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Revision of 1 : 25 000 Topographic Maps by Photogrammetric Methods

Final Report
on the Results of the FRIBOURG test,
carried out by Commission D of the OEEPE

(with 102 Figures and 30 Tables)

By Ernst Spiess

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Final report on the FRIBOURG test:

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Preface

The project of Commission D of the OEEPE to evaluate revision techniques of 1:25 000 topographic maps by photogrammetric methods was proposed by Professor Beck, President of Commission D, in 1974. After consideration of the proposal by the members of Commission D, the Steering Committee of OEEPE approved the FRIBOURG Test at its meeting in October 1975. This report describes the work of the participating agencies and provides a commentary and analysis of the wide variety of techniques adopted by these agencies. The emphasis throughout the project has been on practical methods, adapted where necessary to the needs of this particular project. The report reflects the approach of major mapping organisations to the fundamental task of up-dating or revising national mapping at the scales of 1:25 000, or where this particular scale is not commonly used by a particular nation adapting methods used for updating mapping at scales in the range 1:10 000 to 1:50 000.

The results of the FRIBOURG Test are of importance to every organisation involved in mapping at the scale of 1:25 000, or adjacent scales. The report highlights two main methods of photogrammetric revision, namely stereoplotting and the use of orthophotos. Both methods have been found to be of equal merit. One of the surprising results of the project has been the diversity of the cartographic techniques used by the participants, and these techniques are particularly deserving of attention by all agencies who may now, or will in the future, need to approach this fundamental matter of designing, compiling and updating mapping of this type.

The work involved in this project has been extremely demanding of all participants, and the success of their endeavours is fully reflected in the report and in the analysis of the results. I am most grateful for the cooperation of all the participants, and for their individual contributions which have made this report a unique commentary on methods of photogrammetric/cartographic revision.

This project has been brought to a successful conclusion through the unstinting efforts of Prof Dipl Ing E Spiess of the Institut für Kartographie der ETH Zürich, and President of Commission D 1976-1981. His enthusiasm and organisation of the project were fundamental to its success. Overall this Report has been compiled by Professor Spiess and, together with his colleagues in this project, I offer my sincere thanks for their outstanding endeavours.

Some results of the FRIBOURG Test have previously been published.

1. 'Revision of Topographic Maps - Results of the Fribourg Test by Commission D of the OEEPE.'
   E Spiess, ISP Hamburg, 1980.

2. 'Revision of Topographic Maps: Photogrammetric and Cartographic Methods of the Fribourg Test.'
   E Spiess, Photogrammetric Record, April 1983.

C N THOMPSON
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30 April 1984

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Summary

The Fribourg test, designed and executed by Commission D of the OEEPE, consists of a comparative study of the entire map revision process at a scale of 1:25 000. Seven participating centres used the same topographic map extract and produced a total of 12 test samples. From a photogrammetric point of view the stereoplotting as well as the orthophoto method were applied. The wide range of photointerpretation and cartographic production procedures adopted by the various organisations is described in full detail. The assessment of the different test samples encompasses aspects of positional and height accuracy, completeness of up-dated map information and line quality. Time and cost for each individual sub-process and for the entire revision work have also been registered and analysed. The numerous illustrations included in this final report document the test conditions, important and interesting intermediate steps and the final results. Together with the quantitative and qualitative evaluation they constitute a rich collection of material useful for future developments in topographic map revision.

Résumé

L'essai de Fribourg, conçu et exécuté par la Commission D de l'OEEPE, comporte une étude comparative du processus complet de la mise à jour de cartes topographiques à l'échelle 1:25 000. Les sept centres, qui ont participé, ont travaillé sur le même extrait de carte et ont produit en tout 12 exemples d'essai. Du point de vue photogrammétrique la stéréorestitution ainsi que la méthode de l'orthophoto ont été appliquées. Toute la gamme des procédés de photointerprétation et de rédaction cartographique, qui a été adoptée par les divers organisations, est déscrite en détail. L'évaluation des différents exemples d'essai comprend aussi bien des aspects de la précision planimétrique et altimétrique que de la complèteté de l'information et de la qualité graphique. Pour chaque procédé partiel les heures et les coûts ont été enregistrés et analysés. Le grand nombre d'illustrations incorporées dans ce rapport final documente les conditions initiales de l'essai, les étappes les plus intéressantes et importantes du travail de la mise à jour et en plus les résultats finaux. En combinaison avec l'évaluation quantitative et qualitative de détail cette collection de matériaux riche sera utile pour tout développement futur de la mise à jour des cartes topographiques.

Zusammenfassung

Der Test Fribourg der Commission D der OEEPE wurde als vergleichende Studie über den gesamten Fortführungsprozess von Karten im Massstab 1:25 000 konzipiert. Die sieben beteiligten Organisationen aus dem Kartenwesen verschiedener Länder benützten alle denselben Ausschnitt aus einer topographischen Karte dieses Massstabes. Insgesamt wurden 12 Testbeispiele erarbeitet. Im photogrammetrischen Teil kamen sowohl die Stereoauswertung wie auch die Orthophotomethode zur Anwendung. Die Verfahrenswege, die in der Photointerpretation und in der kartographischen Bearbeitung beschritten wurden, waren erstaunlich vielfältig. Sie werden in diesem Schlussbericht im Detail beschrieben. Die Beurteilung der verschiedenen Testbeispiele erfolgte sowohl unter dem Gesichtspunkt der Lage- und Höhengenauigkeit, der Vollständigkeit der nachgeführten Information der Karte wie auch bezüglich graphischer Qualität. Ausserdem wurden für jeden Teilprozess der Zeitaufwand und die anfallenden Kosten festgehalten und eingehend analysiert. Die zahlreichen, dem Bericht beigegebenen Illustrationen dokumentieren die Ausgangslage für den Versuch, alle wichtigen oder interessanten Zwischenstufen und das erreichte Ergebnis. Zusammen mit der quantitativen und qualitativen Beurteilung stellt dieses Material eine reiche Fundgrube für die Weiterentwicklung von Fortführungsverfahren für topographische Karten dar.

1. Aims of the map revision test

In 1974, Commission D started discussion on a project on map revision procedures which has since been undertaken. It was at that time evident that many European mapping agencies were being increasingly confronted with map revision problems. With many topographic map series nearing completion, the existing maps were already out of date or under revision. The needs of the map-user today are putting pressure for considerably shorter revision intervals. The rationalisation of map revision processes is therefore becoming a necessity, especially with regard to the production time required between survey and map publication. It was generally recognised that the map revision procedure should be a basic consideration in the design of new topographic series. The operational sequences in revision work have to include all the phases of production from the aerial photography runs, photogrammetric plotting, cartographic draughting to the reproduction itself. Technological as well as economic aspects are essential when decisions have to be taken.

The selection of an appropriate map revision process has to take account of a number of different criteria within the individual organisation itself, as for example:

- personnel structure
- available employment capacity
- available equipment
- financial resources
- existing map bases
- the requirements of topographic map users in terms of precision, completeness and graphic quality.

These constraints vary considerably from country to country. For this reason, a general standardisation of revision procedure could never be envisaged. However, by evaluating the merits of each of the different methods used, it would be possible to conceive the optimal map revision procedure best-suited to a particular case. It is hoped that the findings of this test will constitute a valuable collection of material for use in decision-making in this area.

The major goal in this exercise therefore, has been to disseminate information about current map revision systems and their individual processes, and to assess their advantages and disadvantages though consciously bearing in mind the limitations of every participating institute in terms of personnel in each particular case.

Starting from this information, new revision methods for topographic series could be established or indeed, existing ones improved. As revision policy already plays an important role in the conception of a new map series, these results should prove valuable also to those organisations planning a new 1:25 000 series.

Nowadays, the use of photogrammetric methods in map revision is a matter of course. However, there are differing opinions as to how photogrammetry should be applied to revision work.

It was decided that the above objectives should be best fulfilled in the following four stages:

1. A comparative study of the entire map revision procedure at the scale 1:25 000 employed by the different OEEPE-countries on one common topographic map extract.
2. Determination of the time required and of the cost and necessary infrastructure for each work phase. The intention is that these individual components could be rearranged into new sequences which are both economically and qualitatively superior.
3. Measurement and analysis of the attainable precision in planimetry and elevation of the method employed.
4. Evaluation of the reliability and completeness of revision in each individual map element according to the method used, e.g.
   - with or without field reconnaissance
   - with stereoplotting or with tracing from orthophoto
   - from an image scale of 1:18 000 or from one of 1:30 000

This programme was the result of deliberations in the Commission as well as in the Steering Committee. Originally the number of parameters was much larger. A smaller image scale of 1:44 000 was abandoned partly because of possible problems with flying heights and haze. The potential of colour photography had been studied in Commission E. In practice black-and-white films are used almost exclusively. One was also aware of the fact that often in the revision process, only major changes or a 'partial revision' is carried out rather than a complete up-dating. In this test however the last approach was chosen, because of its unambiguous requirements.

Some discussion was raised on the selected map scale. It was argued that the whole series of scales from 1:5 000 to 1:50 000 should be considered rather than one single scale. In the end however, the scale 1:25 000 was accepted, in the hope that the conclusions from this test could then be extrapolated to the other scales, taking into account of course their different characteristics.

A comparison of the map revision procedures currently incorporating digital methods would have been of great interest. For the time being however, none of those organisations showing an interest in this test was in a position to perform this work with a computer-assisted photogrammetric and cartographic system. These proposals have thus been postponed until the necessary prerequisites are on hand.

In conclusion, one must emphasise that it was decided to design this test in strict accordance with the realistic working pratices currently used for map revision.

2. Preparatory stages

2.1 The proposed test area

There is no doubt that map revision problems vary considerably with different terrain types. Four major regional types were distinguished in the European area, namely town centres, suburban, rural and mountainous areas. It was unanimously agreed that the most numerous and varied changes occur in suburban regions, while the other regions present somewhat more specific problems. It was therefore decided to confine the search for a suitable test area to the fringes of a city undergoing rapid development.

Of course, the existence of a regular topographic map at the scale 1:25 000 was an indispensable condition, but in addition, large scale topographic maps would be needed for verification purposes. Flat, hilly and steep terrain types should characterise the test area. It would also be advantageous, if as many different kinds of changes as possible could be included within the map extract.

The test area finally chosen was the western suburbs of Fribourg, a town situated on the border between the French and German-speaking areas of Switzerland. This town was built in the Middle-Ages on a steeply incised meander of the river Sarine. It was fortified by a wall on the western side, only parts of which have survived the rapid expansion of the town after the construction of the railway from Berne to Lausanne. This important transport artery, together with the railway station area, forms the south-eastern cornèr of the test area. Along this axis towards the south, a first industrial development is visible on the map (fig.1) and opposite the station the Beauregard district has formed a sort of a bridge-head since the late nineteenth century. The various residential areas, characterised by their regular patterns, have mainly developed since 1950. Previously, the whole area was primarily agricultural. A number of farms are still distributed on the open land, though some of them are concentrated in the small villages that lie within the test area. Recently, residential housing has been built to some extent in these communities, but the majority of new homes and flats built within the revision period 1968-76 is concentrated in Fribourg and Villars-sur-Glâne.

