the Reichenbach test methods, each of the 26 models was restituted three times with analog instruments and three times with stereo comparators, each time by a different restitution centre, whereby one strip was usually divided between 2 centres. Absolute orientation was carried out by computation afterwards using 9 to 11 control points: control point selection was decided by the first restitution centres of the models, EPF Lausanne and BAEV Vienna. These also produced lists of all those points which were to be restituted in the repeated measurements. The signalized points were measured in 2 runs, and the mean taken. As in other actual projects, in practice the detail points were measured only once per model. On purpose there were no detailed regulations, e. g. on model orientation, point measuring or distortion compensation. The results were to fully correspond to normal practical work.

The restitution centres (table 4.1) delivered a total of 180 000 point measurements to the centre pilot, the Institute for Photogrammetry of the Technical University of Vienna, by the autumn of 1977. The terrestrial coordinates of the points were not known to the restitution centres before that date.

Table 4.1 — Restitution centres of the Vienna test

Restitution centre				Number of models (semistrips) comparator	Analog
Type	Nation	Centre	City		
Public services (institutions)	NL	MDK	Apeldoorn	13 (7)	
	D	IfAG	Frankfurt am Main	2 (2)	
	D	LVA	Hannover		11 (5)
	SF	MMH	Helsinki tog. with TH		
	DK	LLO	Kopenhagen tog. with TH		
	D	MLWF	Mainz		4 (4)
	N	NGO	Oslo	10 (4)	
	A	BAEV	Wien		4 (4)
	A	MA41	Wien		11 (5)
Universities and schools	NL	TH	Delft		11 (5)
	A	TU	Graz		11 (5)
	SF	TH	Helsinki	11 (5)	
	DK	TH	Kopenhagen	5 (5)	
	CH	EPF	Lausanne		17 (7)
	I	PT	Milano	13 (7)	4 (4)
	D	TU	München	13 (7)	
	CH	SSPO	St. Gallen		5 (3)
	CH	ETH	Zürich	11 (5)	
				Totals 78(42)	78(42)

5 The computing programme

5.1 Point comparison

For all points the formal methods were as for the Reichenbach test (*R. Förstner* 1969). The exact analysis of the measurements of the signalized points is being carried out by the Institut für Angewandte Geodäsie, Frankfurt am Main, for which all measurements are used. In Vienna, the pilot centre for the urban survey test, the models were firstly combined in a strip and the multiple measurements from the model overlap zones omitted. Subsequent computations concerned primarily: absolute errors, i. e. deviations of photogrammetric measurements from the values of the first terrestrial measurement; relative errors, i. e. deviations of photogrammetric measurements from the mean value of the three repeats; and systematic errors, i. e. deviations of the mean values mentioned from the values of the first terrestrial measurement; and all these were summarized according to the respective tasks.

5.2 Straight lines comparison

Rails and pavement edges were recorded as "straight lines" by means of 3 approximately equidistant points and as such were seen as a sequence of an infinite number of points with the pending coordinate l and the lateral deviations D(l) so that a quadratic average of all lateral deviations between l_1 and l_2 independent of the length of the straight line $L = l_2 - l_1$ equalled:

$$m_D^2 = \frac{1}{L} \int_{l_1}^{l_2} (D(l))^2 \, dl = \frac{D_1^2 + D_1 D_2 + D_2^2}{3} .$$

The angle error was also ascertained to enable complete evaluation of straight lines, which because of their dependence on the length of the straight line L had to be made uniform for a norm length L_0:

$$m_w = \frac{L}{L_0} \; \frac{D_1 - D_2}{L} = \frac{D_1 - D_2}{L_0} .$$

Planimetry and height were treated in the same manner. Again absolute, relative and systematic errors were computed and summarized according to the particular task (figure 5.1).

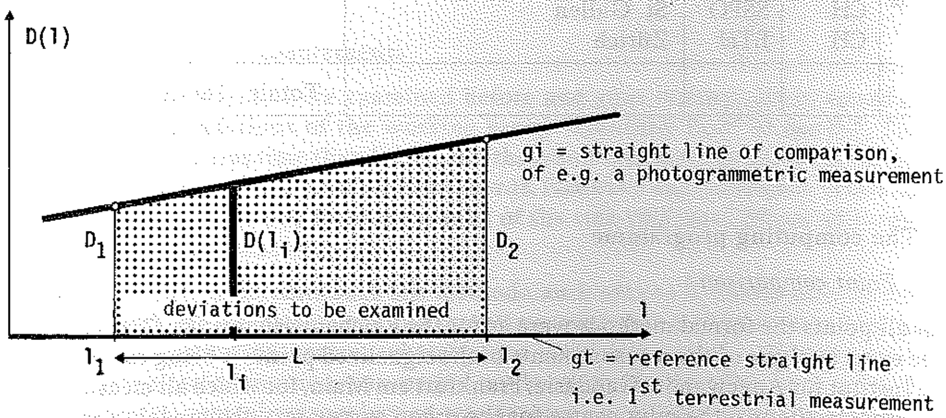


Figure 5.1 — Comparison of straight lines

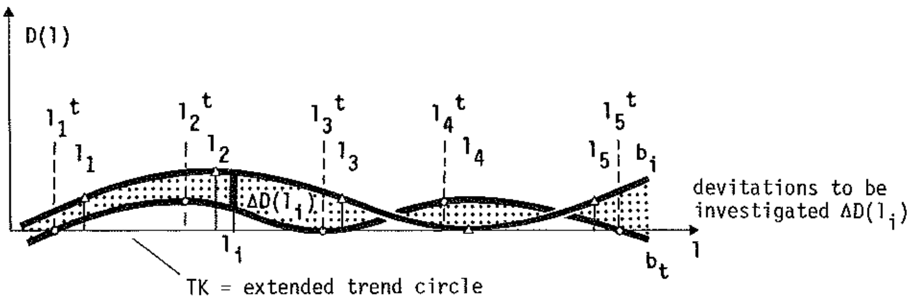
5.3 *Comparison of curves*

Rails and pavement edges also included sections of curves which were measured at 3, 4 or 5 points, approximately 35 curves in each case. The curves were firstly approximated by means of a t r e n d c i r c l e ; deviations from this trend circle were stated in a third order spline function (figure 5.2).

$$D(l) = a + bl + \sum_{j=1}^{n} c_j \quad (l - l_j)_+^3$$

$n = 3,\ 4$ or 5 = number of support points

$(l - l_j)_+$ is defined only positively, i. e. for $l \leq l_j$ it equals 0.



b_i = curve of comparison, e. g. a Photogrammetric measurement

b_t = polynomial of reference, i. e. first terrestrial measurement

l_i^t = fixed nodal points of the spline function

Figure 5.2 — Comparison of curves

The absolute, relative and systematic lateral deviations among the spline functions as well as the relative angle errors among their first derivatives could now be computed in the same fashion as for straight lines.

$$m_D^2 = \frac{1}{L} \int_{l_1}^{l_2} (D(l))^2 \ dl \qquad\qquad m_w^2 = \frac{1}{L_0} \int_{l_1}^{l_2} (D'(l))^2 \ dl \ .$$

As to height, a straight line was defined by means of the 3, 4 or 5 points and was treated as in 5.2.

5.4 Comparison of pavement heights

Points were measured along pavement edges both above and below. The pavement heights $\Delta H = H_o - H_u$ were comparable if the positions of the repeatedly measured points fitted together within a certain range. The comparison of pavement heights was intended primarily to support the results of the comparison of illuminations (sunny — diffuse).

6 Sequence of work of test computations

Computation included format unification, data testing, correcting recognizable gross errors and pre-sorting for the actual test programs. The original data and all preliminary results are in the archives of the Institute for Photogrammetry of the TU in Vienna in the form of lists and magnetic tapes.

An iterative method was used to eliminate gross errors, with at least 2 iterations being computed per test. Firstly, a priori error ceilings were applied, which eliminated only very gross errors. Secondly, new mean square errors were computed and new ceilings defined as 3 times their amount and compared with the earlier ceilings. If they differed less than their confidence interval, the last iteration was discarded and the second to last used as the result.

7 Photogrammetric accuracy depending on photo scale

It is a well-known fact that photogrammetric accuracy, measured in µm in the photograph, is not dependent on photo scale under otherwise similar conditions. Table 7.1 and figure 7.1 show other results, however, since the test comprised photo scales which, because of image motion due to flight speed and aircraft vibration in the more turbulent air near to the ground, represent the limits of the possible and acceptable for fixed-wing aircraft photogrammetry.

Table 7.1 — Compilation of the mean absolute errors of the signalized points AQK in µm in the photo for the Vienna test; photo flights with c = 30 cm (23 cm x 23 cm) under sunny illumination

	Analog restitution			Digital restitution		
Photo scale	AQX	AQY	AQZ	AQX	AQY	AQZ
1 : 1500	11	14	26	9	11	25
1 : 2500	8	9	23	6	6	23
1 : 4000	8	7	17	6	6	16

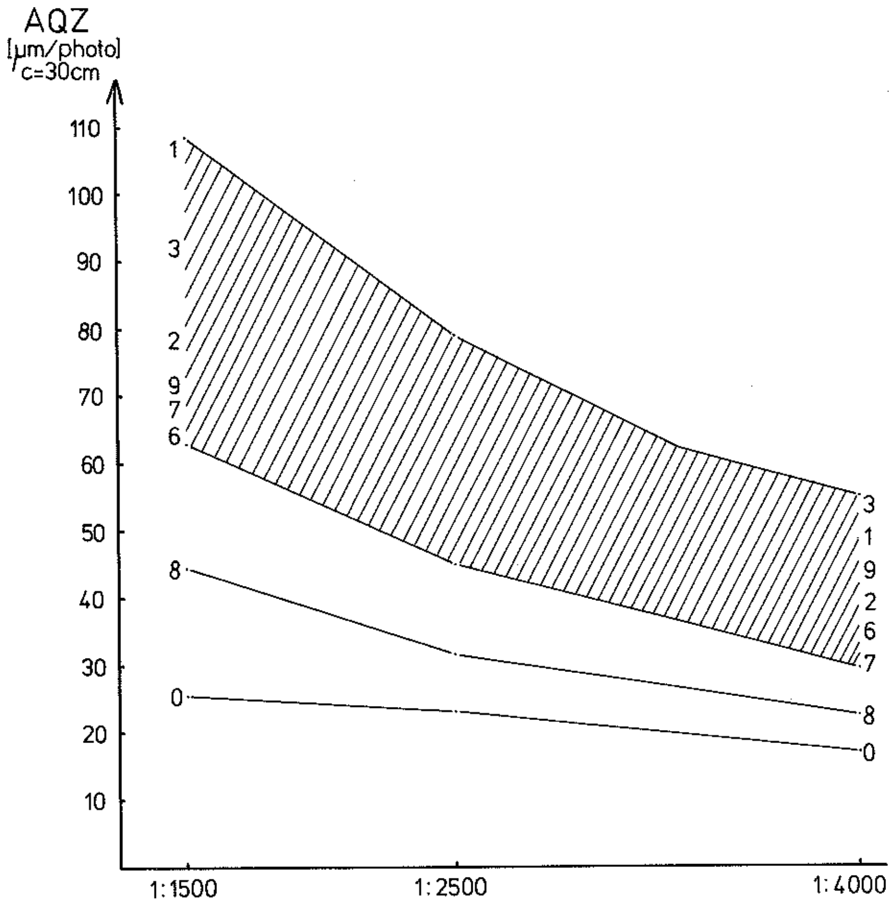


Figure 7.1 — Mean absolute errors AQZ in µm in the photo of all restitutions at the same scale with c = 30 cm for all the details defined in the form of points in (x, y). The numerals next to the lines refer to the detail point groups. All the other AQK are shown in annex 1

The accuracy performance declines clearly with increasing photo scale (50—100 %). This is also the case with the point groups which were defined less well in the form of points (up to 200 %). On the other hand, it can be seen from the errors in mm/nature that enlargement of the photo scale up to the last (1 : 1500) still brought about an absolute increase in accuracy.

On comparing the results of the Reichenbach test for 1 : 8000 with those of the Vienna test for 1 : 4000 there is a jump in accuracy in favour of the more recent test, which was carried out using a better camera and with better analog plotting instruments (table 7.2 and annex 6).

Table 7.2 — Compilation of the mean absolute errors AQK in µm in the photo for the Reichenbach test of the OEEPE/C (from *Förstner* 1969, tables 16 and 17). Photo flights with c = 21 cm (18 cm x 18 cm) under sunny illumination, only signalized points

	Analog restitution			Digital restitution		
Photo scale	AQX	AQY	AQZ	AQX	AQY	AQZ
1 : 8 000	14	15	27	8	8	19
1 : 12 000	11	13	24	7	8	21

8 Photogrammetric accuracy depending on the restitution mode

The relation of the mean absolute errors after analog restitutions to those after comparator (= digital —) restitutions shows that analog restitutions have become relatively better since the Reichenbach test (table 8.1 and annex 6). As to the signalized points restituted on analog instruments, planimetric restitution was only 27 % worse than digital restitution and there was no difference at all for height restitution.

The analog restitution instruments provided 5—20 % better planimetric results and 2—31 % better height results for the less well defined urban detail points.

A graphic survey is given in annex 2.