Fig. 1: Combined base map 1: 25 000 of the test area ,including planimetry, hydrography, topography and vegetation

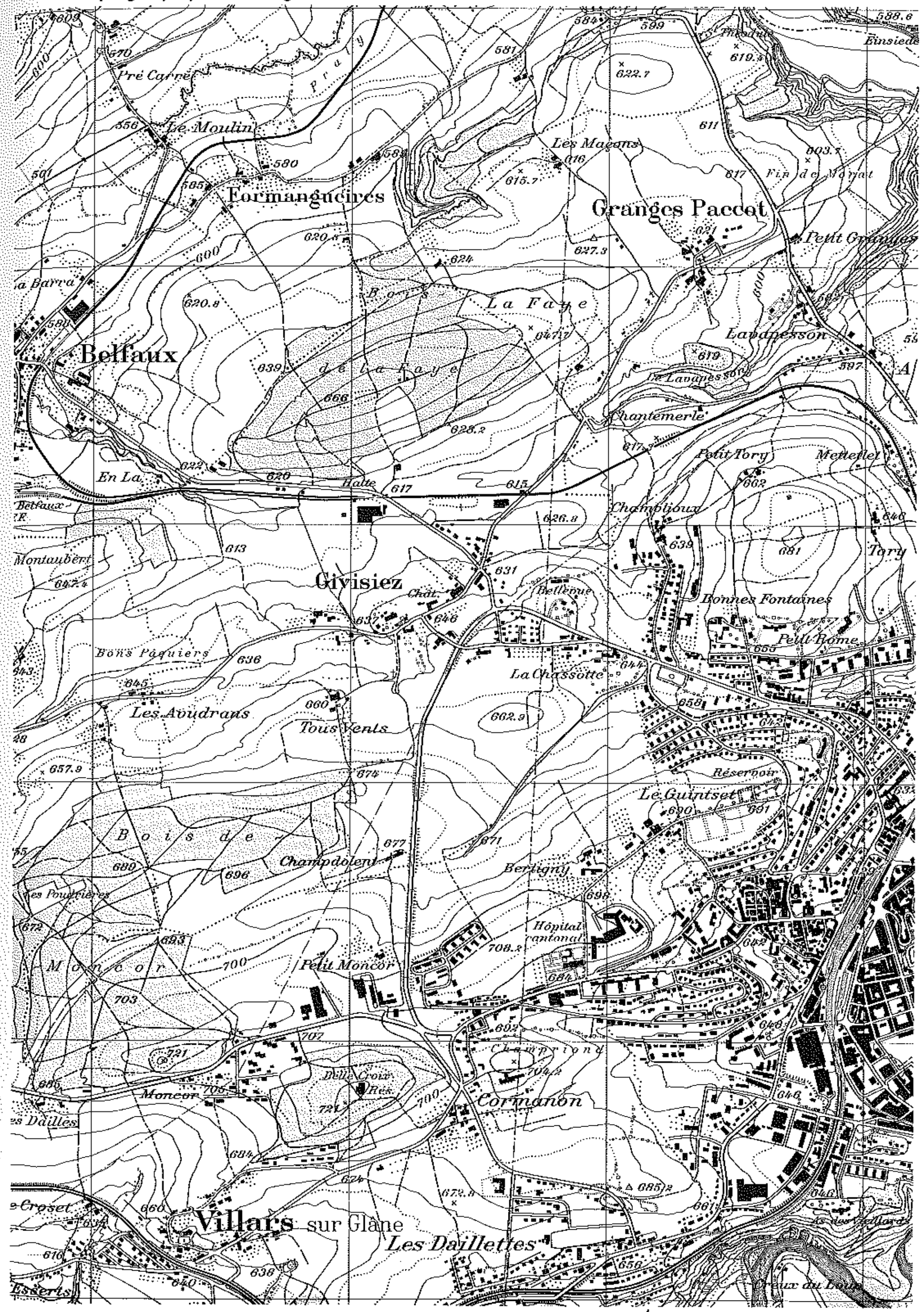


Fig. 2: Residential zone of Beaumont

Fig. 3:
Underground garages at Beaumont

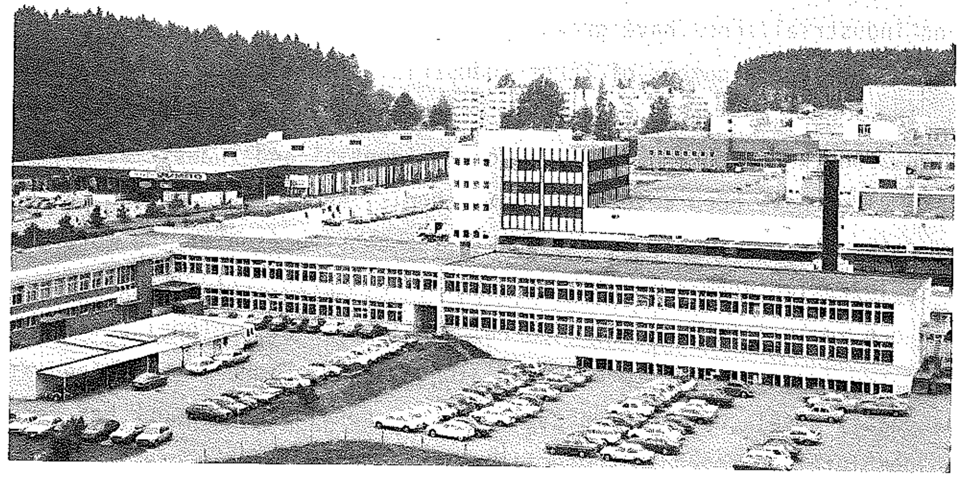


Fig. 4: Industrial areas near Petit Moncor

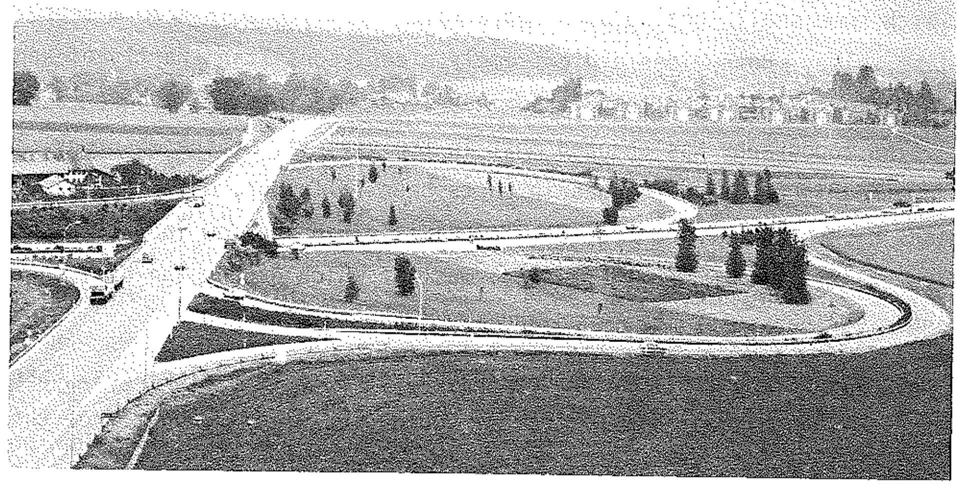


Fig. 5: Motorway junction Fribourg–Sud

There is a great variety of housing types in this area, small individual houses; rows of small uniform houses and blocks; and also complete residential zones such as Beaumont (see fig.2), including housing blocks of up to 20 storeys, shopping areas, underground garages (fig.3) etc.

Initiated by this development and the construction of the highway, new commercial and industrial zones have grown up, especially in Moncor (fig.4) and Givisiez. There are a number of large industrial plants and a huge shopping-centre. They have involved considerable earth-moving operations and road construction. Together with the extension of residential and industrial areas, social services have been developed. New schools, sports grounds and car parks appear in the map. Many changes are due to the construction of the motorway, opened in 1974. Two access points lie within the map extract (fig.5). The northern one includes the traffic control station of the cantonal police. A number of new junctions had to be built along the new highway. Even the railway was partly displaced. In Granges-Paccot the rural road network has recently been completely changed in connection with a reallotment project. Only a few roads have been built in the wooded area. Small parts of the latter have been recently afforested. Finally one should note a number of high tension lines still under construction at the time of the flight runs. Some 10 houses were then in an early stage of construction, so that they have probably been difficult to map.

The test area is situated between 530 and 720 m above sea level. It is mostly hilly, with some small local plains and a river that flows in a 70 m deep gorge-like valley. Both sides are extremely steep, consisting partly of sandstone formations. Below the town, the river is dammed to a small lake (Schiffenensee). The topography has changed most in the vicinity of the motorway. The valley of the river Lavapesson has in parts been filled up. Major earth-moving operations have been carried out north of Givisiez in the new industrial zone. There are relatively few woodland areas, most of which occupy the hill tops and steep river banks. By law, woodland may not be diminished.

In the past few years, fruit trees have disappeared in several places. Changes of names, spot heights and administrative boundaries were excluded from the test in order to facilitate the cartographic production.

The map extract comprises an area of 3,650 x 5,000 km, or 18,250 km^2.

The land use categories are distributed as follows:

Residential area	19%
Public buildings and parkland	2%
Commercial area	1%
Industrial area	4%
Agricultural land (half of it arable land)	60%
Woodland	12%
Transport network	2%
	100%

The high percentage of open land facilitated the task of detecting changes. A few problems occured in wooded areas, because of the limited visibility, and also in the already built-up areas, where new buildings extensions or replaced housing are rather difficult to discern. Somewhat problematic in photointerpretation are the underground garages that are completely covered by vegetation, showing sometimes only the façade.

Approximately one third of the whole test area has not been subject to any changes within the last revision period from 1968 to 1976. Nevertheless the total amount of necessary up-dating was considerable. One realises this already when looking at the two areal photographs that show the beginning and the end of this revision cycle (figs. 6 and 7). Originally there were 2000 houses in the test area. Up to 1976, approximately 500 new ones were constructed and 100 old ones demolished. 35 km of new roads had to be added in the revision process. Together with the above distribution of land use categories the following average values characterise the test area:

Density of the transport network 1968	7,8 km/km^2
New roads within 8 years	2 km/km^2
Density of buildings 1968	110 $/km^2$
New buildings within 8 years	27 $/km^2$
Contour lines 1968	9 km/km^2
Contour line changes	0,6 km/km^2

On the whole, the area chosen for this test seems to be a representative sample for the study of typical map revision problems.

Fig. 6 : Aerial photograph of the test area from 1968

Fig. 7 : Aerial photograph of the test area from 1976 that was used in the test

A critical point was of course the size of the sample compared to a whole map sheet. The commission is aware that this is a weak point in this study, but in view of the considerable time and effort involved in cartographic work for each participant, the test area had to be drastically limited. It was designed to fit well within one stereo model at the scale 1:30 000 with 60% overlap. This corresponds to at least 3 models at the image scale 1:18 000. The relatively small size of the test area will certainly have meant a rather longer than normal working time as all participants needed to gather some experience at the beginning before they could reach their normal output rate. They could really only profit if a number of similar models were to follow. For ease of comparison with normal production times, it was decided to scale all results received for the 18,25 km^2 test area to an area of 100 km^2. Bearing the above considerations in mind, an adjusted multiplication factor of 5 seemed appropriate. It is used of course only where the time needed is dependent on the size of area treated, this not being the case in reproduction processes.

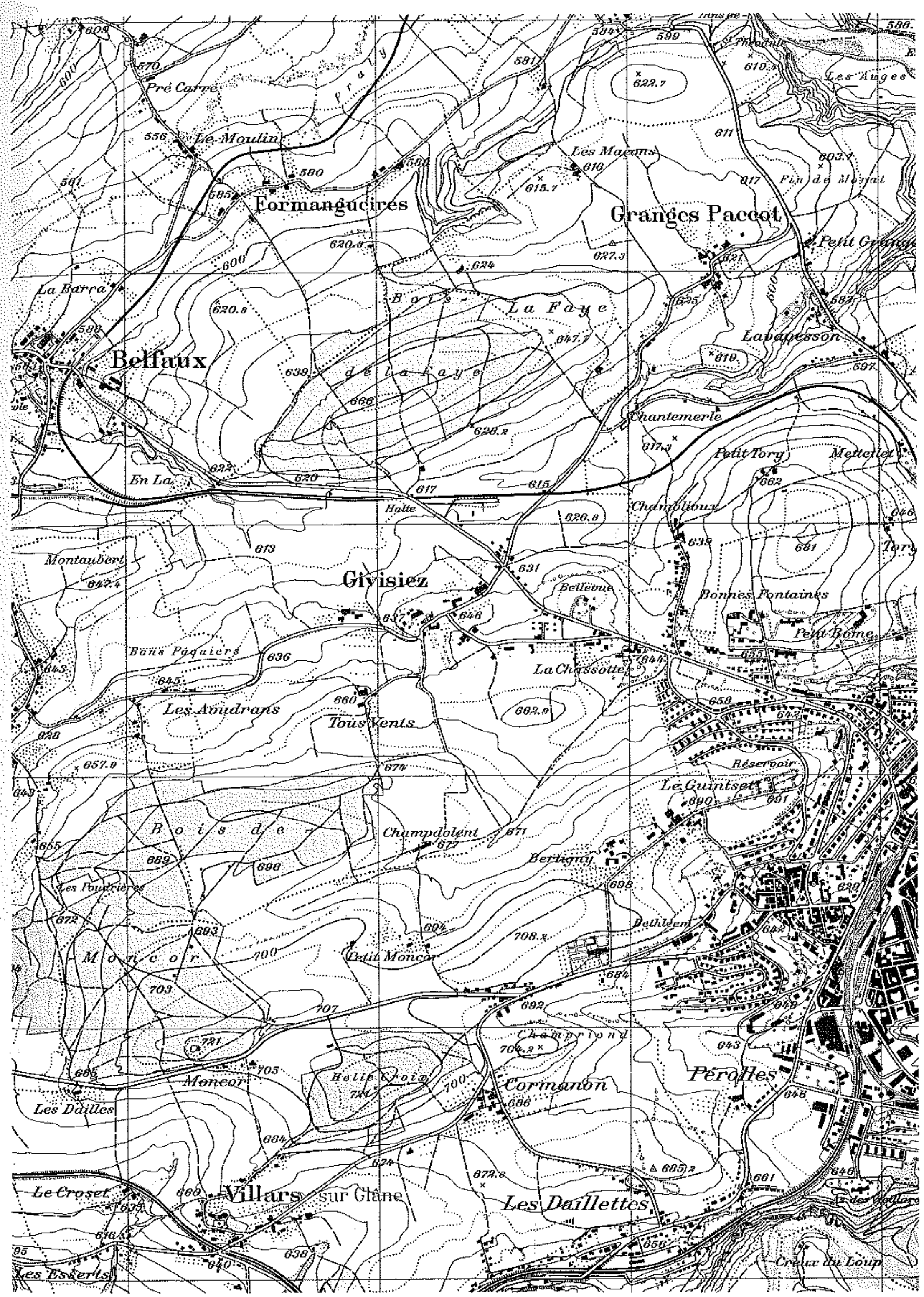
In summarizing we can state that test results refer to a usual map sheet size of 100 km^2 terrain, densly populated and with more than average revision work.