Table 8.1 — Error relations $k_k^{a,d}$ for the mean absolute errors AQK

Point group	$k_x^{a,d}$	$k_y^{a,d}$	$k_z^{a,d}$	$[N_a]$	$[N_d]$
0 = signalized points	+1.18	+1.36	+1.02	3919	3775
1 = house corners	−1.11	−1.05	−1.04	2291	2196
2 = house joints	−1.18	−1.05	−1.01	859	756
3 = house entrances	−1.06	−1.13	−1.18	1482	1227
6 = fences	−1.08	−1.12	−1.02	3314	3092
7 = masts	−1.23	−1.07	−1.31	2285	2181
8 = covers	−1.08	+1.04	−1.12	3825	3570
9 = trees	−1.13	−1.06	−1.24	1793	1546

9 Photogrammetric accuracy depending on illumination

To judge the influence of illumination (sunny — diffuse) we have compiled the results in µm in the photo of all analog and digital restitutions of all 4 flight horizons, calculated the variance quotients and the error relations

$$k_k^{d,s} = \sqrt{(s_k^d)^2 \; / \; (s_k^s)^2}, \quad (k = x, y, z).$$

The positive $k_k^{d,s}$ therefore indicate a multiple which corresponds to the increase of the mean errors under diffuse illumination as compared to sunny illumination, the negatives are reciprocal values! (table 9.1)

Table 9.1 — Error relations $k_k^{d,s} = (AQK_{diffuse} : AQK_{sunny})$ for the mean absolute errors AQK in µm in the photo from all restitutions of all flights. See also annex 3

Point group	$k_x^{d,s}$	$k_y^{d,s}$	$k_z^{d,s}$	$[N_d]$	$[N_s]$
0 = signalized points	1.11	1.13	1.35	3300	4397
1 = house corners	1.16	1.08	−1.08	2213	2274
2 = house joints	1.23	1.30	1.03	834	781
3 = house entrances	1.17	1.29	1.13	1533	1176
4 = pavement edges } { straight lines	1.06		1.40	2578	3188
5 = rails } { curves	−1.05		1.43	742	324
6 = fences	1.21	1.25	1.42	2972	3434
7 = masts	1.19	1.51	1.24	1917	2549
8 = covers	1.25	1.32	1.37	3298	4097
9 = trees	1.03	1.34	1.33	1708	1631

The signalized points show significantly that in diffuse light up to one third worse results in all three coordinates were obtained than for sunny light. If the advantage of diffuse illumination is to be extracted, which is that those points which are at sunlight in deep shadows become visible, a flight altitude of c. 25 % lower is necessary in order to safely compensate for the loss of accuracy compared to sunny illumination. The corresponding results for relative errors showed that z-measurements under diffuse illumination were considerably worse, which must be the result of weaker contrasts and lower image texture.

10 Results of lens comparison

Table 10.1 and annex 4 show that relative photogrammetric accuracy (in the sense of the Vienna test for the reproducibility of photogrammetric results) and absolute photogrammetric accuracy were improved by about 30 % in z because of the improvement in the normal angle optics from Aviotar 21 to Aviotar 30. The Vienna test does not give unambiguous results for situation coordinates; the differences in x or y are not significant, however, there is a uniform improvement with the newer optics.

Table 10.1 — Compilation of the error relations $k_k^{21,30}$ of the mean absolute errors AQK and the mean relative errors RQK for the stereocomparator restitutions of the flights 1 : 4000 under sunny illumination, each for the best defined point groups only

Error type	Point group	$k_x^{21,30}$	$k_y^{21,30}$	$k_z^{21,30}$	$[N_{21}]$	$[N_{30}]$
AQK	0 = sign. pts.	+1.00	+1.18	+1.33	469	562
absolute errors	8 = covers	+1.04	+1.00	+1.20	413	446
	0 + 8	+1.06	+1.04	+1.26	882	1008
RQK	0 = sign. pts.	+1.00	+1.05	+1.42	297	349
relative errors	8 = covers	+1.24	+1.10	+1.33	123	267
	0 + 8	+1.04	+1.02	+1.31	420	616

11 Results of comparison of types of points

If all the results of the 9 detail point groups are summarized separately and related to the corresponding results for the signalized points (first line in 11.1), we get a completely new feeling for how in future we can draw conclusions from accuracy estimations of signalized points about the accuracy of other point groups (table 11.1, figure 11.1).

The point definition errors had, therefore, great influence on measuring accuracy. Height accuracy of the non-signalized points amounted roughly to only 1/2 to 1/3 of that for signalized points, planimetric accuracy to only 1/2 to 1/6. Point group 8 of the low contrast and unequally square man-hole covers and covers of water sluice valves etc. lay between the best signalized test points and the other types of points. Rails could be measured photogrammetrically more accurately than pavement edges, on the one hand, probably because they were defined more exactly and, on the other hand, because the cobblestone pavement around the tracks showed the height more clearly than the asphalt next to the pavement edges.

Table 11.1 — Compilation of the mean absolute errors AQK in µm in the photo and of the corresponding error relations $k_k^{i,o}$. All photo flights and all restitutions were used. For the pavement edges and rails the corresponding lateral deviations (AQD) were compared with the mean from both coordinate errors AQX° and AQY° of the signalized points

Point group i	AQX° $k_x^{i,o}$	AQY° $k_y^{i,o}$	AQZ° $k_z^{i,o}$	$[N_r]^i$
0 = signalized points	8	9	25	7694
1 = house corners	5.7	4.4	3.3	4487
2 = house joints	5.1	4.7	2.7	1615
3 = house entrances	5.6	4.8	3.2	2709
6 = fences	6.1	4.9	1.9	6406
7 = masts	4.8	3.8	1.9	4466
8 = covers	3.0	2.6	1.4	7395
9 = trees	6.5	5.2	2.0	3339
4 = pavement straight lines	3.4		1.5	2104
4 = pavement curves	2.8		1.3	1440
5 = rail straight lines	2.0		1.3	5072
5 = rail curves	1.5		1.1	321

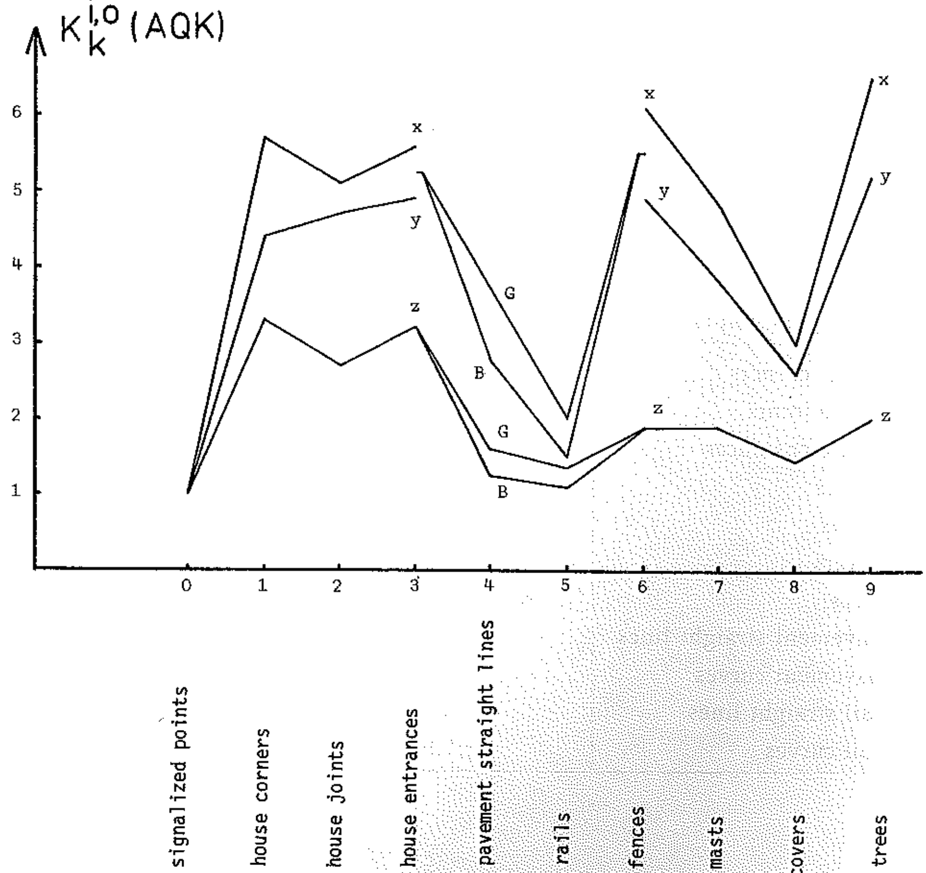


Figure 11.1 — The mean absolute errors of the individual point groups in units of the mean absolute error of the signalized points (see table 11.1). (G = straight lines, B = curves) (see also annex 7)

12 Comparison of both terrestrial measurements

During the second terrestrial measurement only the detail points, not the signalized points were determined a second time. Since the mean errors from control runs were equally large with both surveys, both measurements could be viewed as equally accurate. Between the two terrestrial surveys the same mean planimetric deviations of ± 3 to ± 4 cm were obtained for almost all point groups. Only in the case of covers (point group 8) was correspondence higher (± 2 cm), with trees lower (± 6 cm). The same was the case for height differences.

The photogrammetric analog measurements from photo scales 1 : 1500 were worse in planimetry by a factor of 2—3 in comparison with terrestrial measurements, and for height worse by a factor of 3—4. These unfavourable results for photogrammetry could be due to the fact that with the two terrestrial measurements the same test point net was used, i. e. the directions of observation had been identical to a large extent in contrast to the very different perspectives of photogrammetry. Straight lines, curves and pavement edges could only be compared with great difficulty, since deviations between the two terrestrially measured points were larger than between the photogrammetric ones and therefore a great many measurements were omitted. However, the comparable measurements did not reveal any new aspects.

A graphical representation of these results is given in annex 5.

13 The significance of large photogrammetric tests

The OEEPE large tests include the processing of very extensive data material in order to extract practical calibration factors for theoretical investigations and to estimate the difference between the miraculous results of individual publications and the actual results of repetitions. The future will show if the trend indicated by the Vienna test is actually true.

However, this report should not gloss over the faults of such very expensive large tests. 15 000 man hours were needed for the Vienna test and nevertheless or indeed because of this there are surely many errors. If, however, the relation between the mean absolute lateral errors, for example, of the pavement edges which were measured three times with analog instruments is 3 : 4 : 4 and that of those measured 3 times with stereo comparators 3 : 8 : 17 (all cm values! — 2 centres worked on each value), then in at least 3 centres the carefulness or the skill needed for international cooperation was missing. And if 25 % or 50 % of the promised measurements are not delivered from some of the centres participating in the test and the commission members merely showed surprise, then something is wrong with production control.

Photogrammetry is a relatively easy measuring method but is responsible for mass working which, as everywhere in industry, contains rejects. The Vienna test is a reminder for us that methodologically strict controls should be envisaged and that standard tests, double measuring, block double coverages, controls of model orientations are not measures to be laughed at. The geodetic principle, no measuring without control, must never be forgotten either in the discipline of photogrammetry. Professor *Schermerhorn* always judged a photogrammetric company on the organization of the preparation department. I am convinced he would judge the photogrammetric coordinate factories of today according to their control organization.

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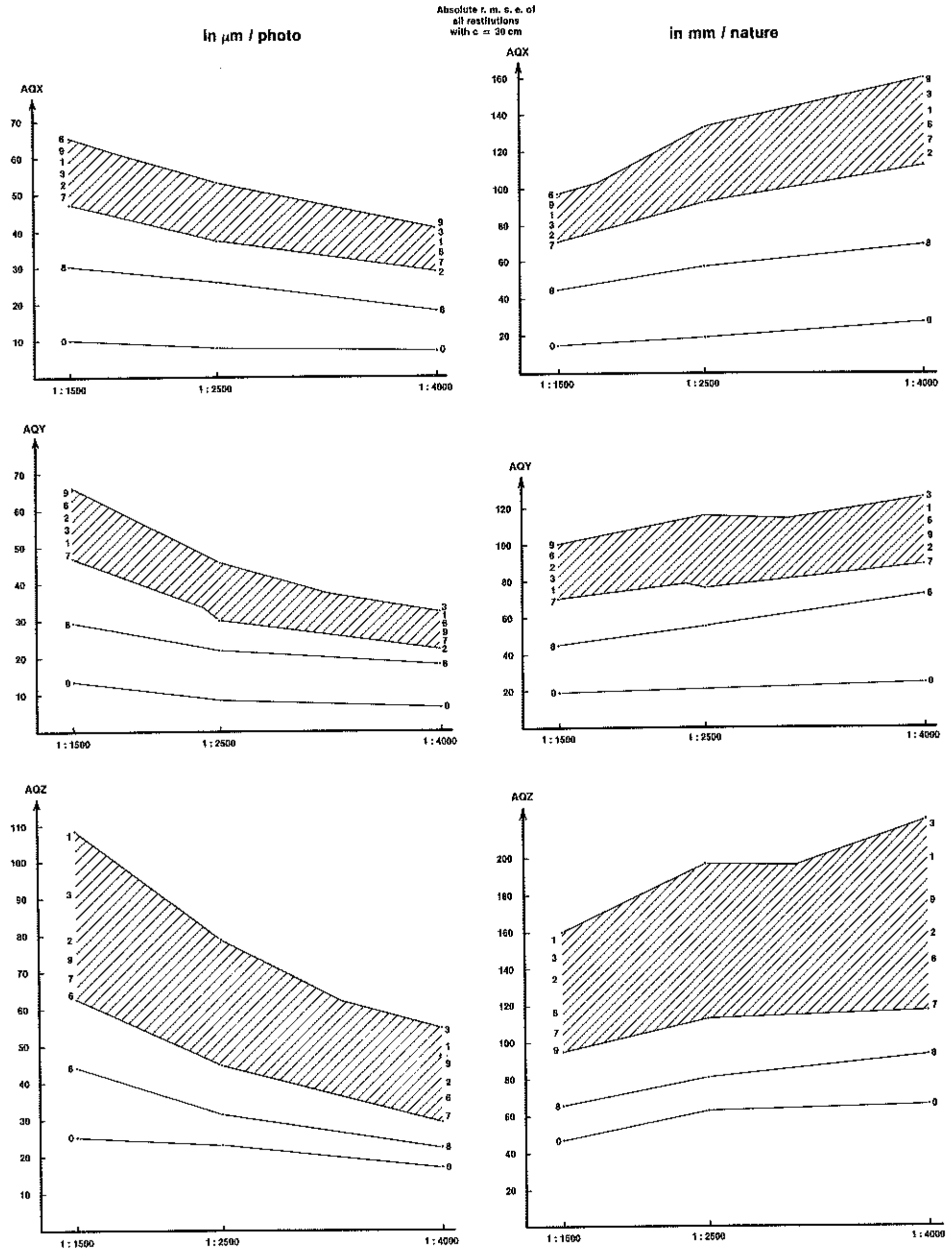
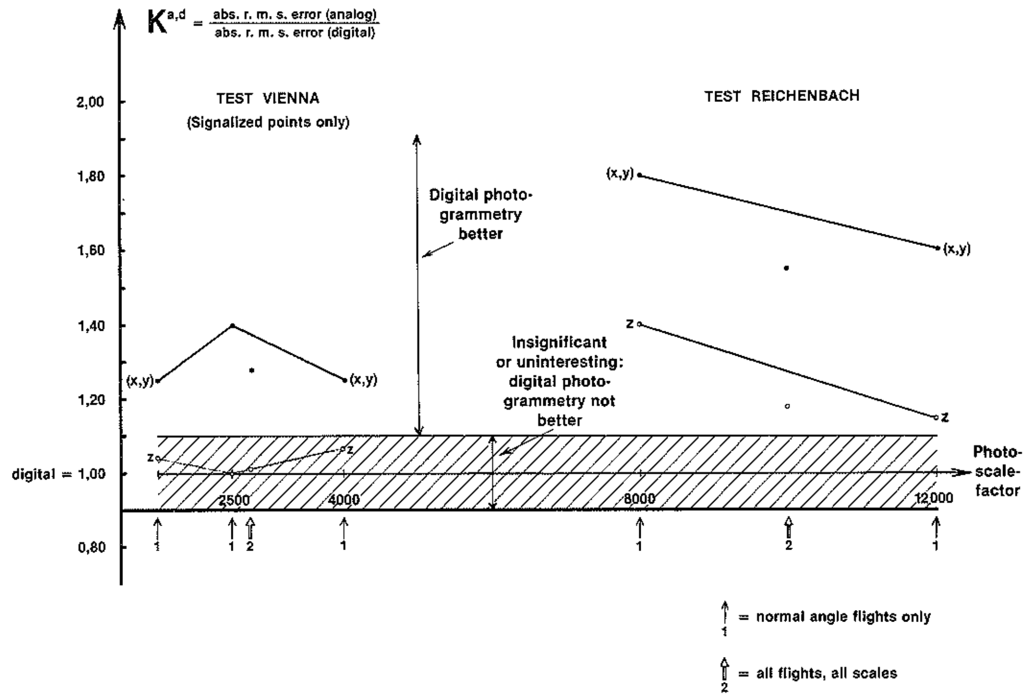
Comparison of Photo – Scales



One expects the accuracy of photogrammetry in µm of the photo to be independent of the photo scale. Results of the Test Vienna show, however, larger r. m. s. errors at increasing photo scales.
Reason : Image motion, point definition

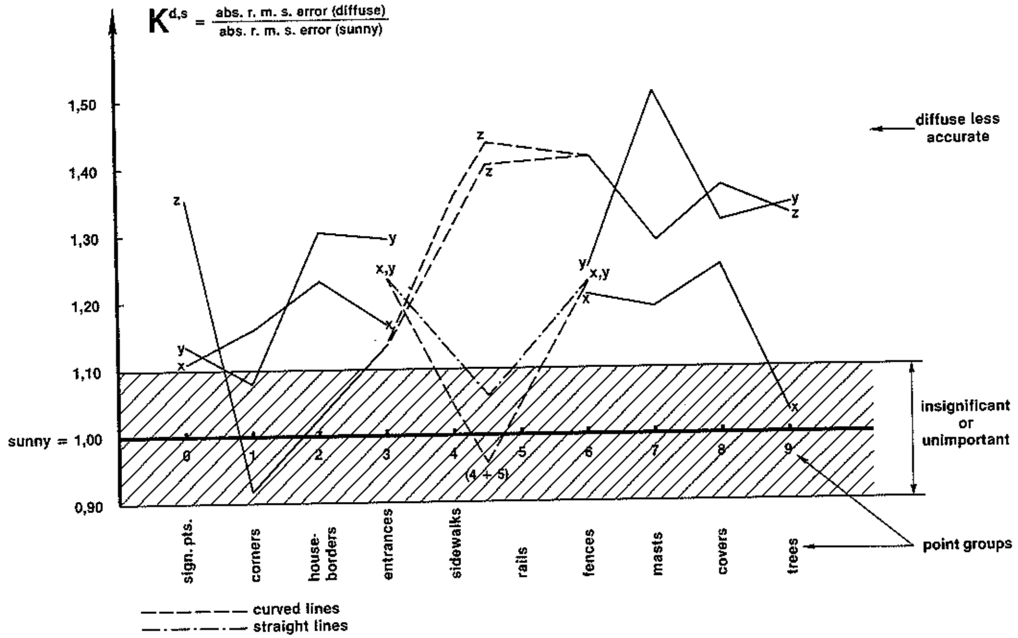
Nevertheless, larger photo scales result in better accuracy.

Analog Instruments versus Stereocomparators



Type of points	Analog-instruments		Stereo-comparators
Signalized points		(x,y)	25% better
	not worse	(z)	not better
Nonsignalized town detail points	a little better	(x,y)	
	significantly better	(z)	

Sunny versus Diffuse Illumination

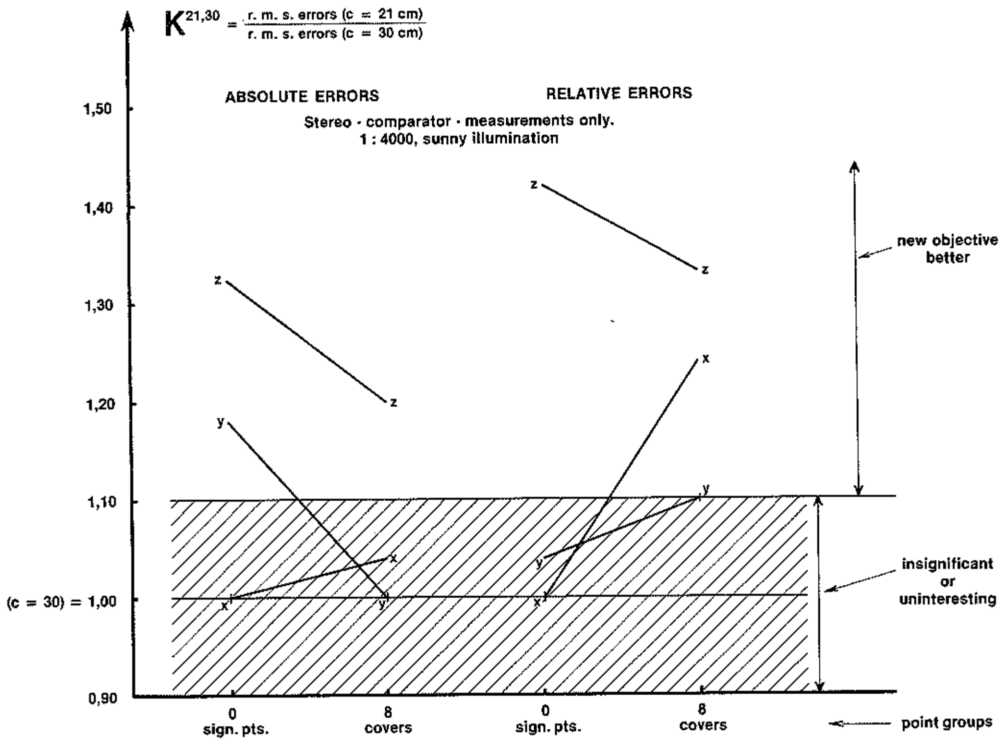


The absolute (and also the relative) errors for diffuse illumination are larger than those for sunny illumination, above all for z.

Reason: Less detail contrast

Conclusion: To maintain the height accuracy corresponding to sunny conditions flying height under cloudy sky has to be decreased by 25%.

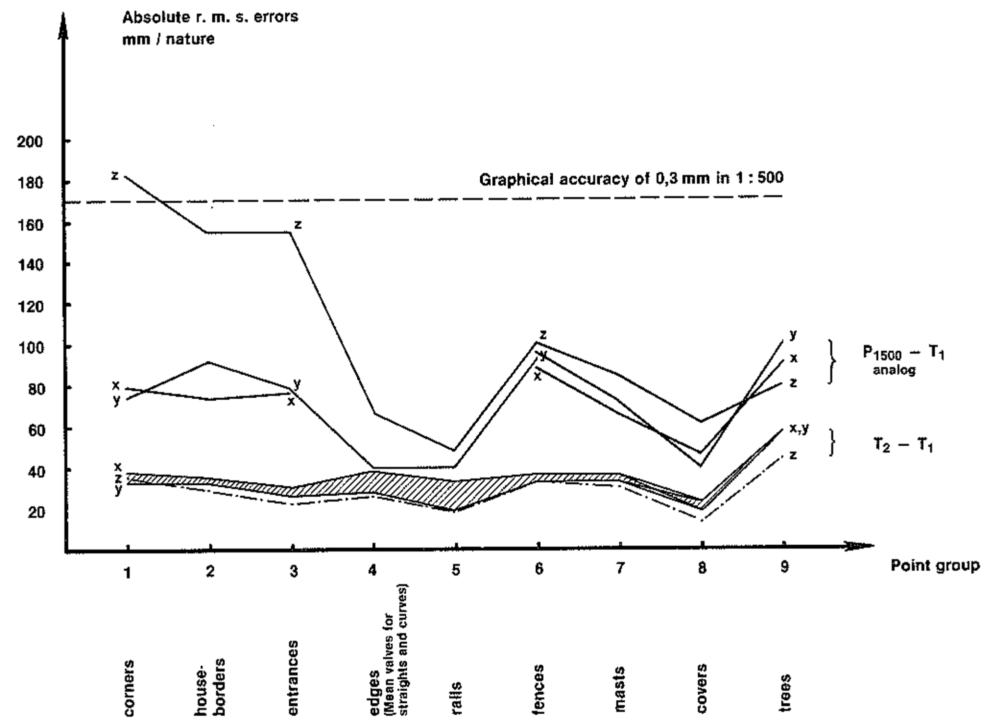
Old Aviotar versus New Aviotar



The height results of the new Aviotar c = 30 cm (1973) are 30% better than those of the old Aviotar c = 21 cm. The planimetric results are also better, but the difference is less significant in this case.

Progress in optics means progress in accuracy.

Terrestrial versus Photogrammetric Accuracy



The difference ($T_2 - T_1$) between the two terrestrial measurements has been compared with the difference ($P_{1500,\,analog} - T_1$) between the photogrammetric measurements (sunny plus diffuse, scale 1 : 1500) and the first terrestrial measurements T_1.

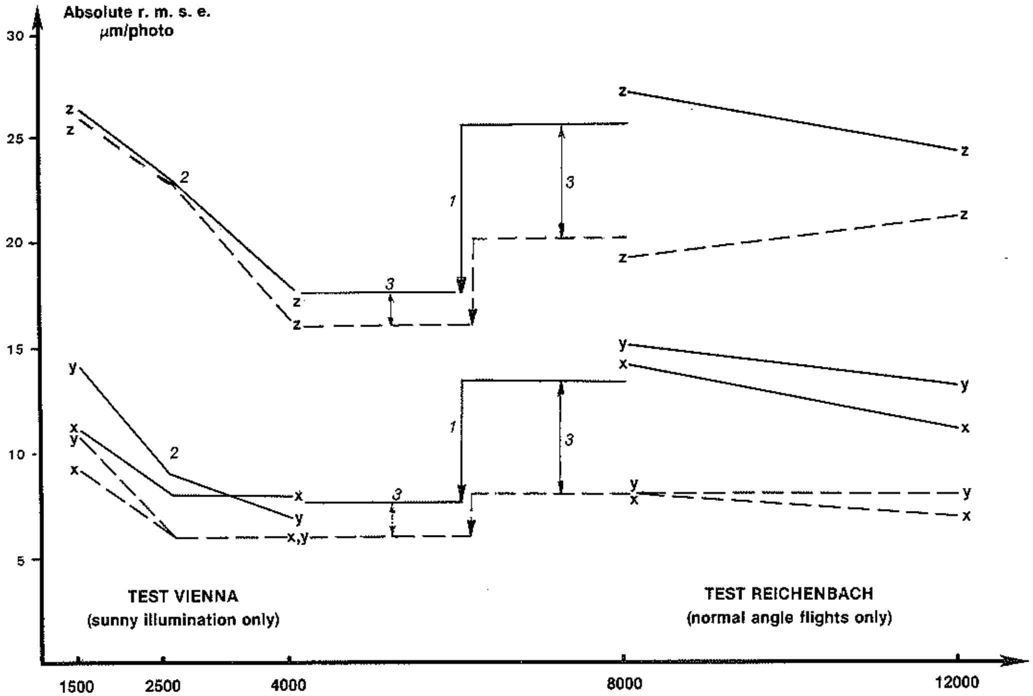
The two terrestrial measurements coincide with each other within 3 – 4 cm for nearly all point groups; in the case of group 8 (installation covers) the coincidence is better (± 2 cm).

Results gained by analog instruments are worse than those of the terrestrial measurements: in planimetry 2 – 3 times, in heights 3 – 6 times.

Reasons: In the cases T_1 and T_2 the direction of vision by theodolite has been idendical always. In the cases of high objects the photogrammetric operators very often do not measure at ground level.

Test Vienna versus Test Reichenbach

(Signalized points only)



1 ✳ TEST VIENNA WAS MORE ACCURATE

in planimetry 33%
in height 25%

Reasons: Better optics, better analog instruments, less height differences

2 ✳ The accuracy performance in μm/photo decreases with the larger photo scale.

Reasons: increased image motion, worse point definition.

3 ✳ Test Vienna shows less difference between the results from analog instruments and stereocomparators.