2.2 The History of the Original Base Map used for this Test

The first edition of the "Fribourg" map sheet at 1:25 000 was published with 1957 data. The General Topographic Map at 1:10 000 served as the original manuscript. This map series is composed of plane table sheets, each of them covering 3 by 4 kms of terrain. Where cadastral surveys already existed, as for example in the town centre, photographic reductions of these plans were used as guide copies. All other items had to be surveyed and mapped. In this region photogrammetry was widely used at an image scale of about 1:15 000 for stereoplotting at 1:10 000. All the blank areas, mostly in woodland, were completed in the field by plane table surveys. The map manuscripts were then draughted with coloured inks.

The finished map originals had to undergo a verification procedure. Control measurements were made in selected areas. The permissable tolerance for the planimetric error is a standard deviation of 0.3 mm at the 1:10 000 scale, of 1 m for spot heights and of 1 + 3tgα for the height error of a contour line, α being the slope angle. Verification results normally showed that the mean errors found were well within these limits. For definition of errors etc. we refer to chapter 5.1.

Fig. 8 : First edition of the topographic map sheet Fribourg at 1:25 000 published 1956



From these map originals, dimensionally-stable copies were made and mounted at the scale 1:10 000 on an aluminium plate with a grid. This assembly was then reduced in the camera to a glass negative at the scale 1:25 000, from which a guide copy was made on the scribing plate.

In the summer of 1957, aerial photography was carried out over the whole map area. It was used for up-dating the above assembly by field checking and stereoplotting. These amendments were added to the guide copy for scribing the colour plates of the first edition at the scale 1:25 000 (fig.8).

With the aerial photographs taken in 1968, a full revision was made and so a second edition of this sheet appeared around 1970 (fig.1). A number of details in the first edition served as base for orienting and scaling the models. In the usual revision process applied by the "Bundesamt für Landestopographie" (LT) the individual colour plates of the line work and a screened woodland plate are assembled to one single plate, the combined base map. A positive film of this combination of the second edition was handed out for this map revision test, together with positive films of all colour plates.

2.3 Flight Plans and Pass Point Selection

The flight plan was arranged so that the test area was covered by one model at 1:30 000 flown east-west and by three or four models when flying from north to south for the image scale 1:18 000. The respective flying heights were 4800 m and 2770 m above ground. An additional flight was arranged for the normal-angle camera, and along three other lines large scale photography at 1:7 400 was to be taken; flying heights were 5600 m and 970 m above ground.

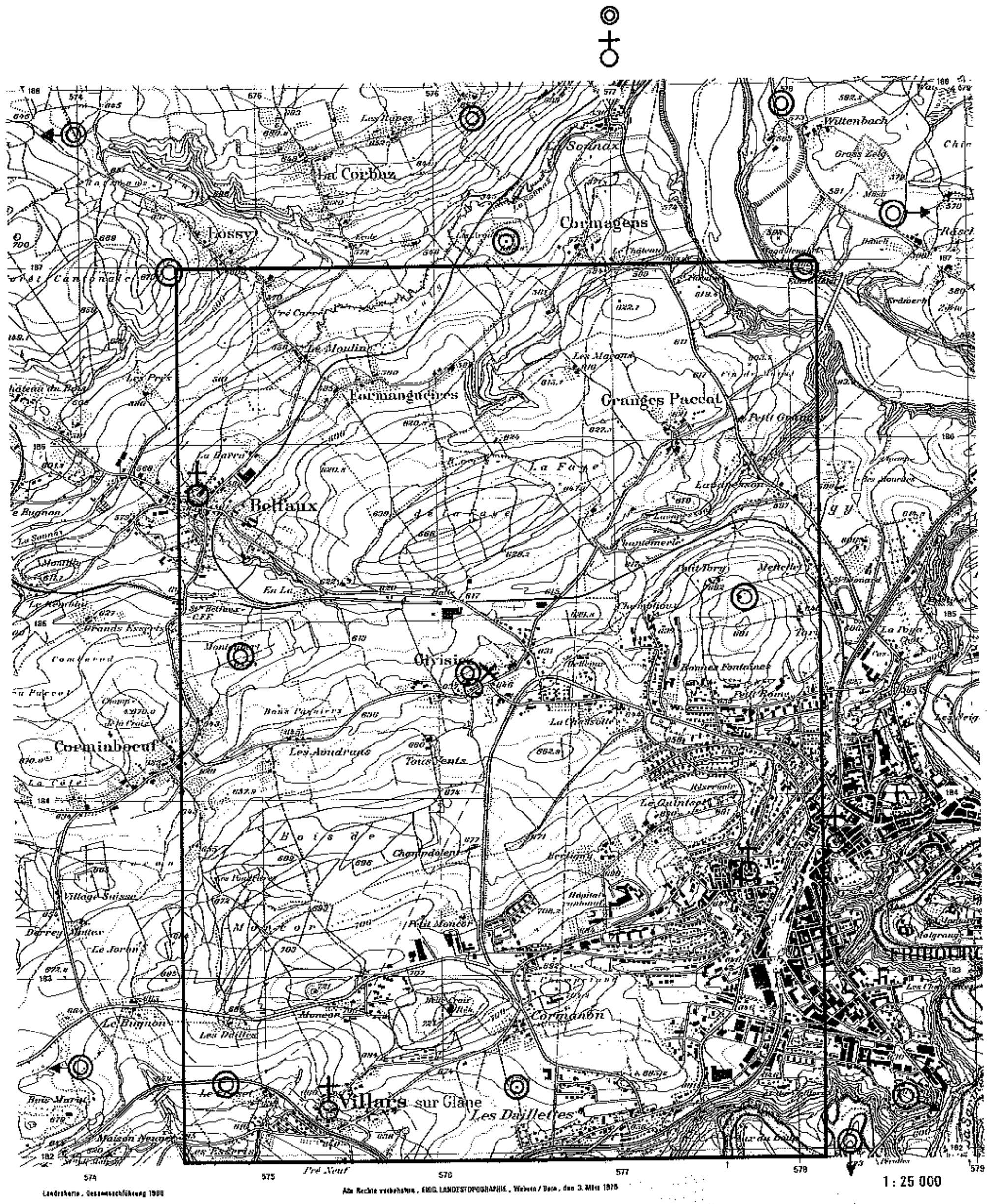
Within the area to be covered by these models, a number of pass points were selected for each stereopair. Each of them contained at least 8 or 9 signalised points. Additional controls for the planimetry were provided by giving the coordinates of 5 church spires (fig.9). All pass points and their type of signalisation are indicated on a special map (fig.10). According to each individual order only a limited number of control points has been communicated to the participants in the test.

Fig. 9: Aerial photograph with five church spires that served as control points

Fig. 10 : Map section of the test area with all available control points. Participants received only those points they needed for the stereopairs they had ordered.

OEEPE Commission D : Programme de travail no. 2
OEEPE Commission D : Working program nr. 2
OEEPE Kommission D : Arbeitsprogramm Nr. 2

Champ d' essai FRIBOURG
Test area FRIBOURG
Versuchsgebiet FRIBOURG



2.4 Flight Operations and Pass Point Signalisation

In the test field some 50 well-defined points had to be signalised, each one according to the flying height from which it would be seen.

The 10 points for the image scale 1:30 000 were determined as eccentric points to trigonometric stations and marked with aluminium targets of 70x70 cms. In addition two perpendicular strips of sawdust of 15 cms width assisted their detection in the photographs.

As many as 24 targets had to be layed out for the image scale 1:18 000. The size of the signals used was 50x50 cms. The church towers, of course, did not need any further treatment!

A large number of trigonometric and traverse points had to be signalised for the 12 large-scale models, used for up-dating the large scale topographical plans, which were used later on as the verification base in the accuracy tests. Many of these controls had been installed during the construction of the motorway. A variety of signalising methods were applied here.

The preparation of the test field was executed by a private firm. Everything was ready when, on the 6th of April 1976, the first flight was made. Because of excessive haze, this first photo series did not meet the usual standards for 1:30 000 photography.

A second flight was therefore prepared. Because of the weather conditions however, it could not be carried out until the 6th of May, in the meantime some of the targets had disappeared necessitating another field check. This time the whole programme gave satisfactory results. Participants stated later that this photography was excellent or at least better than their normal conditions. Table 1 gives a summary of the available image material flown for this test with a wide-angle and partly with a normal-angle lens (Wild Universal Aviogon II and Aviotar II) on a RC 10 camera. The photographs were checked by the pilot centre for the signalised control points. With a few acceptable exceptions, the signal visibility was good. In order to assess their quality and to verify the coordinates of these points the model at 1:30 000 covering the whole area, was oriented in a A 7 instrument. The final graphical adjustment resulted in residual errors no greater than 0.1 mm at the scale 1:25 000, so the image material was considered ready for delivery.

The photography flights were offered by the Federal Directorate of Cadastral Surveys in Berne and executed with their aircraft, a Twin Pioneer. The development of the films and contact films and copies were produced by the Swiss Federal Office of Topography (LT).

Table 1: Data of the imagery chosen for the FRIBOURG test

No.	Date	Lens	Focal length	Image scale	Flying height, above sea level
2335-39	6.5.76	WILD UAg II	153.05 mm	1 : 30 000	5430 m
1823-31	6.4.76	WILD UAg II	153.05 mm	1 : 18 000	3400 m
2319-27	6.4.76	WILD At II	305.35 mm	1 : 18 000	6230 m
1801-05	6.4.76	WILD UAg II	153.05 mm	1 : 7 400	1600 m
1806-14	6.4.76	WILD UAg II	153.05 mm	1 : 7 400	1600 m
1815-22	6.4.76	WILD UAg II	153.05 mm	1 : 7 400	1600 m
Flight operations by The Federal Directorate of Cadastral Surveys, Berne					