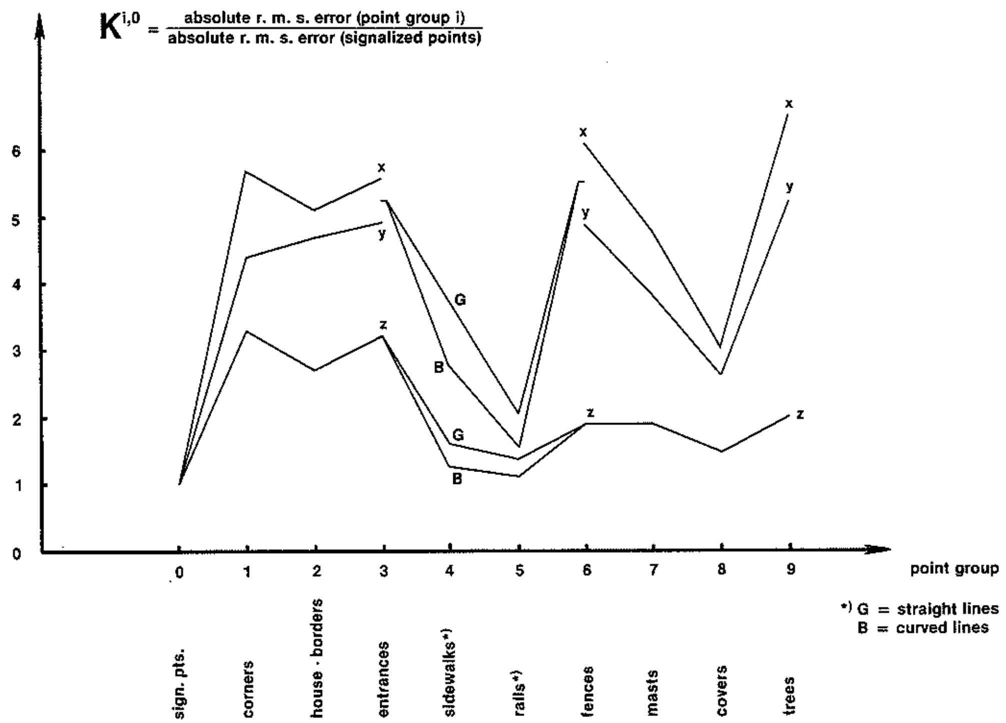
Reasons: Better analog instruments, less height differences.

——— analog instruments

- - - - stereocomparators

Non - signalized Town Detail Points versus Signalized Points

$$K^{i,0} = \frac{\text{absolute r. m. s. error (point group i)}}{\text{absolute r. m. s. error (signalized points)}}$$



1. Signalized points are always the most accurate ones.
2. The heights of the details are 2 – 3 times less accurate than the heights of the signalized points.
3. The planimetry of the details is 2 – 6 times less accurate than the planimetry of the signalized points.
4. Only the installation covers and gullies show comparably good results, everything with heightextension is less accurate.
5. Rails yield better accuracy than edges of sidewalks do.
6. Straight lines (from 3 points) are less accurate than curved lines (from 3 – 5 pts!).

DK 528.74:528.45(436.14)
528.45—187
771.537

Photogrammetric Versus Terrestrial Town Survey

(Supplement to the "Report on the Results of the Test Vienna")

(with 12 Figures and 1 Table)

O. Kölbl

1 Introduction

The test Vienna allowed very detailed research into the problems of photogrammetry raised by town surveys. The wide diversification of the photogrammetric restitutions enabled to analyze in great detail the precision and completeness of this working process. However one should not overlook the fact that this research was executed under purely experimental conditions. Neither the completeness of the photogrammetric measurements as such, nor the problem of supplementary terrestrial measurements has been touched upon.

A priori these limitations must not be considered as a deficiency and it is well understood that for every research it is necessary to define the working hypothesis. However it is dangerous when a procedure is qualified only on the base of a comparison with an other procedure. Indeed the preceding report concludes that the photogrammetric analog measurements from the largest photo scale were worse in planimetry by a factor 2—3 in comparison with terrestrial measurements (cf. section 12). The author makes some restrictions in the following as for the quality of the terrestrial measurements. Nevertheless the report gives the impression that photogrammetry is only of limited value for a town survey due to lack of precision and the omission of a great number of points.

Three centres of Switzerland were heavily engaged in this OEEPE test and we had the impression that the rather general conclusions should be analyzed more in detail. Is it really true that terrestrial measurements are considerably more precise than photogrammetric measurements or could it be that systematic errors influenced heavily these rather disappointing result? Furthermore within the last 10 years great progress has been made to improve image quality and it could be that the test material is no more representative for modern picture material. Therefore the Swiss Group of OEEPE has taken upon itself to re-analyze the test material. The considerations are purposely limited to the measurements done by the swiss centres. They should be sufficient to view the test Vienna from a wider angle. However, it would greatly exceed the frame fixed by the OEEPE for the test Vienna if one were to try and treat these plausibility considerations as profoundly as the experiments on the numerical photogrammetric restitutions.

2 Numerical analysis of the measurements

The precision of the terrestrial measurements is specified in chapter 2 of the preceding report. It is indicated that the coordinates of the signalized points have an "average mean error of ± 1 cm". Whereas for the urban detail points the mean coordinate errors is estimated of ± 2 cm from control distance measurements. So far the terrestrial measurements seem to be sufficiently precise to serve as reference for photogrammetric measurements. But, photogrammetric measurements and terrestrial measurements have a very different error propagation. Remaining systematic error components in the two measurements influence in a very different way the point coordinates. An indication that the terrestrial measurements are attached with systematic errors is the fact that the residual errors of photogrammetric measurements calculated in the picture scale diminish for the smaller scales (cf. table 7.1, page 20).

Table 1 — Comparison of the mean residual coordinate errors of 5 photogrammetric restitutions with their standard deviation (according to the praxis of the test Vienna residuals > 140 mm have been eliminated). As the residuals deviate highly significantly from zero the 5 photogrammetric restitutions together seem twice as precise as the terrestrial survey

Section	Nature of points	Number of points	Means of residual coordinate errors (x, y) (standard deviation)	Standard error of the means of coordinate errors (x, y) (standard deviation)
Section 1 Models 181, 191, 281,	signalized points	30	± 13	± 5
291, 381	shafts	36	± 28	± 20
Section 3 Models 183, 193, 282,	signalized points	33	± 15	± 6
292, 381	shafts	51	± 37	± 16

In order to find a way to analyze the precision of photogrammetric measurements in a rather independent way it was decided to compare the residuals in the different pictures scales after a Helmert transformation (similarity transformation) and analyze their consistency.

For this investigation 2 sections have been chosen delimitated by the perimeter of the models with the largest picture scale. Section 1 is covered by the models 181, 191 (picture scale 1 : 1500), 281, 291 (picture scale 1 : 2500) and 381 (picture scale 1 : 4000), for section 3 the models 183, 193 (1 : 1500), 282, 292 (1 : 2500) and 381 (1 : 4000) are used. The analyzed sections cover in the photographs with the smaller picture scales only a small zone of the entire model. It was hoped that by this combination of the different picture scales the systematic error components of the picture material will be meaned out.

The two sections contained approximately 30 signalized points. All these points were used for the absolute orientation (numerical Helmert transformation). Whereas these control points covered entirely the model area of the large-scale photographs only a section of the smaller scale photographs has been used. Special attention was given that all successive 5 models were orientated with the same control points of one specific section.

The superposition of the residuals for the different models (cf. figures 1—4) shows that the photogrammetric measurements are very consistent. This consistence can also be tested numerically by calculating the mean of the residuals of the 5 restitutions and the spread around the mean (cf. table 1). For the signalized points the mean deviation is $\pm$ 13 and $\pm$ 15 mm whereas the standard deviation referring to the mean value itself is only $\pm$ 5 and $\pm$ 6 mm (first value always for section 1).

In a similar way also the shafts have been analyzed as one of the detail points which are rather clearly defined. For this category of points a standard deviation of $\pm$ 28 and $\pm$ 36 mm has been found after Helmert transformation, whereas the spread of the mean value itself amounts to only $\pm$ 20 and $\pm$ 16 mm. For the shafts it was necessary to exclude gross errors and values exceeding 14 cm have been considered as blunders. They are not shown either in the figures 3 and 4.

The results of these analyses suggest that the 5 photogrammetric restitutions together are nearly twice as precise as the terrestrial measurements. It also seems that the precision estimated for the terrestrial measurement is too optimistic and does not sufficiently take into consideration the systematic error components in the reference system. Also for photogrammetric measurements still other error components could have affected the precision which have not been analyzed in detail, as for example: systematic restitution errors, film deformations, errors in point signalization or, for natural points, definition errors. However, systematic photogrammetric errors should be very well compensated when using 3 different picture scales. The only systematic error component which cannot be detected in this way is the affinity. An analysis of the residual errors of the signalized points showed however that an affine deformation cannot be detected in a significant way and would not contribute to a noticeable reduction of the residuals.

It is true that errors in signalization of the points cannot be controlled in this way. An analysis of the shafts shows similar systematic errors components; the image quality of these objects is rather good and cannot explain this effect. For better understanding microenlargements of a few shafts have been made and the residuals have been plotted for these points in figures 5—8. Decentring of the signalization marks as main errors source can therefore be excluded and the assumption seems very likely that systematic errors in the terrestrial measurements have caused the rather unfavourable result of the photogrammetric measurements.

3 Analysis of the image quality

When analyzing results of photogrammetric measurements, it is appropriate to include the image quality into these considerations, although, obviously, no direct relationship between image quality and measuring precision can be given. However, an inferior image quality encourages identification errors and blunders in measurements; an effect which interfered very seriously in the test Vienna and provoked a discussion on the reliability of photogrammetry. The report on the test Vienna in no way analyzes the image quality of the picture material. It was only indicated in an earlier report that one strip (picture scale 1 : 4000), taken in diffuse light, was eliminated due to double exposures and image movement.

A purely visual judgement of the picture material used in the test Vienna shows that the image sharpness seems to be below the usual standard and that the image contrast of the photographs taken in diffuse light is in no way optimal. On several occasions, the staff involved in the picture measurements has pointed out this problem. However it is problematic to judge a parameter of such an importance as the image quality merely on the basis of subjective impressions. To avoid this difficulty, the Institute of Photogrammetry of the Swiss Federal Institute of Technology of Lausanne (EPFL), with the kind assistance of the Chaire de mécanique appliquée et photoélasticité of the EPFL, has undertaken microdensitometer measurements of the large-scale photographs of Vienna.

In order to find a reference for these density profiles, analogue measurements have been made on photographs recently taken over a test field of the Institute of Photogrammetry near Lausanne. The density measurements have been limited to signalized points, as the considerations on precision concentrated on these objects.

For the density measurements a Zeiss Scanning Microscope Photometer 03 has been used. The slit size for profile measurements was 2 μm x 10 μm, small side in scanning direction. The rectangular shape is preferable in order to suppress noise due to the granularity of the film. Most of the profiles have been measured in flight direction and perpendicular to it.

A comparison of the microdensitometric profiles of the signalized points used for the test Vienna with those used for the test field of Echallens (Lausanne) shows great differences as for the slope of the curve and the maximum reached (cf. figures 9—13). The rather long slope of nearly 100 μm for the test Vienna compared to about 50 μm indicates a difference in resolution of about a factor two. The considerable lower maximum points out the rather low contrast of the signals against their surrounding.

It is difficult for the user to explain the great differences in image quality. For the test Vienna in 1973, a prototype of the Wild Aviotar (f = 30 cm) was used; a lens which has been meanwhile replaced by a new type. For the survey flights of Echallens (Lausanne), an Aviogon UAG 15/4 (No. 13 003) was used. In both cases the microdensitometric measurements were made on glass plate diapositives. The film used for the survey flights of Echallens was a Kodak Double-X film. The prints were made on a Agfa-Gevaert Aviphot Dia C glass plate using a Zeiss contact printer.

4 Conclusions

Photogrammetric restitution is a relatively complex process which depends on several environmental factors. Only the strict control of these environmental conditions can guarantee an optimum precision and fiability of photogrammetric measurements, as is also true for other high precision geodetic measurements. One result of the test Vienna should be that the precision of photogrammetric measurements is more or less equivalent to the precision of terrestrial measurements. But the real limits of photogrammetric surveying methods can only be tested if appropriate standards are used. A direct comparison of photogrammetric and terrestrial measurements very often comes up against the different error propagations. In general, the precision of a photogrammetric survey is more homogenious than terrestrial measurements, which has led to a reconsideration of the adjustment procedures in photogrammetry. The test Vienna, which was conceived in the beginning of the seventies, was not intended to cover this problem. The results should therefore be considered as a detailed study of numerical restitution under experimental conditions with the equipment in use about ten years ago.

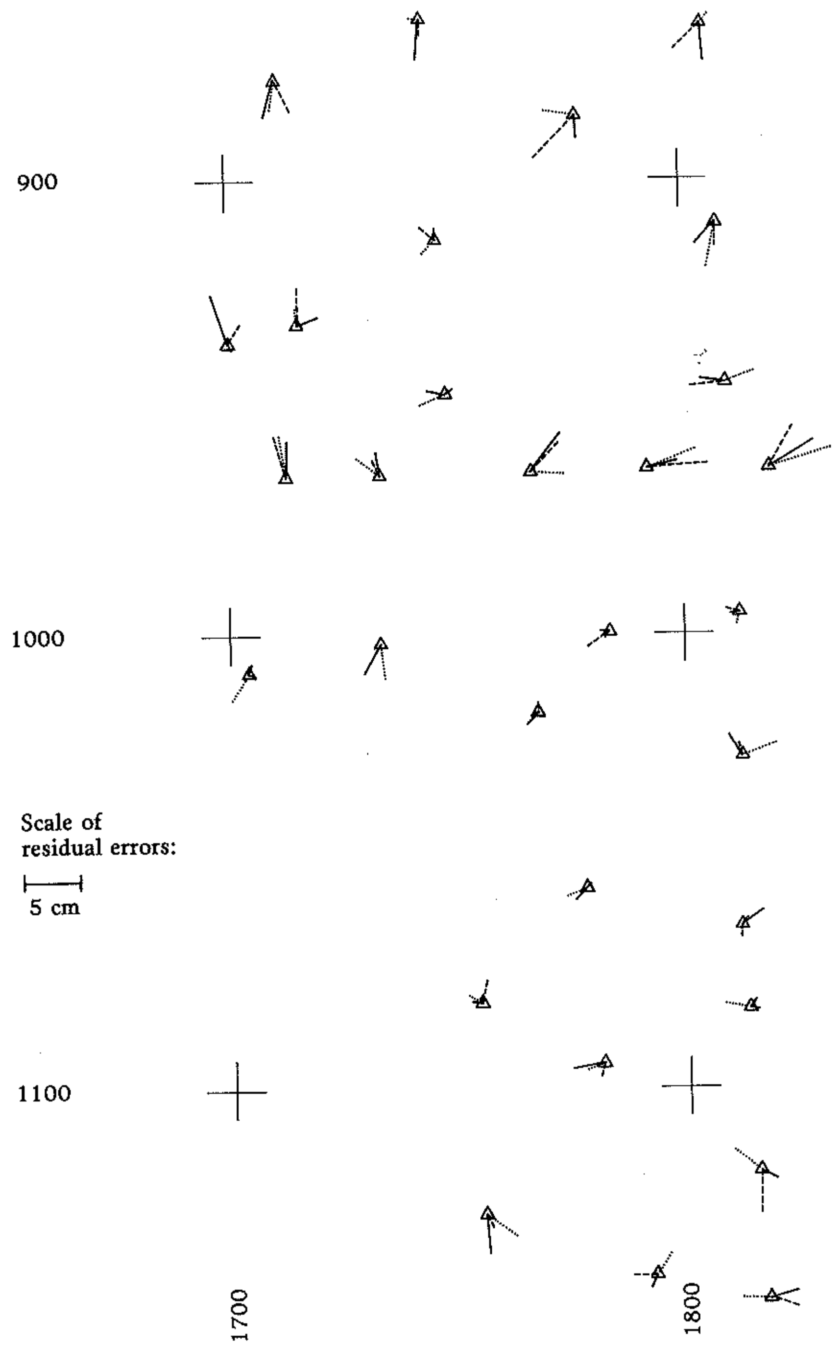


Figure 1 — Graphical presentation of the residual errors of the signalized points of section 1, models 181 (continous line), 281 (dashed line) and 381 (pointed line). All points have been used for absolute orientation of the individual section.

The graphic is limited to 3 models in order to simplify the presentation

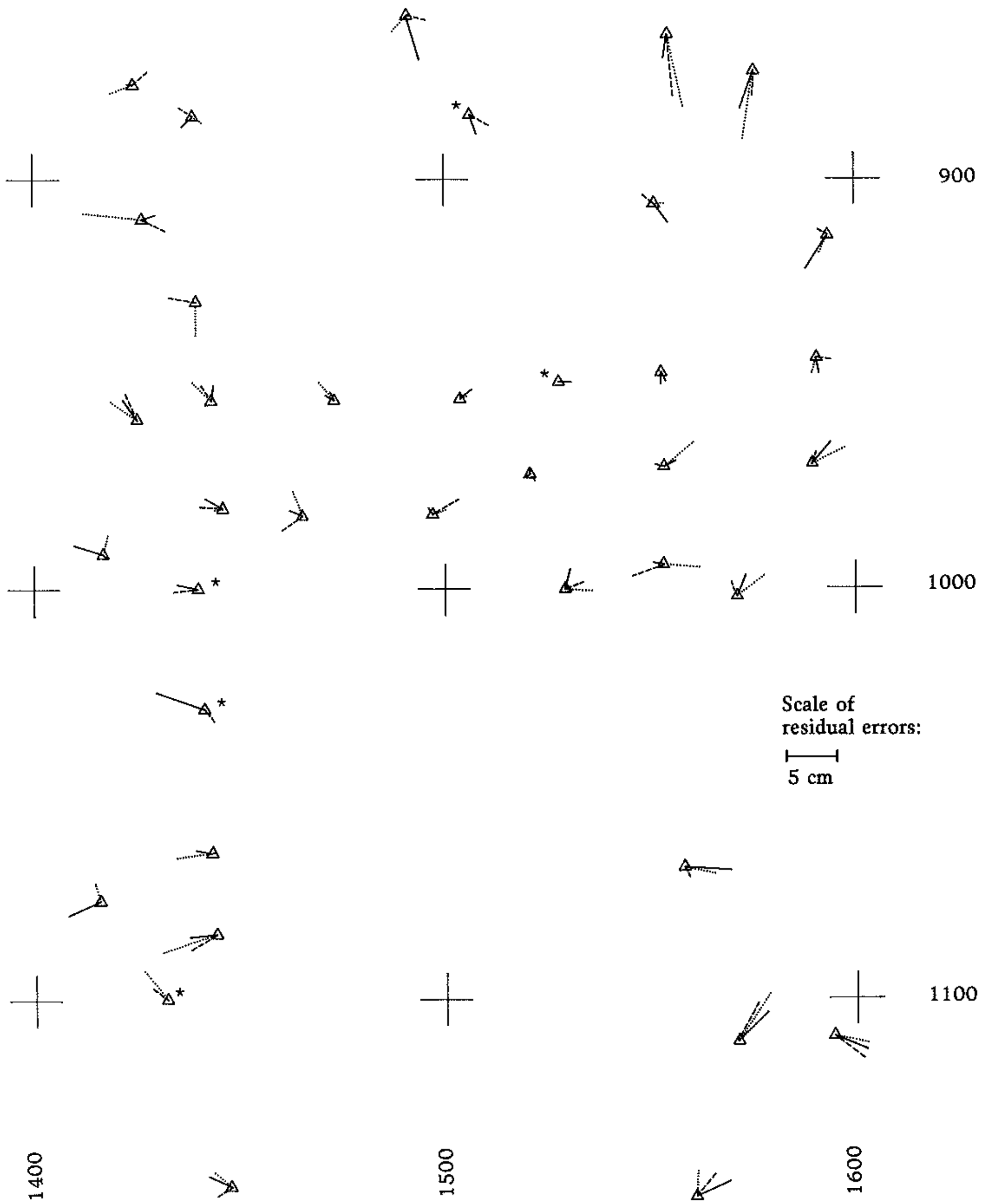


Figure 2 — Residuals of section 3 for models 183 (continous line), 282 (dashed line) and 381 (pointed line); presentation as for section 1. Points marked by * have not been used for absolute orientation of the section

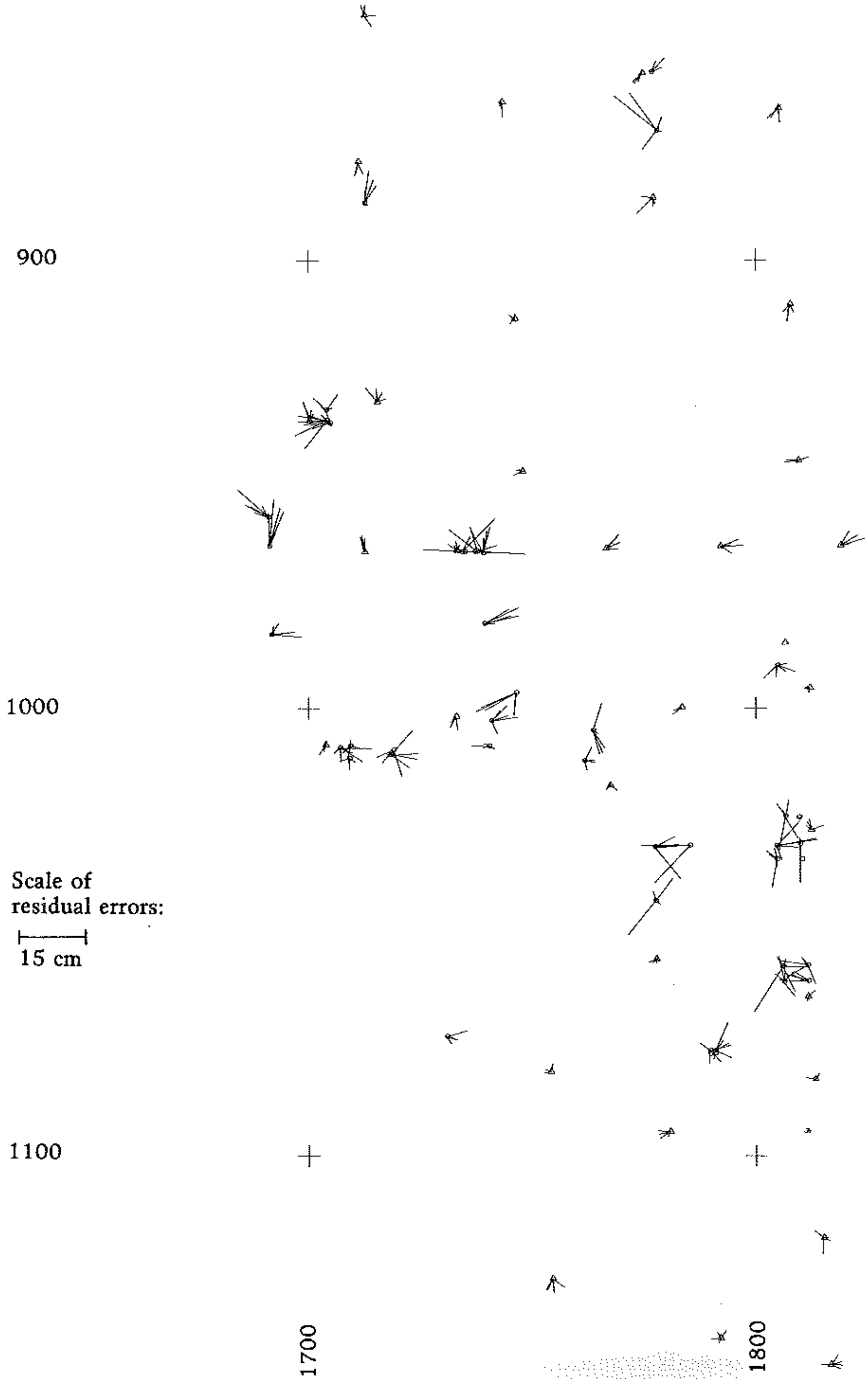


Figure 3 — Superposition of residuals of all 5 models for signalized points (△) and shafts (○) for section 1 (models 181, 191, 281, 291, 381)

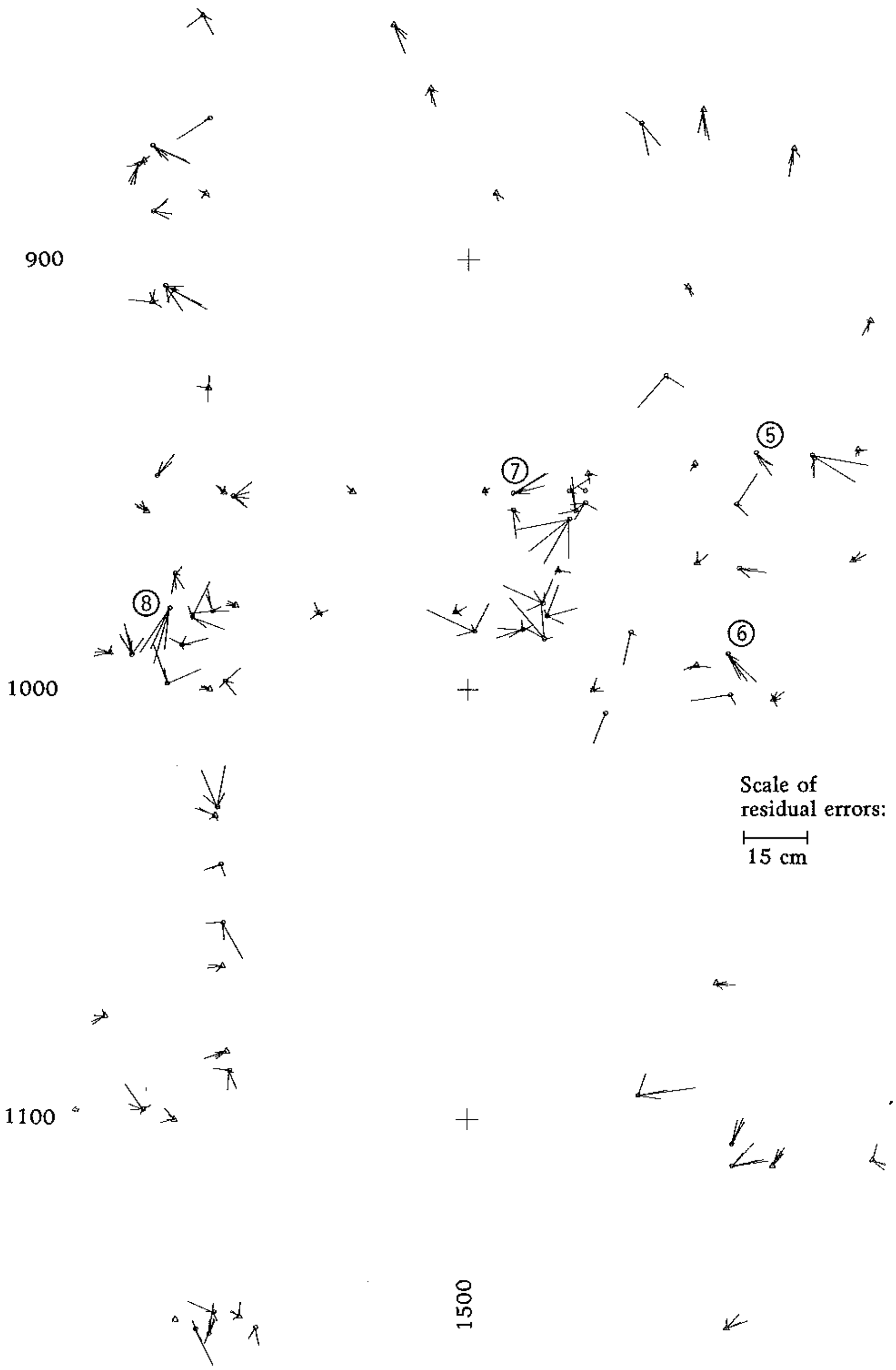


Figure 4 — Residuals for signalized points (△) and shafts (○) for section 3 (models 183, 193, 282, 292, 381). The numbers correspond to the detailed enlargements of figure 5—8