Fig. 11: Location of 40 spot heights to be plotted

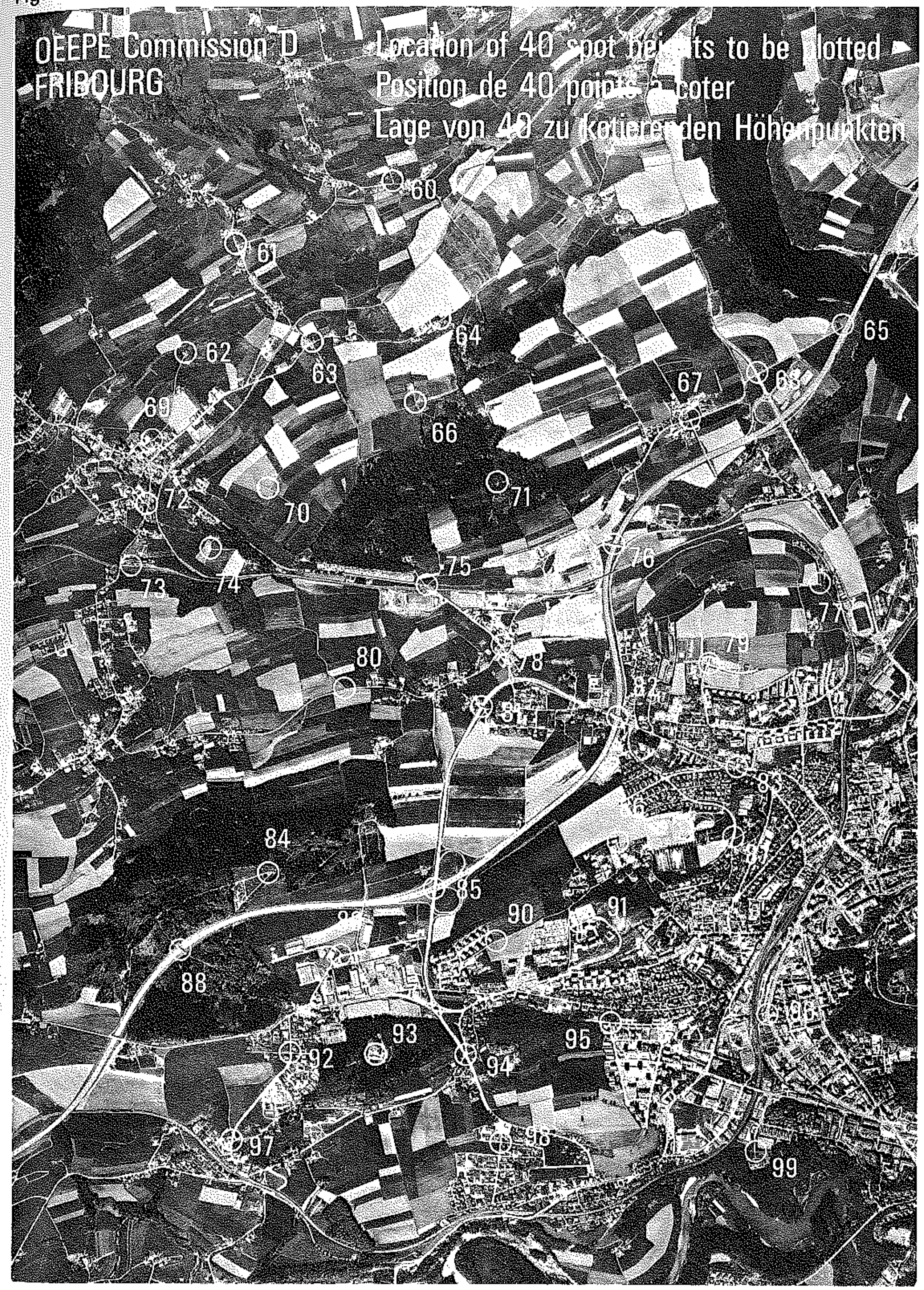


Fig. 12 : Orthophoto of the test area (reduction of the orthophoto 1 : 10 000 produced by WILD HEERBRUGG to the scale 1 : 25 000)

Fig. 13 : Flight plan for images at 1 : 18 000, focal length 153 mm, 3 models with 60 % overlap

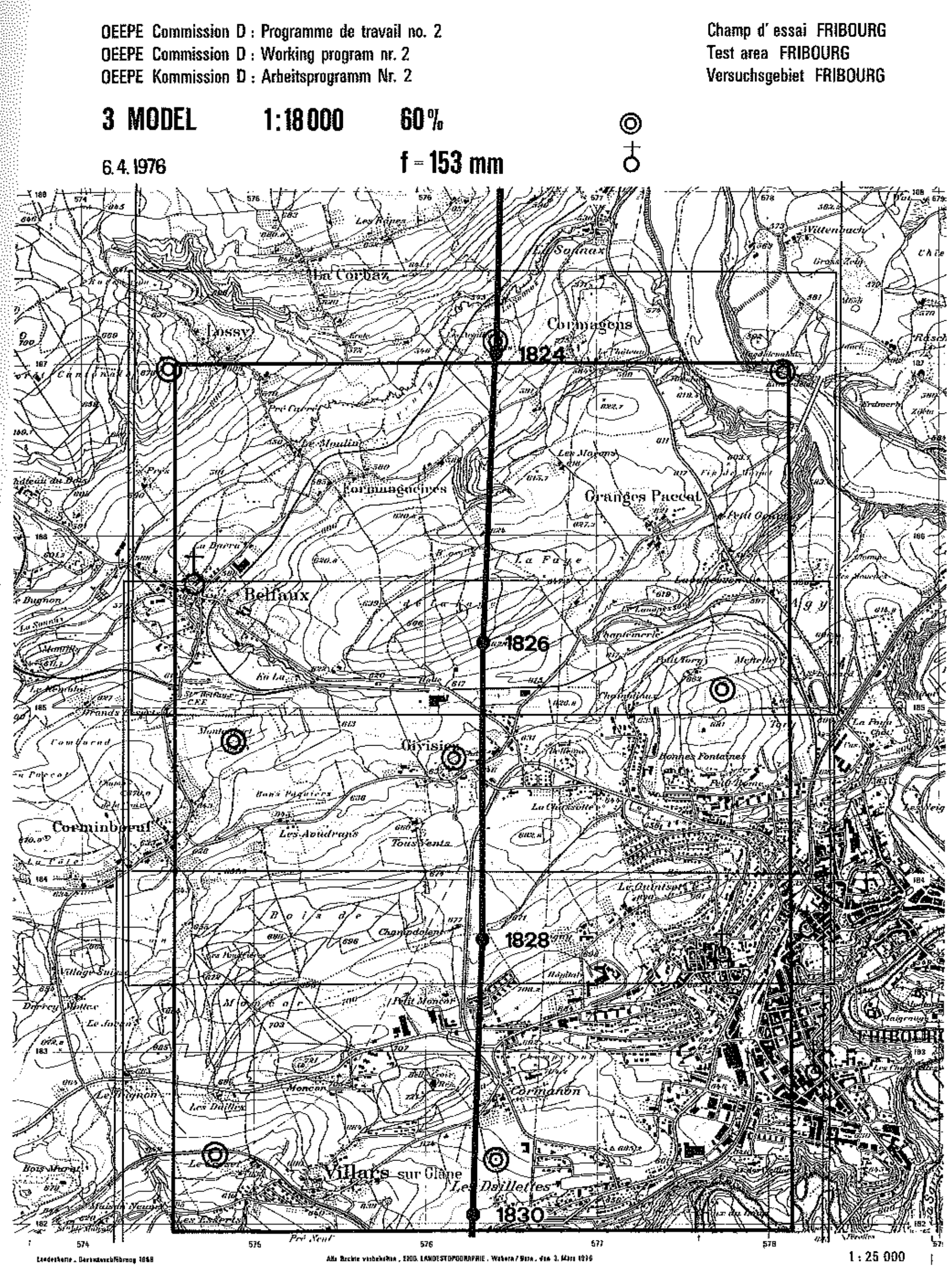


Fig. 14 : Flight plan for images at 1 : 30 000, focal length 153 mm, 1 model with 60 % overlap

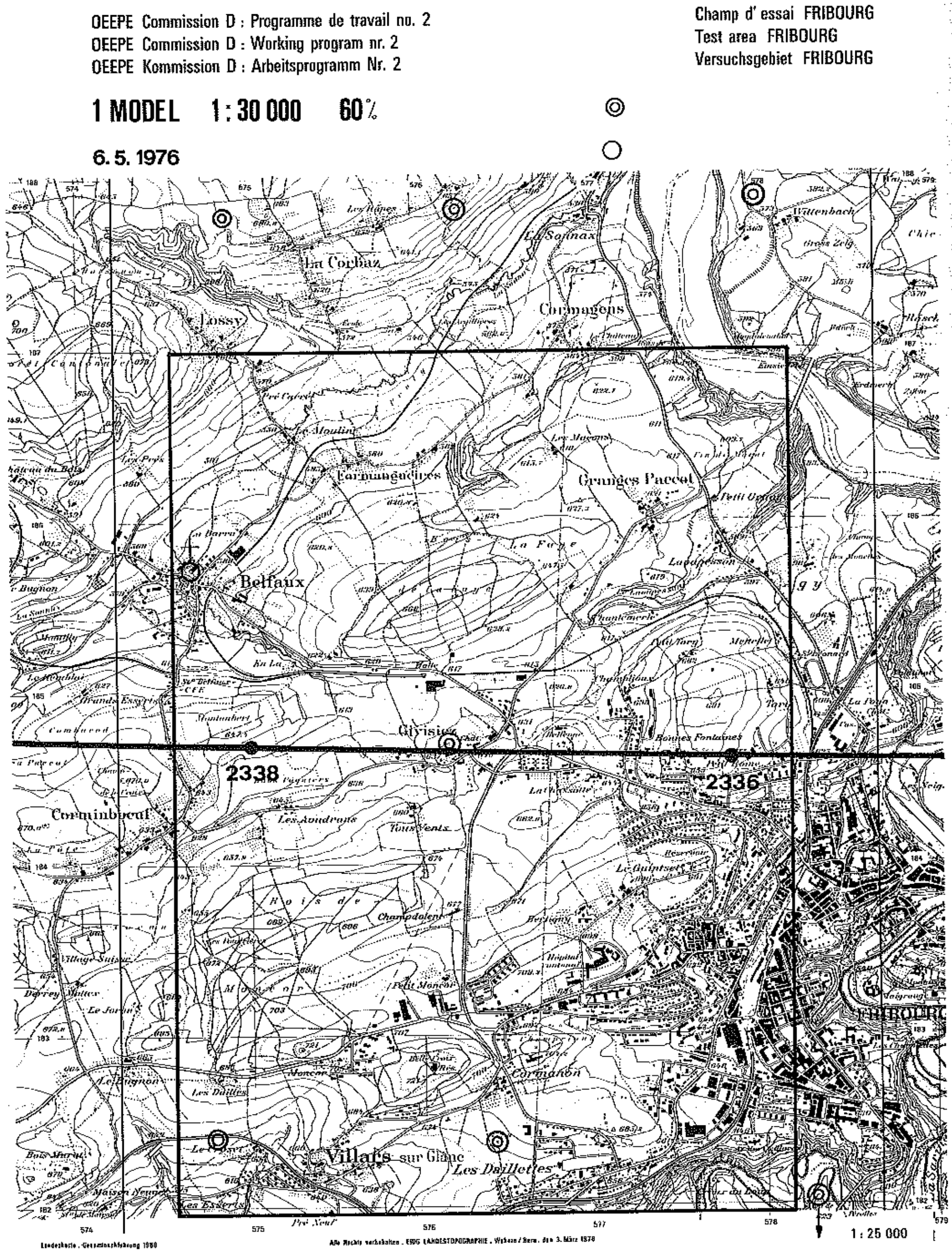
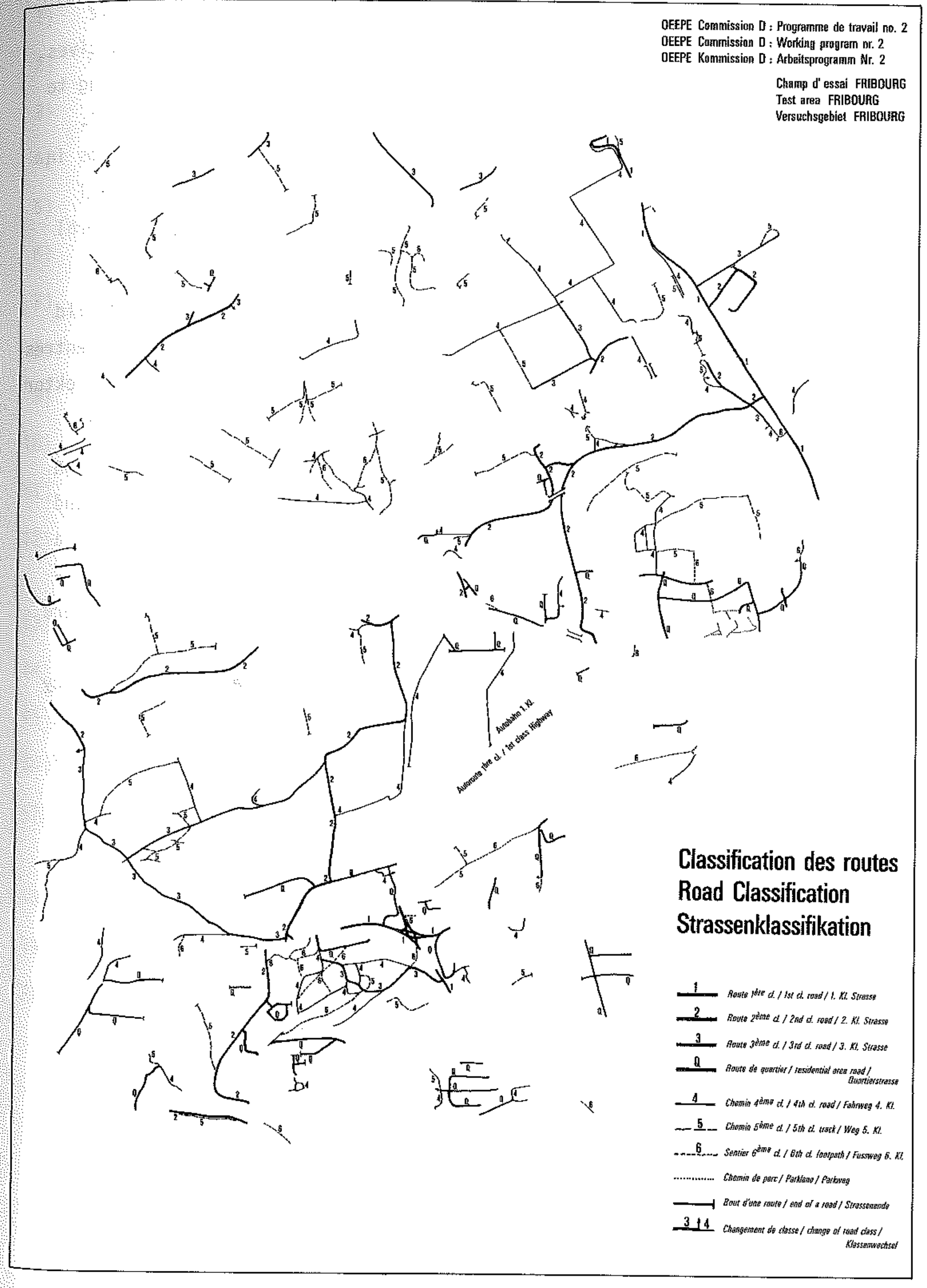


Fig. 15 : Road classification in the test area, submitted to all participants on an aerial photograph as result of the field reconnaissance



2.5 Preparation of the test material

Each participating centre received the aerial photography in the form most suited to the process envisaged. Wishes varied between ordinary film positives, second generation negatives and glass diapositives and, of course according to the models selected. For each picture used, paper prints were sent as well. These demands are summarised in table 2. A set of seven base map components in the form of wrong-reading positives were prepared for each participant. All these films were produced by the reproduction department of the Swiss Federal Office of Topography.