Figure 5—8 — In order to illustrate that the encountered systematic errors can hardly be inherent to the photogrammetric procedure, the residuals of 4 shafts are put against detailed enlargements of these objects. The left (lower) part of the figures shows the outline of the cover with the centre (double circle); the other symbols (□ = model 183, ● = 193, ○ = 282, △ = 292, + = 381) indicate the supposed pointing of the photogrammetric measurements according to the comparison with the terrestrial measurements. The photographs to the right (above) are about 15 times enlarged and were taken from the large-scale diapositives 9782 and 9783 used for photogrammetric measurements

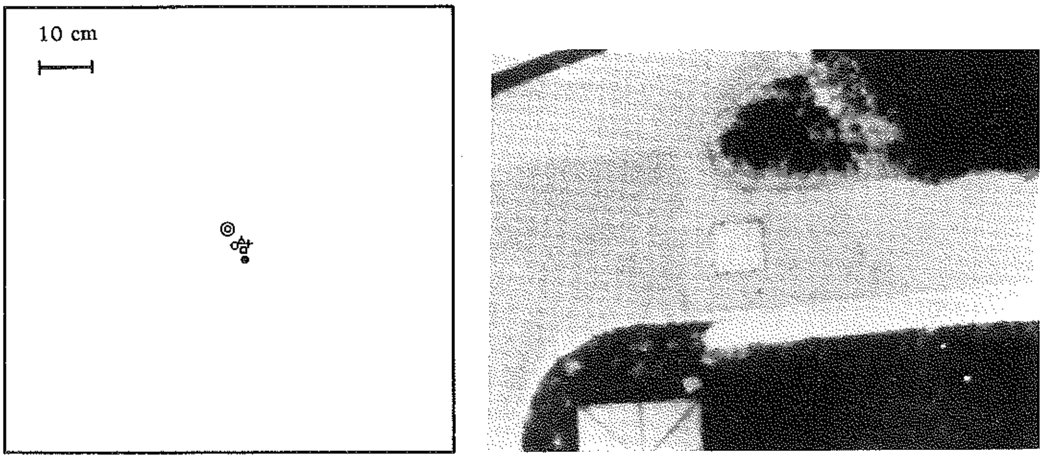


Figure 5 — Shaft no. 3570

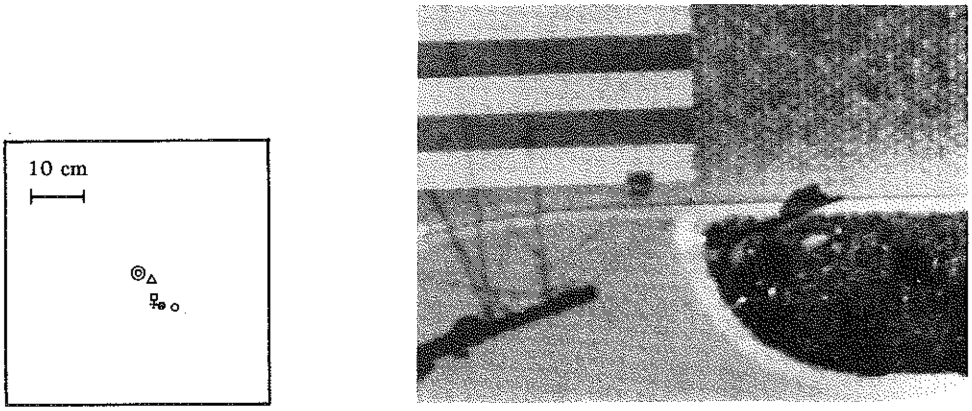


Figure 6 — Shaft no. 3758

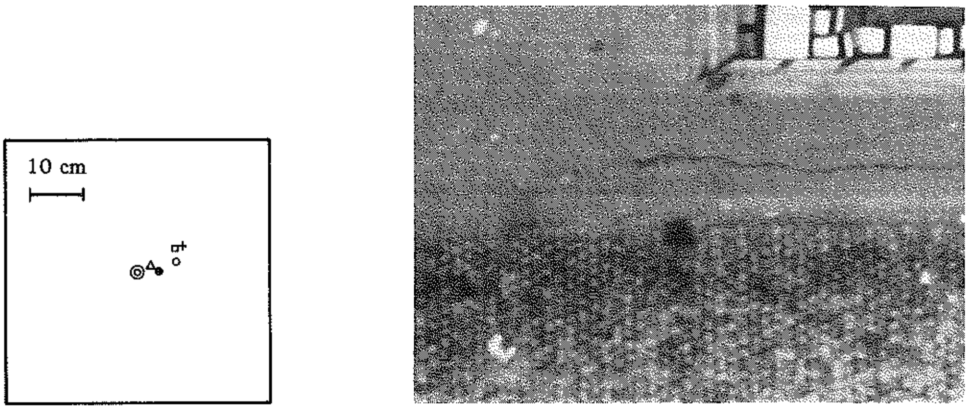


Figure 7 — Shaft no. 3841

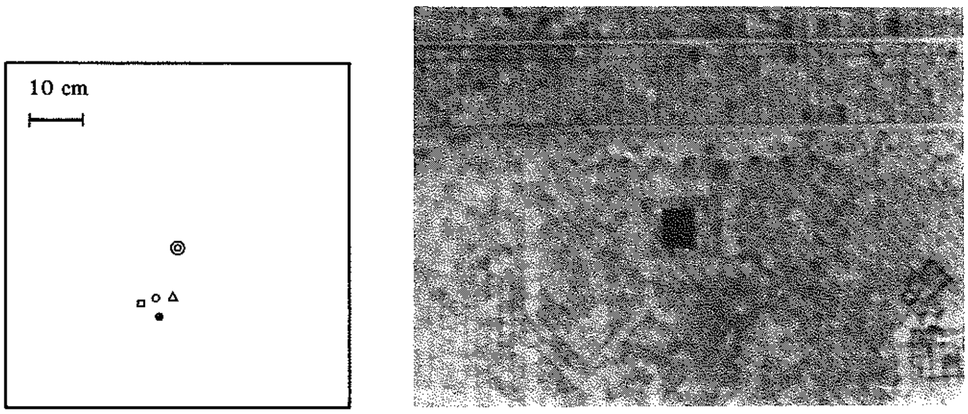


Figure 8 — Shaft no. 3951

Figure 9—11 — Density profiles and photographic enlargements of signalized points used for the test Vienna, left photograph about 15 times enlarged, right photograph about 250 times. The signal in the micro photo is only very vaguely visible (patch 2 cm x 2 cm in the centre) and only contrasts with its surrounding by the lower granularity. The density profiles are measured in flight direction (left) and perpendicular to it (right). Remarkable are the irregular and flat slopes of the curves and the faint contrast

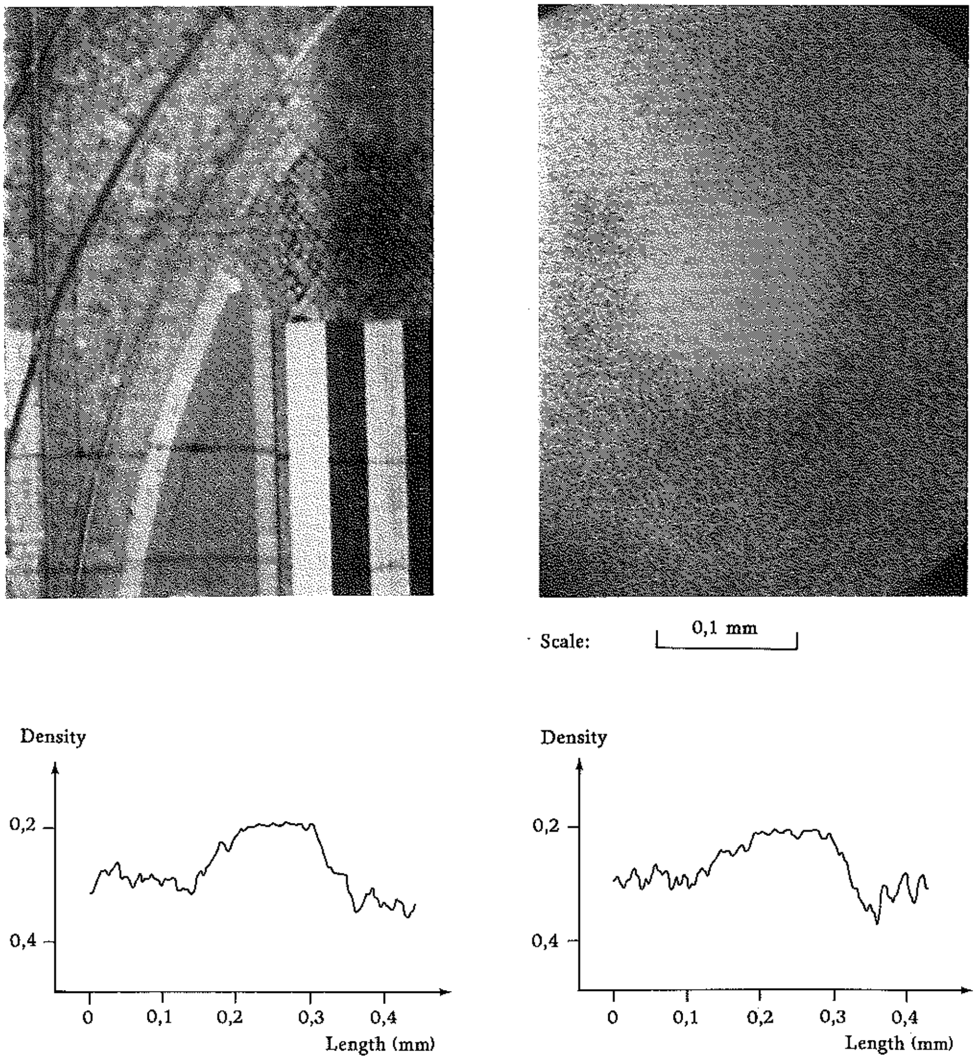


Figure 9 — Signalized point no. 100081 in centre of photograph 9782

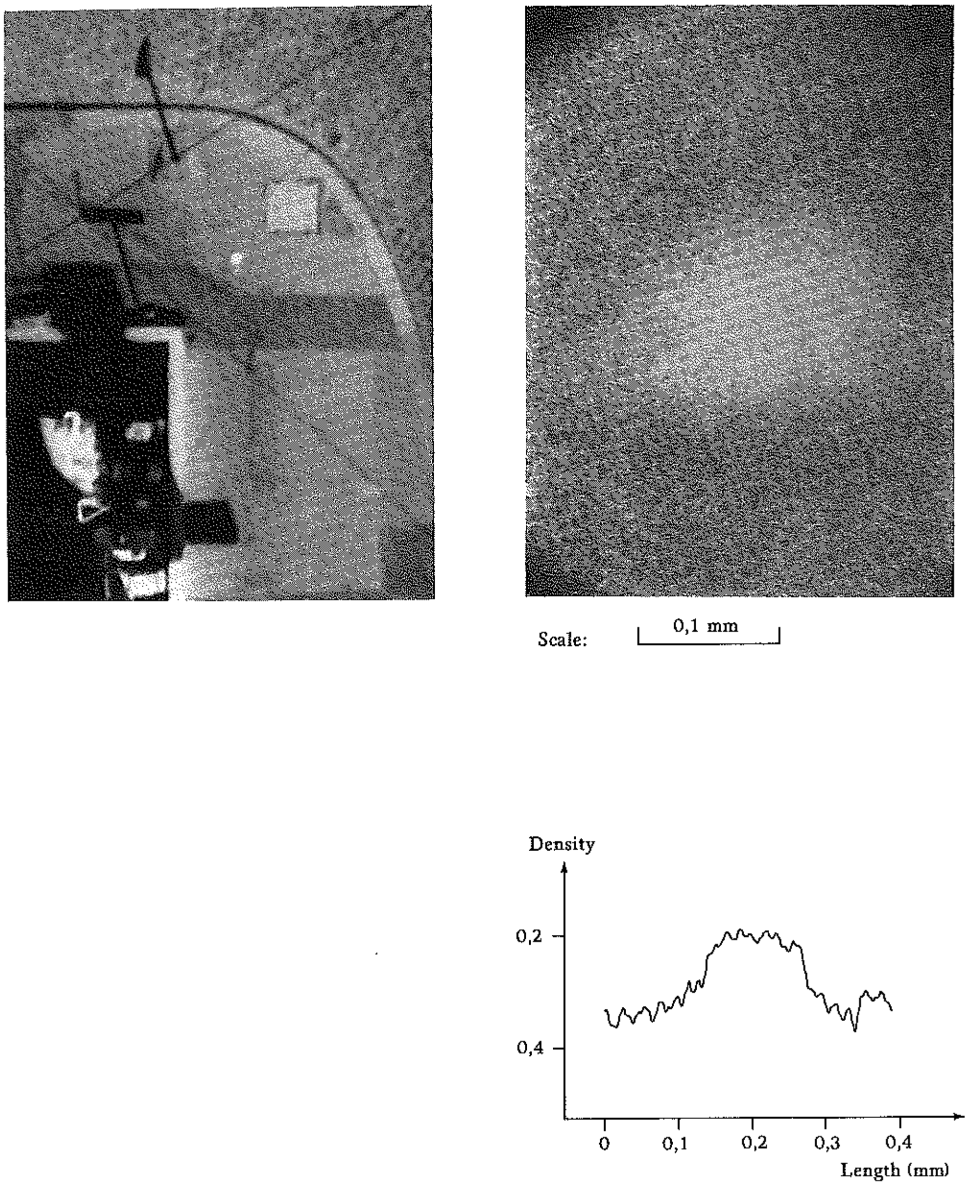
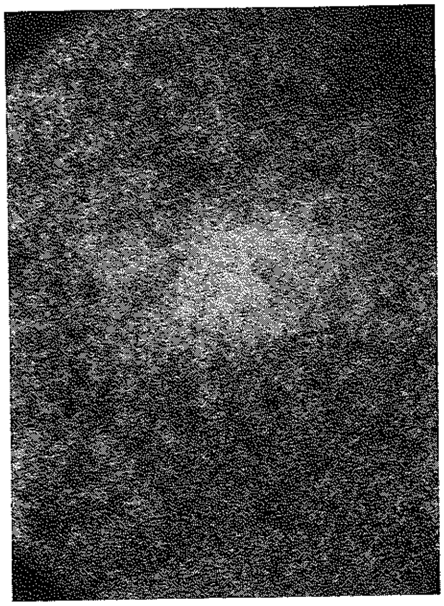
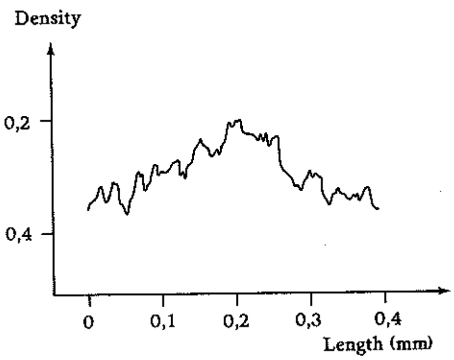


Figure 10 — Signal no. 219129 at the edge of photograph 97882

cf. Figure 10



Scale: 0,1 mm



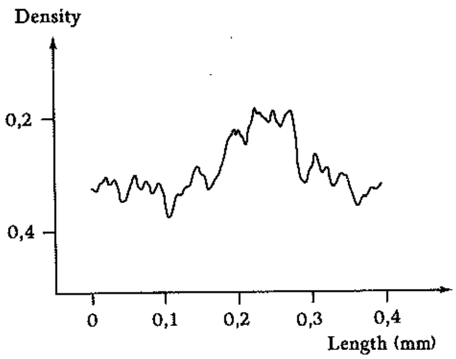


Figure 11 — Signal no. 219129 at the edge of photograph 9705

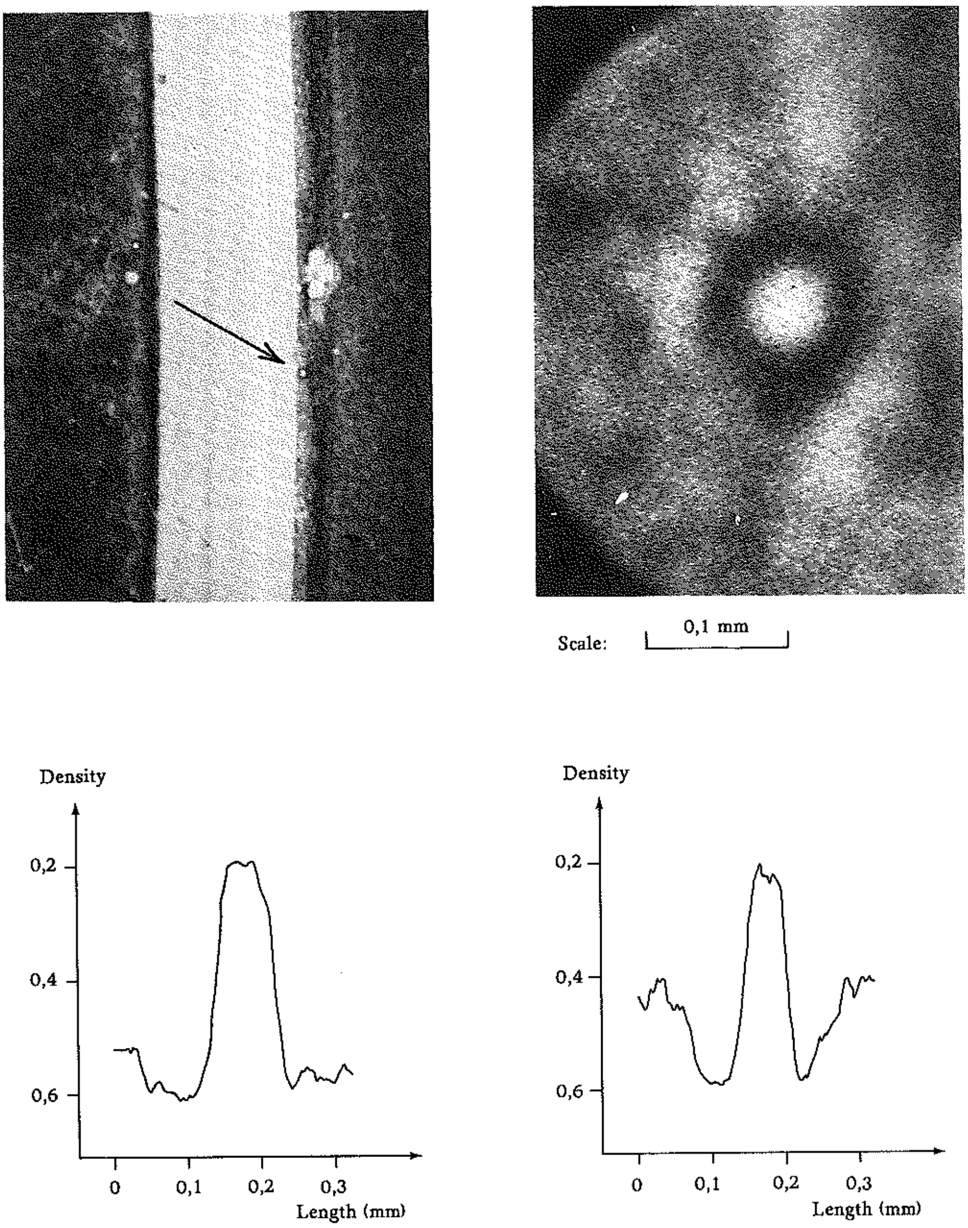


Figure 12 — Density profiles and photographs of signals taken over the test field of the Institute of Photogrammetry of EPF-Lausanne. By using a contrast colour and a recently designed lens (Wild Aviogon UAG4) the contrast differences as well as the slope angles of the density curves are much more favourable than for the test Vienna. Density profiles measured in flight direction, only the right curve corresponds to the shown micro photograph

LIST OF THE OEEPE PUBLICATIONS

State — August 1985

A. Official publications

1 *Trombetti, C.:* „Activité de la Commission A de l'OEEPE de 1960 à 1964" — *Cunietti, M.:* „Activité de la Commission B de l'OEEPE pendant la période septembre 1960—janvier 1964" — *Förstner, R.:* „Rapport sur les travaux et les résultats de la Commission C de l'OEEPE (1960—1964)" — *Neumaier, K.:* „Rapport de la Commission E pour Lisbonne" — *Weele, A.J. v. d.:* „Report of Commission F." — Frankfurt a. M. 1964, 50 pages with 7 tables and 9 annexes.

2 *Neumaier, K.:* „Essais d'interprétation de »Bedford« et de »Waterbury«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests" — „The Interpretation Tests of »Bedford« and »Waterbury«. Common Report Established by all Participating Centres of Commission E of OEEPE" — „Essais de restitution »Bloc Suisse«. Rapport commun établi par les Centres de la Commission E de l'OEEPE ayant participé aux tests" — „Test »Schweizer Block«. Joint Report of all Centres of Commission E of OEEPE." — Frankfurt a. M. 1966, 60 pages with 44 annexes.

3 *Cunietti, M.:* „Emploi des blocs de bandes pour la cartographie à grande échelle — Résultats des recherches expérimentales organisées par la Commission B de l'O.E.E.P.E. au cours de la période 1959—1966" — „Use of Strips Connected to Blocks for Large Scale Mapping — Results of Experimental Research Organized by Commission B of the O.E.E.P.E. from 1959 through 1966." — Frankfurt a. M. 1968, 157 pages with 50 figures and 24 tables.

4 *Förstner, R.:* „Sur la précision de mesures photogrammétriques de coordonnées en terrain montagneux. Rapport sur les résultats de l'essai de Reichenbach de la Commission C de l'OEEPE" — „The Accuracy of Photogrammetric Co-ordinate Measurements in Mountainous Terrain. Report on the Results of the Reichenbach Test Commission C of the OEEPE." — Frankfurt a. M. 1968, Part I: 145 pages with 9 figures; Part II: 23 pages with 65 tables.

5 *Trombetti, C.:* „Les recherches expérimentales exécutées sur de longues bandes par la Commission A de l'OEEPE." — Frankfurt a. M. 1972, 41 pages with 1 figure, 2 tables, 96 annexes and 19 plates.

6 *Neumaier, K.:* „Essai d'interprétation. Rapports des Centres de la Commission E de l'OEEPE." — Frankfurt a. M. 1972, 38 pages with 12 tables and 5 annexes.

7 *Wiser, P.:* „Etude expérimentale de l'aérotriangulation semi-analytique. Rapport sur l'essai »Gramastetten«." — Frankfurt a. M. 1972, 36 pages with 6 figures and 8 tables.

8 „Proceedings of the OEEPE Symposium on Experimental Research on Accuracy of Aerial Triangulation (Results of Oberschwaben Tests)"
Ackermann, F.: „On Statistical Investigation into the Accuracy of Aerial Triangulation. The Test Project Oberschwaben" — „Recherches statistiques sur la précision de l'aérotriangulation. Le champ d'essai Oberschwaben" — *Belzner, H.:* „The Planning. Establishing and Flying of the Test Field Oberschwaben" — *Stark, E.:* Testblock Oberschwaben, Programme I. Results of Strip Adjustments" — *Ackermann, F.:* „Testblock Oberschwaben, Program I. Results of Block-Adjustment by Independent Models" — *Ebner, H.:* Comparison of Different Methods of Block Adjustment" — *Wiser, P.:* „Propositions pour le traitement des erreurs non-accidentelles" — *Camps, F.:* „Résultats obtenus dans le cadre du project Oberschwaben 2A" — *Cunietti, M.; Vanossi, A.:* „Etude statistique expérimentale des erreurs d'enchaînement des photogrammes" — *Kupfer, G.:* „Image Geometry as Obtained from Rheidt Test Area Photography" — *Förstner, R.:* „The Signal-Field of Baustetten. A Short Report" — *Visser, J.; Leberl, F.; Kure, J.:* „OEEPE Oberschwaben Reseau Investigations" — *Bauer, H.:* „Compensation of Systematic Errors by Analytical Block Adjustment with Common Image Deformation Parameters." — Frankfurt a. M. 1973, 350 pages with 119 figures, 68 tables and 1 annex.

9 *Beck, W.:* „The Production of Topographic Maps at 1 : 10,000 by Photogrammetric Methods. — With statistical evaluations, reproductions, style sheet and sample fragments by Landesvermessungsamt Baden-Württemberg, Stuttgart." — Frankfurt a. M. 1976, 89 pages with 10 figures, 20 tables and 20 annexes.

10 „Résultats complémentaires de l'essai d'«Oberriet» de la Commission C de l'OEEPE — Further Results of the Photogrammetric Tests of «Oberriet» of the Commission C of the OEEPE"
Härry, H.: „Mesure de points de terrain non signalisés dans le champ d'essai d'«Oberriet» — Measurements of Non-Signalized Points in the Test Field «Oberriet» (Abstract)" — *Stickler, A.; Waldhäusl, P.:* „Restitution graphique des points et des lignes non signalisés et leur comparaison avec des résultats de mesures sur le terrain dans le champ d'essai d'«Oberriet» — Graphical Plotting of Non-Signalized Points and Lines, and Comparison with Terrestrial Surveys in the Test Field «Oberriet»" — *Förstner, R.:* „Résultats complémentaires des transformations de coordonnées de l'essai d'«Oberriet» de la Commission C de l'OEEPE — Further Results from Co-ordinate Transformations of the Test «Oberriet» of Commission C of the OEEPE" — *Schürer, K.:* „Comparaison des distances d'«Oberriet» — Comparison of Distances of «Oberriet» (Abstract)." — Frankfurt a. M. 1975, 158 pages with 22 figures and 26 tables.

11 „25 années de l'OEEPE"
Verlaine, R.: „25 années d'activité de l'OEEPE" — „25 Years of OEEPE (Summary)" — *Baarda, W.:* „Mathematical Models." — Frankfurt a. M. 1979, 104 pages with 22 figures.

12 *Spiess, E.:* „Revision of 1 : 25,000 Topographic Maps by Photogrammetric Methods." — Frankfurt a. M. 1985, 228 pages with 102 figures and 30 tables.

13 *Timmerman, J.; Roos, P. A.; Schürer, K.; Förstner, R.:* On the Accuracy of Photogrammetric Measurements of Buildings — Report on the Results of the Test "Dordrecht", Carried out by Commission C of the OEEPE. — Frankfurt a. M. 1982, 144 pages with 14 figures and 36 tables.

14 *Thompson, C. N.:* Test of Digitising Methods. — Frankfurt a. M. 1984, 120 pages with 38 figures and 18 tables.

15 *Jaakkola, M.; Brindöpke, W.; Kölbl, O.; Noukka, P.:* Optimal Emulsions for Large-Scale Mapping — Test of "Steinwedel" — Commission C of the OEEPE 1981—84. — Frankfurt a. M. 1985, 102 pages with 53 figures.

B. Special publications

— Special Publications O.E.E.P.E. — Number I

Solaini, L.; Trombetti, C.: Relation sur les travaux préliminaires de la Commission A (Triangulation aérienne aux petites et aux moyennes échelles) de l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (O.E.E.P.E.). I^{ère} Partie: Programme et organisation du travail. — *Solaini, L.; Belfiore, P.:* Travaux préliminaires de la Commission B de l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (O.E.E.P.E.) (Triangulations aériennes aux grandes échelles). — *Solaini, L.; Trombetti, C.; Belfiore, P.:* Rapport sur les travaux expérimentaux de triangulation aérienne exécutés par l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (Commission A et B). — *Lehmann, G.:* Compte rendu des travaux de la Commission C de l'O.E.E.P.E. effectués jusqu'à présent. — *Gotthardt, E.:* O.E.E.P.E. Commission C. Compte-rendu de la restitution à la Technischen Hochschule, Stuttgart, des vols d'essai du groupe I du terrain d'Oberriet. — *Brucklacher, W.:* Compte-rendu du centre «Zeiss-Aerotopograph» sur les restitutions pour la Commission C de l'O.E.E.P.E. (Restitution de la bande de vol, groupe I, vol. No. 5). — *Förstner, R.:* O.E.E.P.E. Commission C. Rapport sur la restitution effectuée dans l'Institut für Angewandte Geodäsie, Francfort sur le Main. Terrain d'essai d'Oberriet les vols No. 1 et 3 (groupe I). — I.T.C., Delft: Commission C, O.E.E.P.E. Déroulement chronologique des observations. — Photogrammetria XII (1955—1956) 3, Amsterdam 1956, pp. 79—199 with 12 figures and 11 tables.