For the two centres that requested an orthophoto (IfAG and NBS) the firm Wild Heerbrugg AG prepared the orthophotos on their Avioplan, OR 1. Two other centres prepared their orthophotos themselves: LVA Stuttgart with a Zeiss Orthoprojektor GZ 1 and Delft on the Wild A 8 with the orthophoto device PPO-8.

A problem at the beginning of this test was the fact that, with the exception of Wabern, no other participant was familiar with the instructions and legend guiding the compilation of this map series. Therefore, each centre received a complete list of the conventional signs annotated with the dimensional specification for each symbol. It must be mentioned here that the participants were not requested to match precisely the line widths and spacing of the original map. In addition to the legend, a detailed commentary elaborated on the policy adopted in the selection and symbolisation of the large variety of situations occuring in the field. With these guide-lines, it was hoped to standardise to some extent the test work of the various centres.

The following is a summary of the test material sent to each participant:

1) Selected (dia)positives or negatives
2) Paper prints of the whole flight line
3) Summary of participating institutes
4) Form for the description of the whole plotting process
5) Data sheet for the imagery data of the test
6) List of co-ordinates of all church-spires
7) List of co-ordinates of control points requested
8) Paper print with the precise position of these control points
9) Paper print with the location of the 40 spot heights (fig.11)
10) Form: sheet for the recording of these spot heights
11) 2 maps with flight plans 1:18 000 and 1:30 000, f = 153.05 mm
12) Positive film of the base map, a combination of all 4 linear elements and a screened tint for the woodland (fig.1)
13) Positive film of the black plate, planimetry with names
14) Positive film of the blue plate, hydrography
15) Positive film of the light blue plate, with a solid tint for water areas
16) Positive film of the brown plate with topography
17) Positive film of the dark green plate, with the outlines of woodland and vegetation areas
18) Positive film of the light green plate, with woodland areas
19) Conventional signs and dimensional specification for 1:25 000
20) Commentary on the selection and classification of different features in the National Map Series

2.6 Time schedule for the test work

First proposal submitted by the Commission president Prof.Beck	April 2, 1974
Meeting of Commission D in Stuttgart: Decision on proposal for new project	September 17/18, 1975
Decision by the Steering Committee	October 1/2, 1975
Flight programme approved	February 27, 1976
First flight run	April 6, 1976
Commission Meeting in Wabern	April 29/30, 1976
Second flight run	May 6, 1976
Field identification	May 21/22, 1976
Pilot centre transferred from Stuttgart to Zurich	September 1976
Control points survey large scale plotting	September 29, 1976
Checking of image quality and pilot restitution	October 1976
Nomination of a new Commission President by the Steering Committee	October 28/29, 1976
Delivery of photographic and cartographic materials to participants	January 28, 1977
Delivery of restitution documentation	March 15, 1977
Delivery of orthophotos ZEISS prepared by Stuttgart	March 30, 1977
Meeting of Commission D in Zürich	April 14/15, 1977
Delivery of orthophotos prepared by WILD HEERBRUGG	June 22/28, 1977
Additional information on field identification sent to Stuttgart	May 18, 1977
Intermediate reports of participants	October 31, 1977
First test material returned	February 2, 1978
Last test material returned	May 22, 1978
Meeting of Commission in Zurich: Final decision on verification procedure	June 15/16, 1978
Final decision on verification procedure in Vienna	October 10/11, 1978

Evaluation of accuracy and completeness by the pilot centre	March/April 1979
Evaluation of line quality and generalisation procedures	August/September 1979
Meeting of Commission D in Frankfurt	May 6/7, 1979
Meeting of Commission D in Brussels	November 29/30, 1979
Scientific Exhibition International Congress for Photogrammetry in Hamburg	July 1980
Paper: Revision of Topographic Maps - Results of the Fribourg Test by Commission D of the OEEPE, Hamburg	July 25, 1980
Nomination of a new Commission President	May 1981
Meeting of Commission D in Southampton	September 30/ October 1, 1981
Presentation of the test results at the Swedish map days in Gävle	March 25, 1982
Presentation of a paper on the Fribourg test at the Thompson Symposium of the British Photogrammetry Society in Birmingham	March 27, 1982
Meeting of Commission D in Hønefoss	June 11/12, 1982
Provisional publication on some test result in "The Photogrammetric Record", Vol.11, No.61: "Revision of Topographic Maps: Photogrammetric and cartographic methods of the Fribourg test" by E.Spiess	April 1983
Evaluation of time and cost by the pilot centre	September 1983
Meeting of Commission D in Southampton	November 15/16, 1983
Completion of the manuscript and of the illustrations for the final report	March/April 1984

3. Participation in the FRIBOURG test

Table 2: Participating centres and methods applied

Contribution No.	Name of restitution centre	Abbreviation	Image scale	Number of models used	Overlap	Restitution scale	Method used: Ortho or Stereoplotting	Cartographic method used mainly
1	Landesvermessungsamt Baden-Württemberg, Stuttgart, FRG Land Survey Office Baden-Württemberg, Stuttgart, FRG	LVA	1:30 000	2	60%	1:10 000	Ortho	drawing
2	Topografischer Dienst, Delft Topographic Service Delft The Netherlands	TD	1:30 000	1	60%	1:15 000	Ortho	scribing
3	Institut Géographique National Bruxelles, Belgique National Geographic Institute of Belgium, Brussels	IGN	1:18 000	4	60%	1:16 666	Stereo	scribing
4	the same	IGN	1:30 000	1	60%	1:16 666	Stereo	scribing
5	Norges Geografiske Oppmåling, Geographical Survey of Norway, Oslo	NGO	1:18 000	3	60%	1:25 000	Stereo	scribing
6	the same	NGO	1:30 000	1	60%	1:25 000	Stereo	scribing
7	National Board of Survey Helsinki, Finland	NBS	1:30 000	1	60%	1:10 000	Stereo	drawing
8	the same	NBS	1:30 000 1:18 000	1 2	60%	1:10 000	Ortho Stereo	drawing (contours)
9	the same	NBS	1:30 000	1	60%	1:10 000	Stereo Facet Plotter	manuscript only
10	Institut für Angewandte Geodäsie, Frankfurt a.M. Institute for Applied Geodesy, Frankfurt a.M., FRG	IfAG	1:30 000	1	60%	1:10 000 1:20 000	Ortho Stereo	scribing (contours)
11	Bundesamt für Landestopographie, Wabern-Bern Federal Office of Topography, Wabern, Switzerland	LT	1:30 000	1	80%	1:25 000	Stereo	manuscript only
12	the same	LT	1:27 000 (photography of 1975)	1	80%	1:25 000	Stereo	scribing

3.2 Test specifications

In May 1976 participants received some first test specifications given in form A, on which the centres at the same time had to state their intentions about executing this test. The participating institutions were asked to use if possible their standard map revision procedures with normal care and speed. They were entitled to ask for additional interpretation detail.

Each centre had to prepare a complete description on the whole procedure and to give a detailed report about hours and cost involved. They had to deliver the 6 up-dated colour plates but also the intermediate products, plotting manuscripts etc. and if possible a colour proof copy. The up-dated positive films were to contain all the new map elements in red, the remaining ones in black, a requirement that was accepted only by a few participants, because most centres were not used to this type of procedure. Another request, namely plotting all contours in the northwest quarter, was abandoned, again because it was not in accordance with normal revision pratice and therefore a strange element within this test. Some additional informations were gathered on the usually used printing presses and the kind of processes envisaged for this test.

The test data were to be delivered on form C/D with eventually additional remarks on the procedures used. This form C/D provided for a summarized description of the whole revision process including the time needed for its completion. For each step the instruments or major tools used and the hours and materials needed had to be indicated. This form was organized in a chronological order of the expected sequence of procedures. There were two different forms, one for stereoplotting, the other for the orthophoto method.

For the photogrammetric part of the stereoplotting method the kind of images used had to be listed, photo scale, focal length, film or glass plates, as well as the numbers of the pictures used. The preparatory work was devided up in the preparation of the plotting manuscript, including registering and reporting control points and in necessary reproductions for this step. Next some information was gathered on the orientation of the models in the plotting instrument, scale of model, kind of instruments used, time needed for the relative and absolute, numerical or graphical orientation. The records of the orientation were received as well. Another step was concerned with a possible preinterpretation, followed by the proper stereoplotting process. The list of questions included the scale of the plotting manuscript and whether the operator had an assistant, used a preinterpretation, direct registering of the colour separation films, pencil, ink or scribing for plotting. Then the professional category of the operator and the hours he needed for plotting all new roads and railways, buildings, land use and hydrographic features were recorded. In cases of gaps the results of the field reconnaissance could be asked from the pilot centre. Finally we wanted to know whether the manuscript was subsequently redrawn by pencil, ink or scribing with or without care for generalisation. Plotting of contours, spot heights and slopes were treated as a separate item. A complementary question concerned the form of reconnaissance done by the participating centre in their regular map revision tasks.

3.3 Some remarks on peculiarities and departures from the test specifications

Within the 12 test samples that were finally prepared, three of them departed in one kind or the other from all the others:

The Federal Office of Topography in Wabern had revised the whole sheet Fribourg of the Topographic Map Series at 1:25 000 with photography taken in 1975. The cartographic work was nearly completed, when the test work was started in summer 1976. The Federal Office therefore renounced repeating the cartographic part of the test. A new plotting manuscript on the base of the test photography was however prepared. As a result we have data about a complete sheet of 210 km^2 of the Swiss Topographic Map at 1:25 000 for 1975 and of a plotting manuscript of the test area for 1976. Where these two contributions do not allow comparisons, they have been left out.

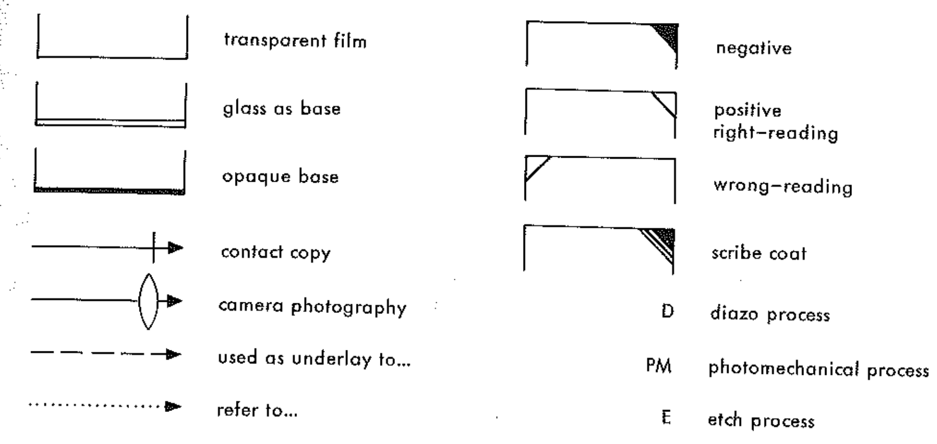
The other exception is the test with the stereo facet plotter. It must be noted that here again we have only a plotting manuscript that was not further treated cartographically.

In general it has been quite a problem for most participants to adapt their standard procedures to the specific test conditions. With the exception of the Swiss participants they were not familiar with the terrain nor with the map legend. For the others the problems were more or less equal, although Oslo, Helsinki and the IfAG reported that their standard map scale was not 1:25 000. They were experimenting with new methods on purpose. In this way or the other all centres had to adapt their usual methods to this test. All these peculiarities should be kept in mind when comparing test results.