— Publications spéciales de l'O.E.E.P.E. — Numéro II

Solaini, L.; Trombetti, C.: Relations sur les travaux préliminaires de la Commission A (Triangulation aérienne aux petites et aux moyennes échelles) de l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (O.E.E.P.E.). 2^{e} partie. Prises de vues et points de contrôle. — *Gotthardt, E.:* Rapport sur les premiers résultats de l'essai d'«Oberriet» de la Commission C de l'O.E.E.P.E. — Photogrammetria XV (1958—1959) 3, Amsterdam 1959, pp. 77—148 with 15 figures and 12 tables.

— *Trombetti, C.:* Travaux de prises de vues et préparation sur le terrain effectuées dans le 1958 sur le nouveau polygone italien pour la Commission A de l'OEEPE. — Florence 1959, 16 pages with 109 tables.

— *Trombetti, C.; Fondelli, M.:* Aérotriangulation analogique solaire. — Firence 1961, 111 pages, with 14 figures and 43 tables.

— Publications spéciales de l'O.E.E.P.E. — Numéro III

Solaini, L.; Trombetti, C.: Rapport sur les résultats des travaux d'enchaînement et de compensation exécutés pour la Commission A de l'O. E. E. P. E. jusqu'au mois de Janvier 1960. Tome 1: Tableaux et texte. Tome 2: Atlas. — Photogrammetria XVII (1960—1961) 4, Amsterdam 1961, pp. 119—326 with 69 figures and 18 tables.

– „OEEPE – Sonderveröffentlichung Nr. 1"

Gigas, E.: „Beitrag zur Geschichte der Europäischen Organisation für photogrammetrische experimentelle Untersuchungen" – *N. N.:* „Vereinbarung über die Gründung einer Europäischen Organisation für photogrammetrische experimentelle Untersuchungen" – „Zusatzprotokoll" – *Gigas, E.:* „Der Sechserausschuß" – *Brucklacher, W.:* „Kurzbericht über die Arbeiten in der Kommission A der OEEPE" – *Cunietti, M.:* „Kurzbericht des Präsidenten der Kommission B über die gegenwärtigen Versuche und Untersuchungen" – *Förstner, R.:* „Kurzbericht über die Arbeiten in der Kommission B der OEEPE" – „Kurzbericht über die Arbeiten in der Kommission C der OEEPE" – *Belzner, H.:* „Kurzbericht über die Arbeiten in der Kommission E der OEEPE" – *Schwidefsky, K.:* „Kurzbericht über die Arbeiten in der Kommission F der OEEPE" – *Meier, H.-K.:* „Kurzbericht über die Tätigkeit der Untergruppe „Numerische Verfahren" in der Kommission F der OEEPE" – *Belzner, H.:* „Versuchsfelder für internationale Versuchs- und Forschungsarbeiten." – Nachr. Kt.- u. Vermesss.-wes., R. V, Nr. 2, Frankfurt a. M. 1962, 41 pages with 3 tables and 7 annexes.

– *Rinner, K.:* Analytisch-photogrammetrische Triangulation eines Teststreifens der OEEPE. – Österr. Z. Vermess.-wes., OEEPE-Sonderveröff. Nr. 1, Wien 1962, 31 pages.

– *Neumaier, K.; Kasper, H.:* Untersuchungen zur Aerotriangulation von Überweitwinkelaufnahmen. – Österr. Z. Vermess.-wes., OEEPE-Sonderveröff. Nr. 2, Wien 1965, 4 pages with 4 annexes.

– „OEEPE – Sonderveröffentlichung Nr. 2"

Gotthardt, E.: „Erfahrungen mit analytischer Einpassung von Bildstreifen." – Nachr. Kt.- u. Vermess.-wes., R. V, Nr. 12, Frankfurt a. M. 1965, 14 pages with 2 figures and 7 tables.

– „OEEPE – Sonderveröffentlichung Nr. 3"

Neumaier, K.: „Versuch »Bedford« und »Waterbury«. Gemeinsamer Bericht aller Zentren der Kommission E der OEEPE" – „Versuch »Schweizer Block«. Gemeinsamer Bericht aller Zentren der Kommission E der OEEPE." – Nachr. Kt.- u. Vermess.-wes., R. V, Nr. 13, Frankfurt a. M. 1966, 30 pages with 44 annexes.

– *Stickler, A.; Waldhäusl, P.:* Interpretation der vorläufigen Ergebnisse der Versuche der Kommission C der OEEPE aus der Sicht des Zentrums Wien. – Österr. Z. Vermess.-wes., OEEPE-Sonderveröff. (Publ. Spéc.) Nr. 3, Wien 1967, 4 pages with 2 figures and 9 tables.

– „OEEPE – Sonderveröffentlichung Nr. 4"

Schürer, K.: „Die Höhenmeßgenauigkeit einfacher photogrammetrischer Kartiergeräte. Bemerkungen zum Versuch »Schweizer Block« der Kommission E der OEEPE." – Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M., 1968, 25 pages with 7 figures and 3 tables.

— „OEEPE — Sonderveröffentlichung Nr. 5"

Förstner, R.: „Über die Genauigkeit der photogrammetrischen Koordinatenmessung in bergigem Gelände. Bericht über die Ergebnisse des Versuchs Reichenbach der Kommission C der OEEPE." — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1969, Part I: 74 pages with 9 figures; Part II: 65 tables.

— „OEEPE — Sonderveröffentlichung Nr. 6"

Knorr, H.: „Die Europäische Organisation für experimentelle photogrammetrische Untersuchungen — OEEPE — in den Jahren 1962 bis 1970." — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1971, 44 pages with 1 figure and 3 tables.

— „OEEPE — Sonderveröffentlichung Nr. D–7"

Förstner, R.: „Das Versuchsfeld Reichenbach der OEEPE." — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1972, 191 pages with 49 figures and 38 tables.

— „OEEPE — Sonderveröffentlichung Nr. D–8"

Neumaier, K.: „Interpretationsversuch. Berichte der Zentren der Kommission E der OEEPE." — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1972, 33 pages with 12 tables and 5 annexes.

— „OEEPE — Sonderveröffentlichung Nr. D–9"

Beck, W.: „Herstellung topographischer Karten 1 : 10 000 auf photogrammetrischem Weg. Mit statistischen Auswertungen, Reproduktionen, Musterblatt und Kartenmustern des Landesvermessungsamts Baden-Württemberg, Stuttgart." — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1976, 65 pages with 10 figures, 20 tables and 20 annexes.

— „OEEPE — Sonderveröffentlichung Nr. D–10"

Weitere Ergebnisse des Meßversuchs „Oberriet" der Kommission C der OEEPE. *Härry, H.:* „Messungen an nicht signalisierten Geländepunkten im Versuchsfeld «Oberriet»" — *Stickler, A.; Waldhäusl, P.:* „Graphische Auswertung nicht signalisierter Punkte und Linien und deren Vergleich mit Feldmessungsergebnissen im Versuchsfeld «Oberriet»" — *Förstner, R.:* „Weitere Ergebnisse aus Koordinatentransformationen des Versuchs «Oberriet» der Kommission C der OEEPE" — *Schürer, K.:* „Streckenvergleich «Oberriet»." — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1975, 116 pages with 22 figures and 26 tables.

— „OEEPE — Sonderveröffentlichung Nr. D–11"

Schulz, B.-S.: „Vorschlag einer Methode zur analytischen Behandlung von Reseauaufnahmen." — Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1976, 34 pages with 16 tables.

- „OEEPE – Sonderveröffentlichung Nr. D-12"

  Verlaine, R.: „25 Jahre OEEPE." – Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1980, 53 pages.

- „OEEPE – Sonderveröffentlichung Nr. D-13"

  Haug, G.: „Bestimmung und Korrektur systematischer Bild- und Modelldeformationen in der Aerotriangulation am Beispiel des Testfeldes „Oberschwaben." – Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1980, 136 pages with 25 figures and 51 tables.

- „OEEPE – Sonderveröffentlichung Nr. D–14"

  Spiess, E.: „Fortführung der Topographischen Karte 1 : 25 000 mittels Photogrammetrie" (in Vorbereitung).

- „OEEPE – Sonderveröffentlichung Nr. D–15"

  Timmerman, J.; Roos, P. A.; Schürer, K.; Förstner, R.: „Über die Genauigkeit der photogrammetrischen Gebäudevermessung. Bericht über die Ergebnisse des Versuchs Dordrecht der Kommission C der OEEPE." – Nachr. Kt.- u. Vermess.-wes., Sonderhefte, Frankfurt a. M. 1983, 131 pages with 14 figures and 36 tables.

C. Congress reports and publications in scientific reviews

— *Stickler, A.:* Interpretation of the Results of the O.E.E.P.E. Commission C. — Photogrammetria XVI (1959—1960) 1, pp. 8—12, 3 figures, 1 annexe (en langue allemande: pp. 12—16).

— *Solaini, L.; Trombetti, C.:* Results of Bridging and Adjustment Works of the Commission A of the O.E.E.P.E. from 1956 to 1959. — Photogrammetria XVI (1959—1960) 4 (Spec. Congr.-No. C), pp. 340—345, 2 tables.

— *N. N.:* Report on the Work Carried out by Commission B of the O.E.E.P.E. During the Period of September 1956—August 1960. — Photogrammetria XVI (1959—1960) 4 (Spec. Congr.-No. C), pp. 346—351, 2 tables.

— *Förstner, R.:* Bericht über die Tätigkeit und Ergebnisse der Kommission C der O.E.E.P.E. (1956—1960). — Photogrammetria XVI (1959—1960) 4 (Spec. Congr.-No. C), pp. 352—357, 1 table.

— *Bachmann, W. K.:* Essais sur la précision de la mesure des parallaxes verticales dans les appareils de restitution du I^er^ ordre. — Photogrammetria XVI (1959—1960) 4 (Spec. Congr.-No. C), pp. 358—360).

— *Wiser, P.:* Sur la reproductibilité des erreurs du cheminement aérien. — Bull. Soc. Belge Photogramm., No. 60, Juin 1960, pp. 3—11, 2 figures, 2 tables.

— *Cunietti, M.:* L'erreur de mesure des parallaxes transversales dans les appareils de restitution. — Bull. Trimestr. Soc. Belge Photogramm., No. 66, Décembre 1961, pp. 3—50, 12 figures, 22 tables.

— „OEEPE — Arbeitsberichte 1960/64 der Kommissionen A, B, C, E, F"

Trombetti, C.: „Activité de la Commission A de l'OEEPE de 1960 à 1964" — *Cunietti, M.:* „Activité de la Commission B de l'OEEPE pendant la période septembre 1960—janvier 1964" — *Förstner, R.:* „Rapport sur les travaux et les résultats de la Commission C de l'OEEPE (1960—1964)" — *Neumaier, K.:* „Rapport de la Commission E pour Lisbonne" — *Weele, A.J. van der:* „Report of Commission F." — Nachr. Kt.- u. Vermess.-wes., R. V. Nr. 11, Frankfurt a. M. 1964, 50 pages with 7 tables and 9 annexes.

— *Cunietti, M.; Inghilleri, G.; Puliti, M.; Togliatti, G.:* Participation aux recherches sur les blocs de bandes pour la cartographie à grande échelle organisées par la Commission B de l'OEEPE. Milano, Centre CASF du Politecnico. — Boll. Geod. e Sc. affini (XXVI) 1, Firenze 1967, 104 pages.

— *Gotthardt E.:* Die Tätigkeit der Kommission B der OEEPE. — Bildmess. u. Luftbildwes. 36 (1968) 1, pp. 35—37.

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- *Förstner, R.:* Résumé du Rapport sur les résultats de l'essai de Reichenbach de la Commission C de l'OEEPE. — Présenté à l'XIe Congrès International de Photogrammétrie, Lausanne 1968, Comm. IV (en langues française, anglaise et allemande), 28 pages, 2 figures, 2 tables.
- *Timmerman, J.:* Proef „OEEPE-Dordrecht". — ngt 74, 4. Jg., Nr. 6, Juni 1974, S. 143—154 (Kurzfassung: Versuch „OEEPE-Dordrecht". Genauigkeit photogrammetrischer Gebäudevermessung. Vorgelegt auf dem Symposium der Kommission IV der I.G.P., Paris, 24.—26. September 1974).
- *Timmerman, J.:* Report on the Commission C. "OEEPE-Dordrecht" Experiment. — Presented Paper for Comm. IV, XIIIth Congress of ISP, Helsinki 1976.
- *Beck, W.:* Rapport de la Commission D de l'OEEPE sur l'établissement de cartes topographiques au 1/10 000 selon le procédé photogrammétrique. — Presented Paper for Comm. IV, XIIIth Congress of ISP, Helsinki 1976.
- *Verlaine, R.:* La naissance et le développement de l'OEEPE — Festschrift — Dr. h. c. *Hans Härry*, 80 Jahre — Schweizerische Gesellschaft für Photogrammetrie und Wild Heerbrugg AG, Bern 1976.
- *Förstner, R.:* Internationale Versuche (Essais contrôlés) — Festschrift — Dr. h. c. *Hans Härry*, 80 Jahre. — Schweizerische Gesellschaft für Photogrammetrie und Wild Heerbrugg AG, Bern 1976.
- *Baj, E.; Cunietti, M.; Vanossi, A.:* Détermination Expérimentale des Erreurs Systématiques des Faisceaux Perspectifs. — Société Belge de Photogrammétrie, Bulletin trimestriel, Brüssel 1977, pp 21—49.
- *Timmerman, J.:* Fotogrammetrische stadskaartering de OEEPE-proef Dordrecht. — Geodesia 19, Amsterdam 1977, pp. 291—298.
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