4. Description of the operations sequence

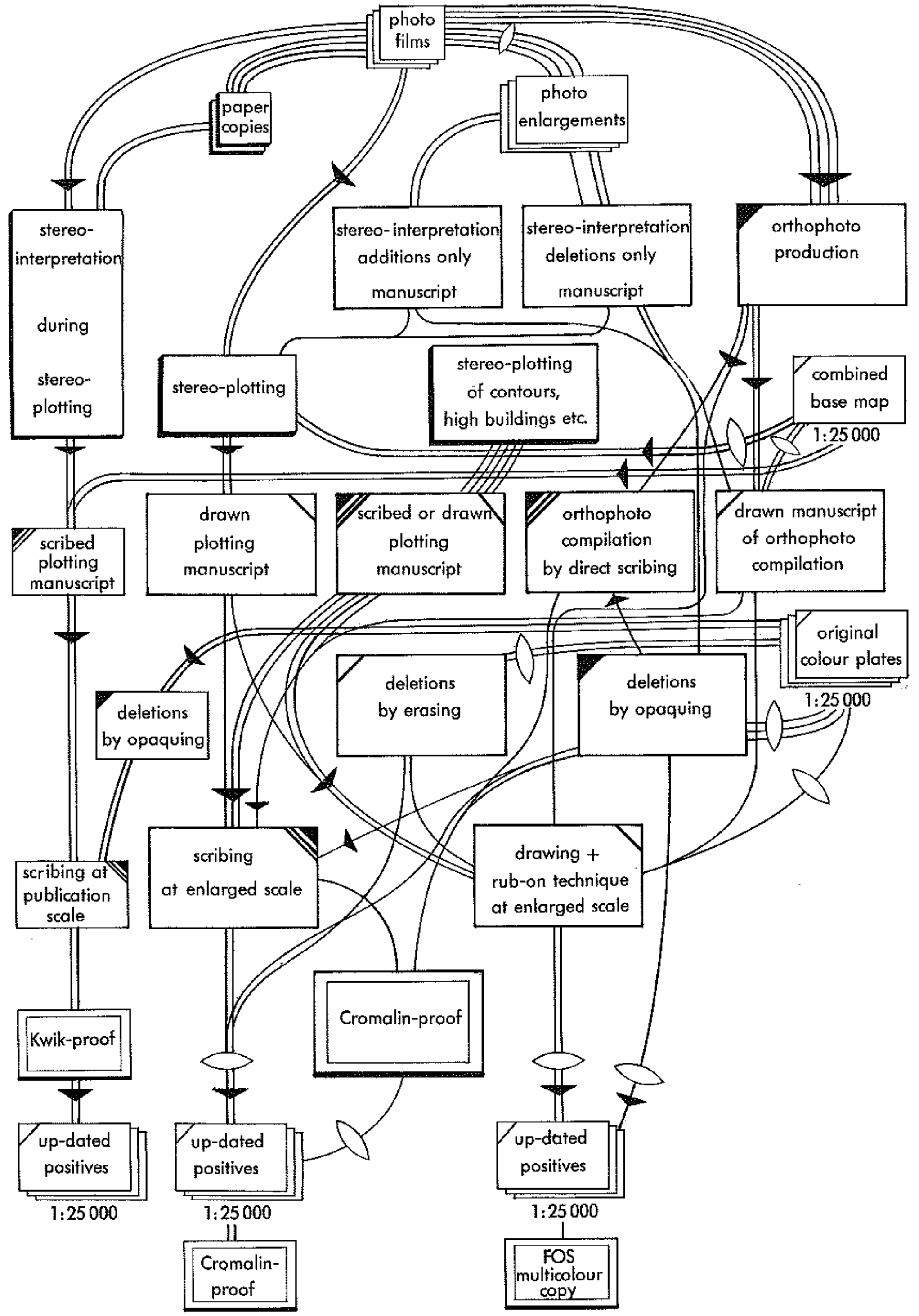
Each participating centre delivered a detailed report on the operation sequence they had followed. These descriptions are given at full length in this paragraph. In order to be able to make comparisons for each test sample a flow diagram was prepared, whereby the following symbology was applied:

Fig. 16 : Legend for flow diagram



A comparison of all these sequences of procedures is one of the most surprising results of this map revision test. There is an extremely large variety of techniques used and an equally large variety in the process sequences. We have tried to summarize as well as possible these variations in fig. 17. Starting down from the original photography we have in the following rows the interpretation phase, stereoplotting or orthophoto production, preparation of compilation manuscripts, deletions, scribing or drawing new items, colour proofing and the preparation of final positives. In each row different techniques are shown, all of them connected by copying, enlargement and reduction processes. Each line symbolizes a sequence applied in one of the 11 test samples.

Fig. 17 : Diagrammatic representation of the great variety of production sequences for map revision applied in this test



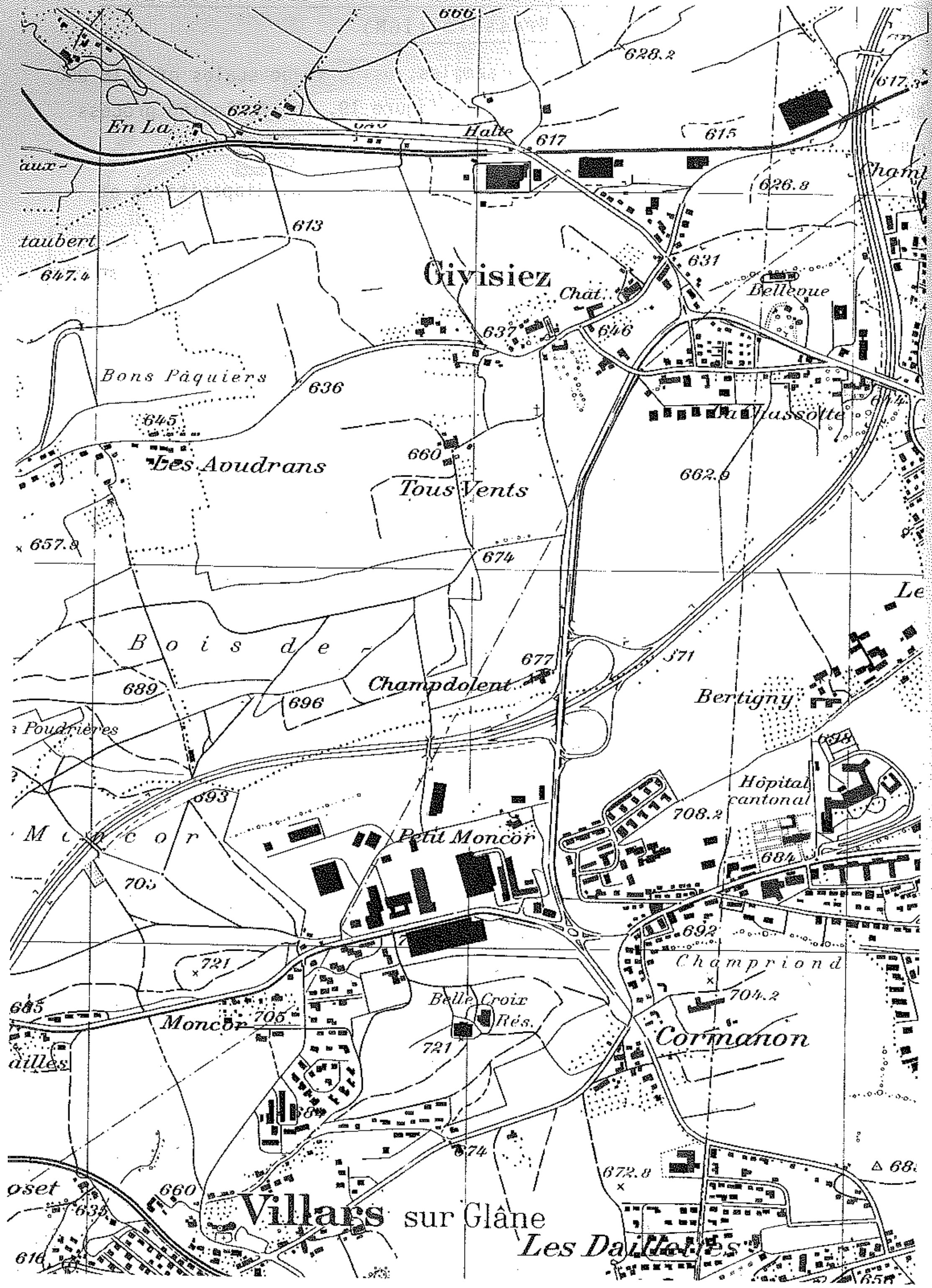
4.1 Sequence of procedures applied by the National Geographic Institute of Belgium in Brussels (IGN)

The same sequence was chosen for both samples, using image scales of 1:18 000 and 1:30 000. The flow diagram is given in figure 19. The following process numbers correspond to those in the diagram.

1. Contact negatives on film were produced from 6 aerial diapositives at 1:18 000 and 4 at 1:30 000.
2. These negatives were enlarged to 1:10 000 in the WILD E4 rectifier and printed on matt photographic paper, dimensions 30x40 cm, in a light tone allowing for drawing directly on the photographs. These images covered the entire plotting area.
3. From each wrong-reading original map element, a photomechanical copy was produced on ASTRALON at the scale 1:25 000, including the planimetry, hydrography and vegetation.
4. From a contact negative of this combination, a wrong-reading positive film a the scale 1:10 000 was prepared in a KLIMSCH COMMODORE reproduction camera.
5. Using an OUDE DELFT stereoscope, the contact copies received with the test material were stereoscopically interpreted within the test area. The enlarged images at 1:10 000 were overlayed by the 1:10 000 films of the 1968 edition. All details for deletion were marked in red ink; those to be added drawn in different colours on the matt photographs. This interpretation involved all planimetric changes.
6. The combination copy on ASTRALON was enlarged in the camera to 1:16 667 and after retouching, a right-reading contact copy on wash-off film (DU-PONT CWO-4) of brownish red colour was prepared.
7. It was on this wash-off film map base that plotting from the models was carried out with reference to the following:
   - the 1:10 000 interpreted photographs
   - the road classification contact print
   - the conventional symbols
   - and the 1968 edition at 1:25 000

   The plotting was executed at the scale 1:16 667 on a WILD A7 with drawing table. Details to be deleted were scraped from the manuscript. New elements were plotted in pencil and fair drawn in ink (fig.18).

Fig. 18 : Copy of the wash-off film carrying the plotting manuscript (IGN Brussels)



8. The original wrong-reading contour positive was enlarged in the camera to a negative at 1:16 667, and after retouching an additional wash-off film contact printed.

9. On this film,the elevation information was revised by stereoplotting. Correction plates were inserted in the optical system. The absolute orientation was accomplished with great care, using the given control points and a number of additional spot heights indicated in the existing map. Where contours had to be altered they were erased and the corrected ones drawn in.

10. Finally the spot heights were measured and adjusted by a planimetric-altimetric compensation to the given control points for the model. This same sequence: planimetry, contour lines, spot heights was applied to all the other models.

11. From all wrong-reading original positives (planimetry, hydrography, vegetation, contours), a right-reading negative at the scale 1:16 667 was made in the camera, absolutely identical in scale to the plotting manuscript. The film material used was AGFA GEVAERT L 081 p.

12. With reference to the plotting manuscript, all details to be deleted were painted out. This was done by overlaying successively the different negatives on the plotting manuscript which was in a brownish colour. The white parts resulting from scraping during restitution had to be opaqued on the negatives.

13. For the scribing of planimetric details, a yellow STABILENE scribe coat was provided with a guide copy consisting of:

    - a rub-on-diazo copy of the KODAK 3571 autoreversal film copied in contact from the plotting manuscript
    - an additional EIDESCO photomechanical copy of the opaqued negative dyed up in a red colour

    On this film all new planimetric details were scribed.

14. For the scribing of vegetation features a scribe sheet was prepared with a guide comprising:

    - a combined positive copied in red by photomechanical positive means from

-- the opaqued negative of the planimetry
-- the scribed new planimetry
-- the opaqued vegetation negative
- an additional rub-on-diazo copy of the plotting manuscript

The new linear elements of the vegetation (dark green) were scribed on this film.

15. On the scribe coat for the hydrography, the following elements were copied:

- in red by photomechanical positive means, a combined wrong-reading positive film was prepared comprising:
  -- the opaqued negative of the planimetry
  -- the scribed new planimetry
  -- the opaqued hydrography negative
- a rub-on-diazo copy of the plotting manuscript

On this film, the new hydrography was scribed.

16. For the scribing of new contours, the following guide copied were required:

- the combined positive, copied by photomechanical positive means in green comprising:
  -- the opaqued negative of the planimetry
  -- the scribed new planimetry
  -- the opaqued negative of the vegetation
- and a second exposure, using the same process, of the combined positive consisting of:
  -- the scribed new vegetation
  -- the opaqued negative of the hydrography
  -- the scribed new hydrography
- a rub-on-diazo process copy of the contour line plotting manuscript
- an EIDESCO photomechanical copy of the opaqued contour line negative

All new contours were scribed on this base.

17. The original positive woodland areas (medium green) was fitted to the line elements by erasing of old details and inking in of new ones. Had there been major changes involved, a new peel- coat would have been prepared from a combination of planimetry and hydrography.

18. The same procedure was applied to revise the tint plate of water areas.

19. Wrong-reading positives at the scale 1:25 000 were produced from reductions of the opaqued negatives of the planimetry, hydrography, vegetation and contour lines.

20. The scribed films of the same features were also reduced to 1:25 000.

21. The positives obtained were used to prepare a colour-composite by the CROMALIN process, which was used for checking. Errors were retouched directly on those postives.

22. Right-reading positives were copied on ASTRAFOIL by photomechanical means, the remaining elements in black, the new items in red. These combinations were prepared for the planimetry, vegetation, hydrography and contour lines.

23. From the positives for woodland and water areas, wrong-reading contact positives were made.

24. From all four, two-colour-composites, wrong-reading contact positives were copied ready for printing. A final CROMALIN proof was prepared from these.

In Belgium map compilation and preparation is normally done at the scale 1:15 000, an intermediate scale allowing for the simultaneous publication of this map at 1:25 000 and 1:10 000.

For the FRIBOURG test, the intention was to apply the same methods, although the original test material was not at this scale. This resulted in a considerable number of enlargements and reductions that influenced of course the cost and quality of the map. The working scale of 1:16 667 was chosen on practical grounds for the application of existing scribing tools with respect to the conventional symbols of the Swiss National Map series 1:25 000.

The two-colour combinations have been made according to test instructions and the usual procedure was abandoned for this reason. Names, spot heights and administrative boundaries were not required of the test.

Fig. 19 : Flow diagram of the production sequence (IGN Brussels)
National Geographic Institute of Belgium, Brussels
Stereoplotting from 1:18 000 or 1:30 000 imagery and scribing at 1:16 667

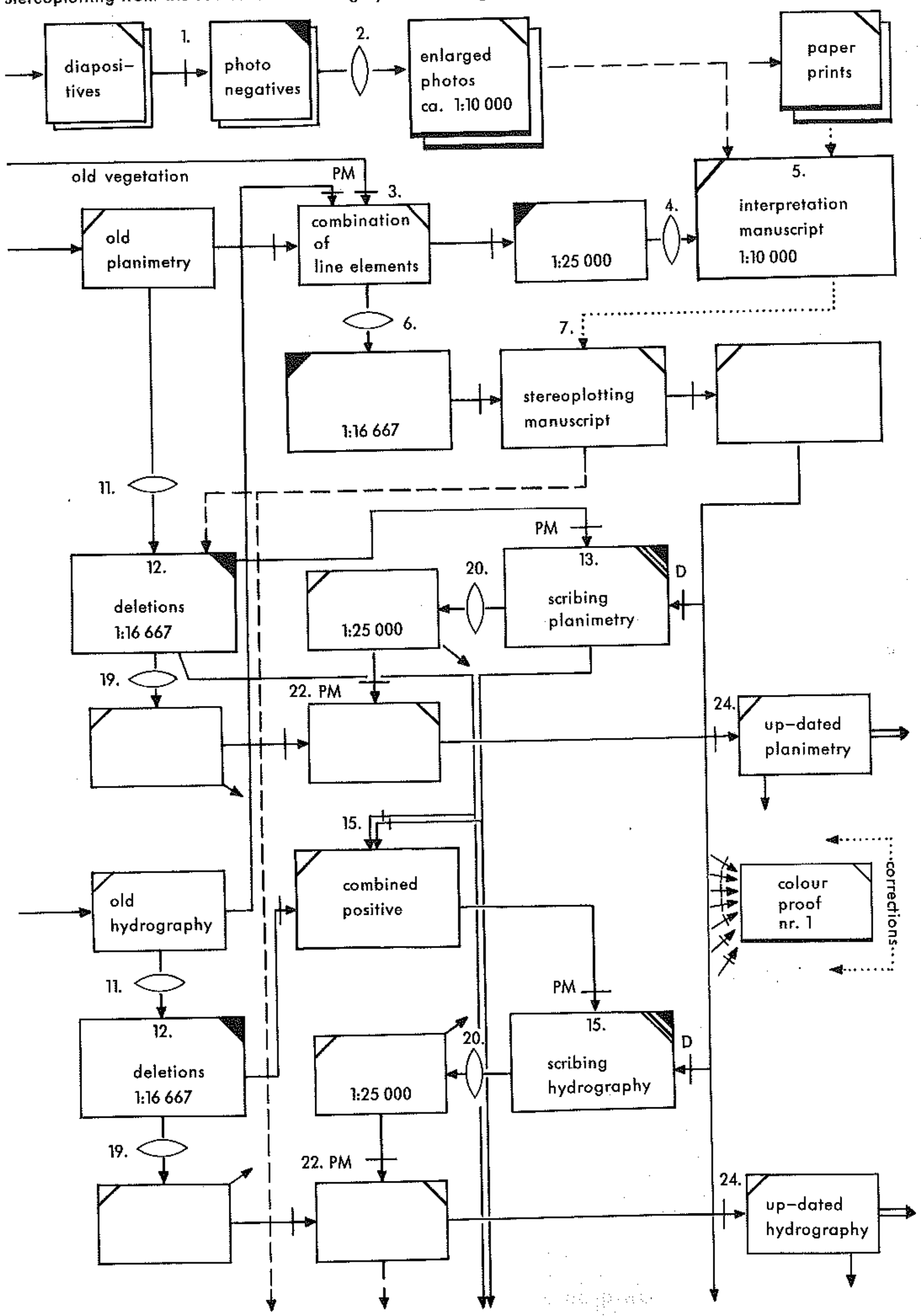
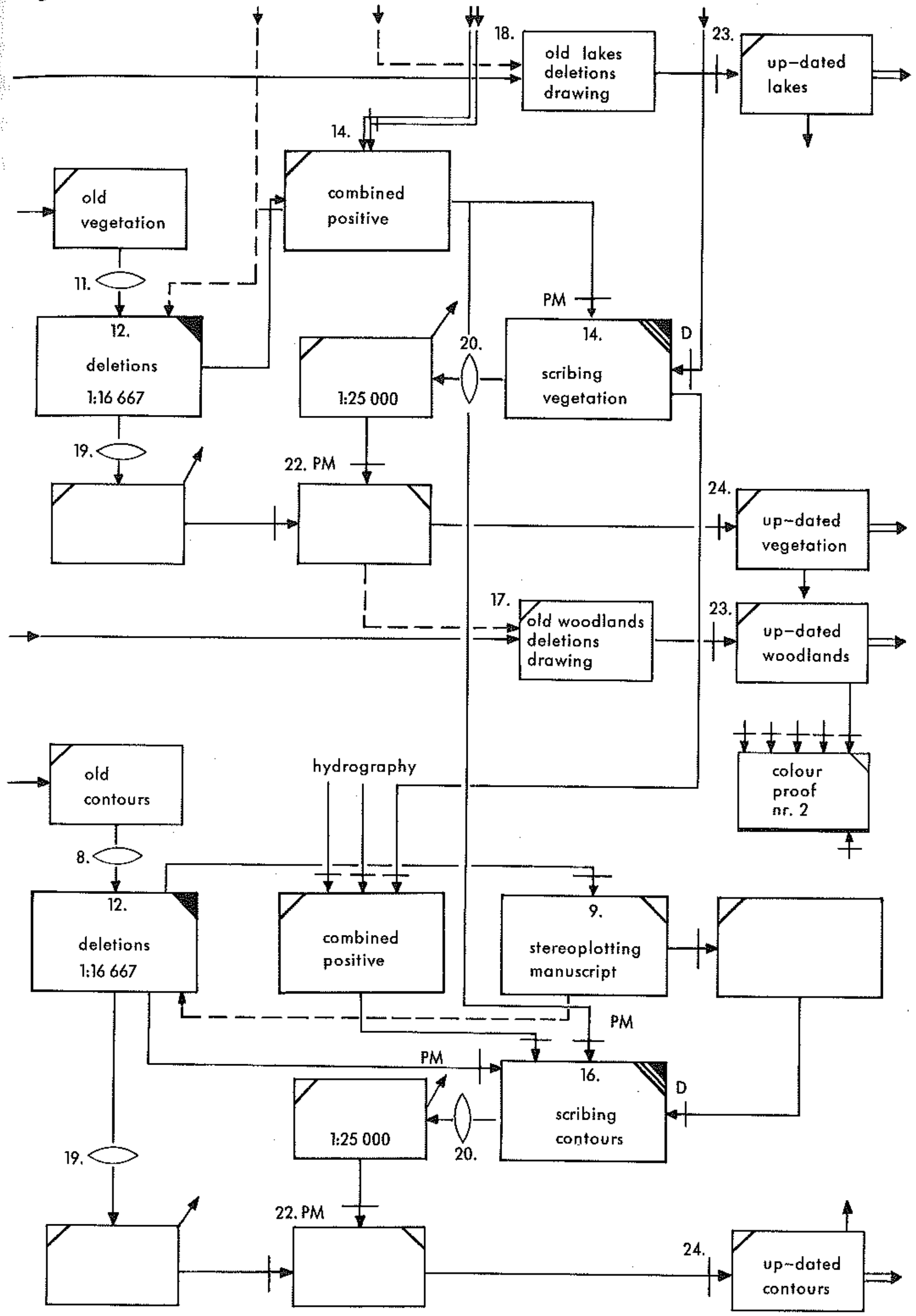


Fig. 19 (continued)



PM=photomechanical process

D=diazo process

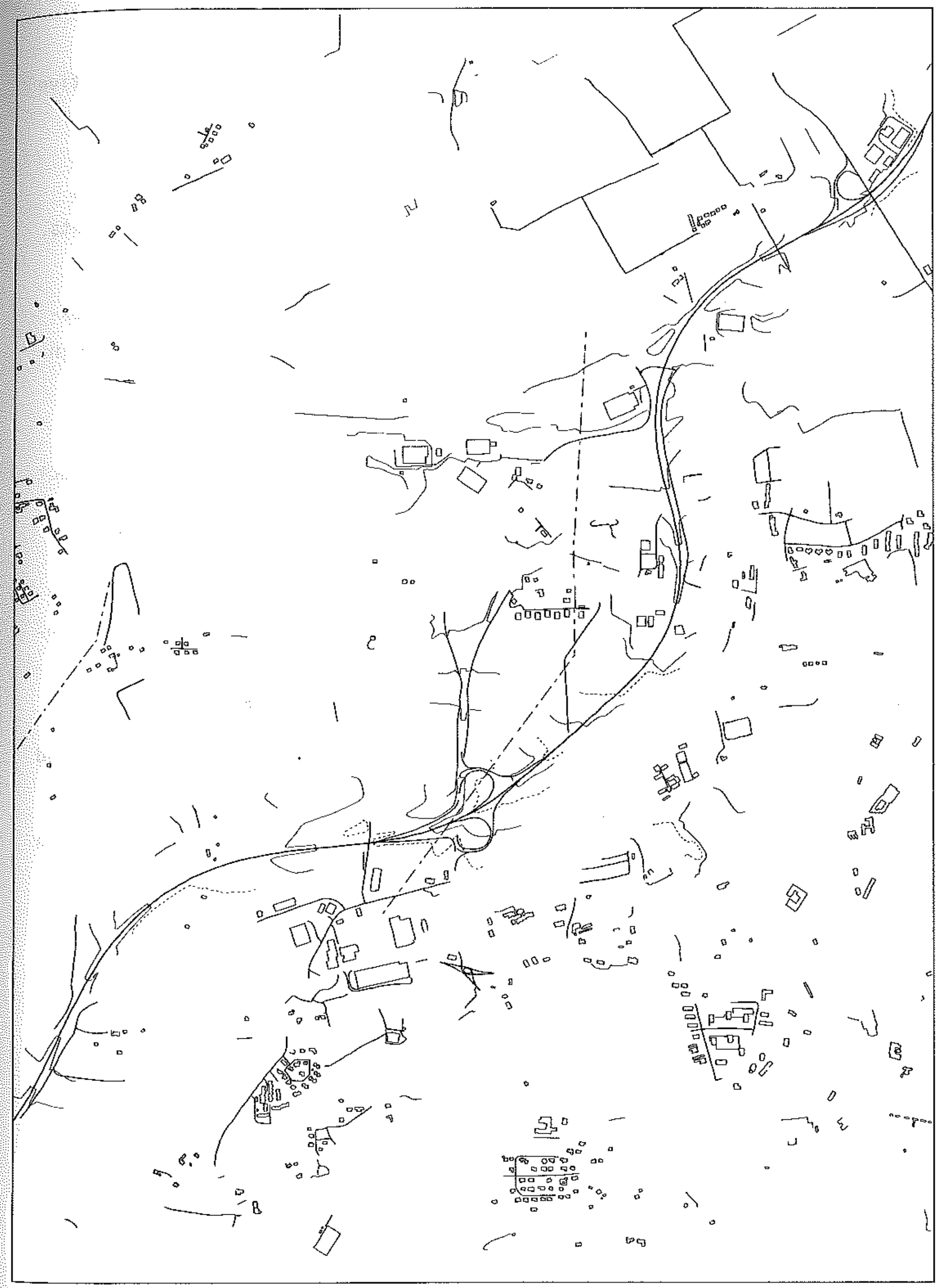
4.2 Sequence of procedures applied by the Geographical Survey of Norway in Oslo (NGO)

In Oslo two tests were executed, one using the pictures nos.2336/38 at 1:30 000 image scale, the other with three models of the 1:18 000 pictures. The procedure was however similar in both cases and was based on stereoplotting and scribing techniques. The two test plots were executed by two different photogrammetric operators, but on the same instrument, a WILD A8. The revision procedure followed the sequence below:

1. The films received from the pilot centre were prepunched for registration.
2. From the comination plate, a contact negative was copied on a DUPONT PC-7 clear polyester film, the material used throughout for all line photography processes in this test.
3. With this negative, a red guide copy for stereoplotting was produced on a 0,18 mm white/red (1:18 000) or white/green (1:30 000) KEUFFEL and ESSER STABILENE scribe coat using the KWIKPROOF photomechanical process.
4. The stereo models were oriented empirically with the above scribe coat as the key for the absolute orientation. The model scales were 1:20 000 for aerial photography at 1:30 000 and 1:12 500 for 1:18 000. No residual errors were observed.
5. The new map detail and new contour lines were plotted at the scale 1:25 000 by direct scribing on the above scribe coat with a saphire graver. Details to be deleted were marked in green on this manuscript (fig.20).

   The photo-interpretation, consisting of comparing the new aerial photo with the original base map, was done by the operator while plotting. Apart from the road classification, no other field reconnaissance manuscript was required from the pilot centre.
6. The outline of embankments and cuttings however were plotted in pencil and afterwards drawn in ink on a polyester sheet in register with the plotting manuscript.
7. The 40 spot heights were measured thereafter from the same models as used for the stereoplotting.
8. From the original wrong-reading positives of the black and brown plates, photographic contact negatives were prepared. Details to be deleted from the black and brown plates respectively, were opaqued on these two nega-

Fig. 20: Plotting manuscript scribed at the scale 1:25 000 (NGO Oslo)



tives by reference to the plotting manuscript (5). The right-reading negatives were then copied through base to right-reading positives.

9. The right-reading positive of remaining black map details was etched through a STABILENE Rust U44-3147 scribe coat using the DEEP ETCH positive process as described in the appendix. A blueline guide copy was then applied onto the same scribe coat by photomechanical KWIKPROOF process. The new map details for the black plate could then be scribed onto this wrong-reading scribe coat fitting with the etch of remaining map elements.

10. The right-reading positive of remaining brown map elements was etched through another scribe coat. A blueline guide copy of the plotting manuscript (5) was then applied onto this coat and the new contours scribed in register with the existing ones. All hachures were also scribed on this wrong-reading scribe sheet.

11. Right-reading direct positive films (DU PONT CRW-4) were copied in contact from the original line positives of the drainage and vegetation.

12. The right-reading positive of the original drainage line elements was etched through a scribe coat, opaqued where details had to be deleted and added to by scribing for new details. No guide copy was made for this purpose.

13. The right-reading positive of the original vegetation line elements was etched in a scribe coat, opaqued where details had to be deleted and added to by scribing for new details. No guide copy was made for this purpose.

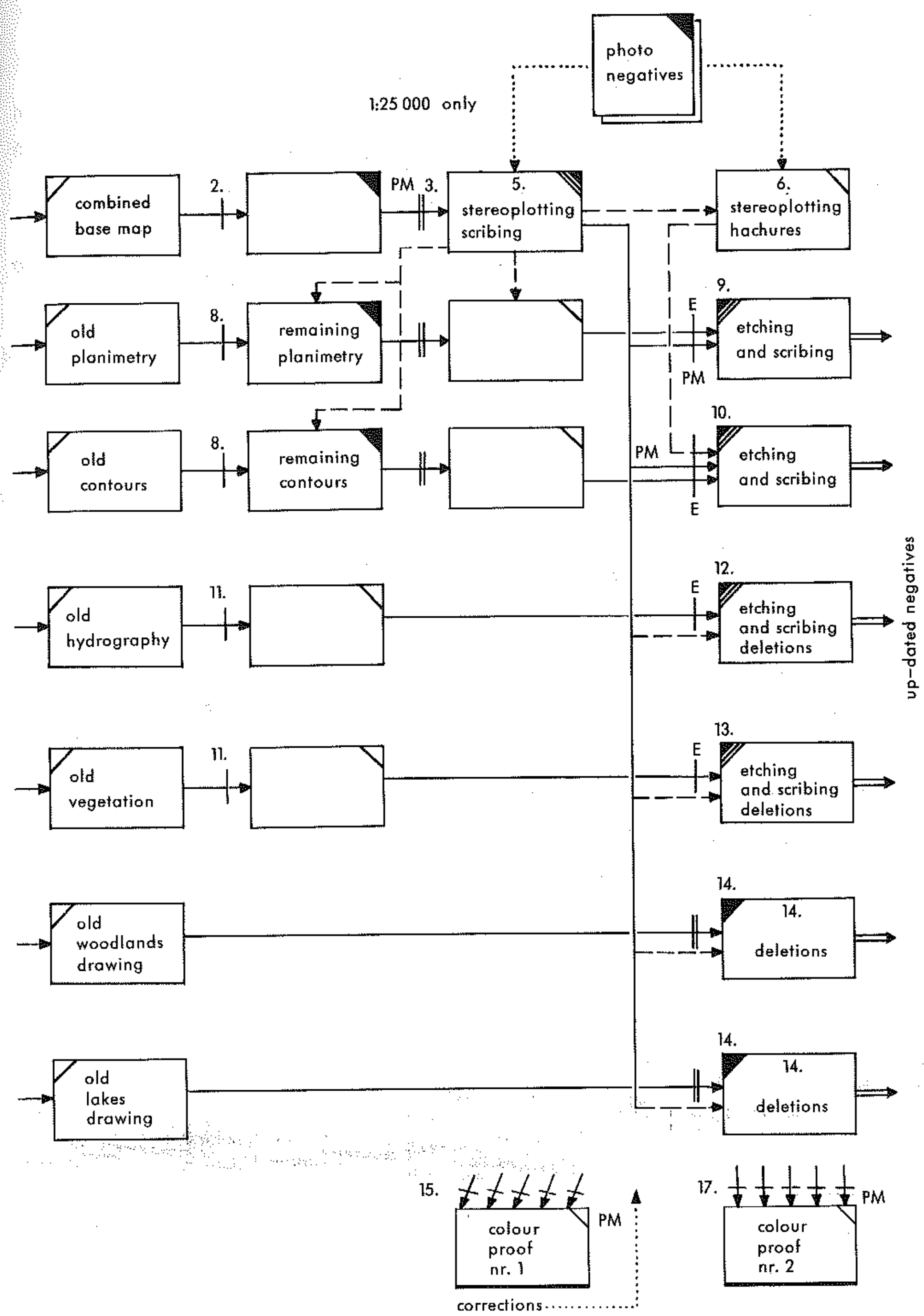
14. The original tint positives for woodland and for lakes were copied through base to wrong-reading negatives, a few changes were added in ink and the negatives retouched.

15. With all these revised scribe coats and negatives, a colour proof was produced on white opaque STABILENE U 44-1107, using the photomechanical KWIKPROOF process.

16. As a result of proof reading, corrections were made directly on the above reproduction negatives, which were then ready for printing.

17. A final colour proof was produced.

Fig. 21: Flow diagram of the production sequence (NGO Oslo)
Geographical Survey of Norway, Oslo
Stereoplotting from 1:18 000 or 1:30 000 imagery and scribing at 1:25 000



At Norges Geografiske Oppmåling the usual map revision work concerns almost exclusively the scale 1:50 000. The main purpose of the field reconnaissance, made after the plotting, is the classification of roads and buildings.

Appendix: Deep etch positive process used by NGO:

The scribe coat sheet is coated with a deep etch positive sensitizer solution in a plate whirler and then exposed and developed with conventional deep etch developer. The sheet is transferred to a light table and an etching solution is spread over the sheet until etching action is completed. The solution is squeezed from the sheet and this is immediately washed under running water to stop the solvent action and removal of the stencil.

The etching solution consists of 48,5% Methyl Alcohol, 3,0% Potassium Hydroxide and 48,5% Ethylene Glycol Monobutyl Ether.

4.3 Sequence of procedures applied by the National Board of Survey of Finland in Helsinki (NBS)

Three tests were simultaneously executed by this centre, all of them based on images at the scale 1:30 000:

a) Stereoplotting and draughting
b) Orthophoto interpretation and draughting
c) Plotting with the Stereo Facet Plotter without cartographic procedures

The cartographic processes being identical for a) and b) we will give in the following just one description that includes both of them.

1a) The glass diapositives nos.2336 and 2338 at the scale 1:30 000 were chosen for the stereoplotting.

1b) The glass diapositives nos.1824/26/28/30 at the scale 1:18 000 were copied in contact to negatives.

2b) They were enlarged to the scale 1:10 000 and rectified in the rectifier (ZEISS SEG V) on semimatt paper (Kodabromide W). These pictures were made to facilitate the orthophoto evaluation.

3a) The positive film of the combination of the base map components at 1:25 000 was enlarged in the reproduction camera (KLIMSCH AUTOHORICA) onto film (AGFA-GEVAERT 081 p) to 1:10 000.

4a) From this negative, a contact positive was made in the copy frame (KLIMSCH Tricop) using the same material. From this positive, a dyed up copy was made on ASTRALON V 60 serving as base for the stereoplotting.

5b) The orthophoto was produced by Wild Heerbrugg from pictures nos.2336 and 2338 on the AVIOPLAN OR 1. From the negative at 1:10 000, a contact positive on paper (Agfa-Gevaert Aviophot PPW 12) was produced.

6b) The enlargements were examined by eye or with stereo spectacles and all detected changes marked in colour onto the combination positive overlying the orthophoto.

7a) The stereo model was plotted with a WILD A8 instrument. New elements were plotted in pencil onto the Astralon with the combination copy, and subsequently inked in with ROTRING FOLIOGRAPH pens.

8) From all the other original colour plates, negatives at the scale 1:10 000 were produced in the camera.

9) Contact positives were copied from all of these negatives.

10) On these positives, all deletions were erased with a special knife by reference to the interpretation manuscript.

11) A dyed up positive copy was produced on ASTRALON V60 in the KLIMSCH ROTOR copy frame from the planimetry positive combined with the plotting manuscript.

12) Fair drawing of the new planimetry was executed on this Astralon, fitting to the guide copy of the stereoplot, or to the underlayed orthophoto with assistance from the interpretation manuscript.

13) On the Astralon bearing the drainage, the new items for the blue plate were drawn up in ink.

14) The positive bearing the lakes was then corrected.

15) The fair drawing of the contour lines and hachures was done on the Astralon of the brown plate.

16) The same applied for the outlines of woodland.

17) Finally the area tint for woodland was altered according to the previous draughts.

18) From all 6 corrected colour separation drawings, photographic reductions to the map scale 1:25 000 were made.

19) Wrong-reading contact positives were copied in contact from these negatives, ready for printing.

c) Plotting with the Stereo Facet Plotter OMI

1) The enlargement of the combined-positive film of all map elements was copied on polyester film (OZALID Reprolar).

2) The contact paper copies of photos nos.2336 and 2338 were oriented in the stereo facet plotter.

3) This image was projected by the instrument onto the base map and new items sketched with a ball-point pen on this polyester film at 1:10 000 (fig.22).

4) The cartographic and reproduction processes were not continued for this test.

Fig. 22 : Section of the plotting manuscript 1 : 10 000 produced on the Stereo Facet Plotter

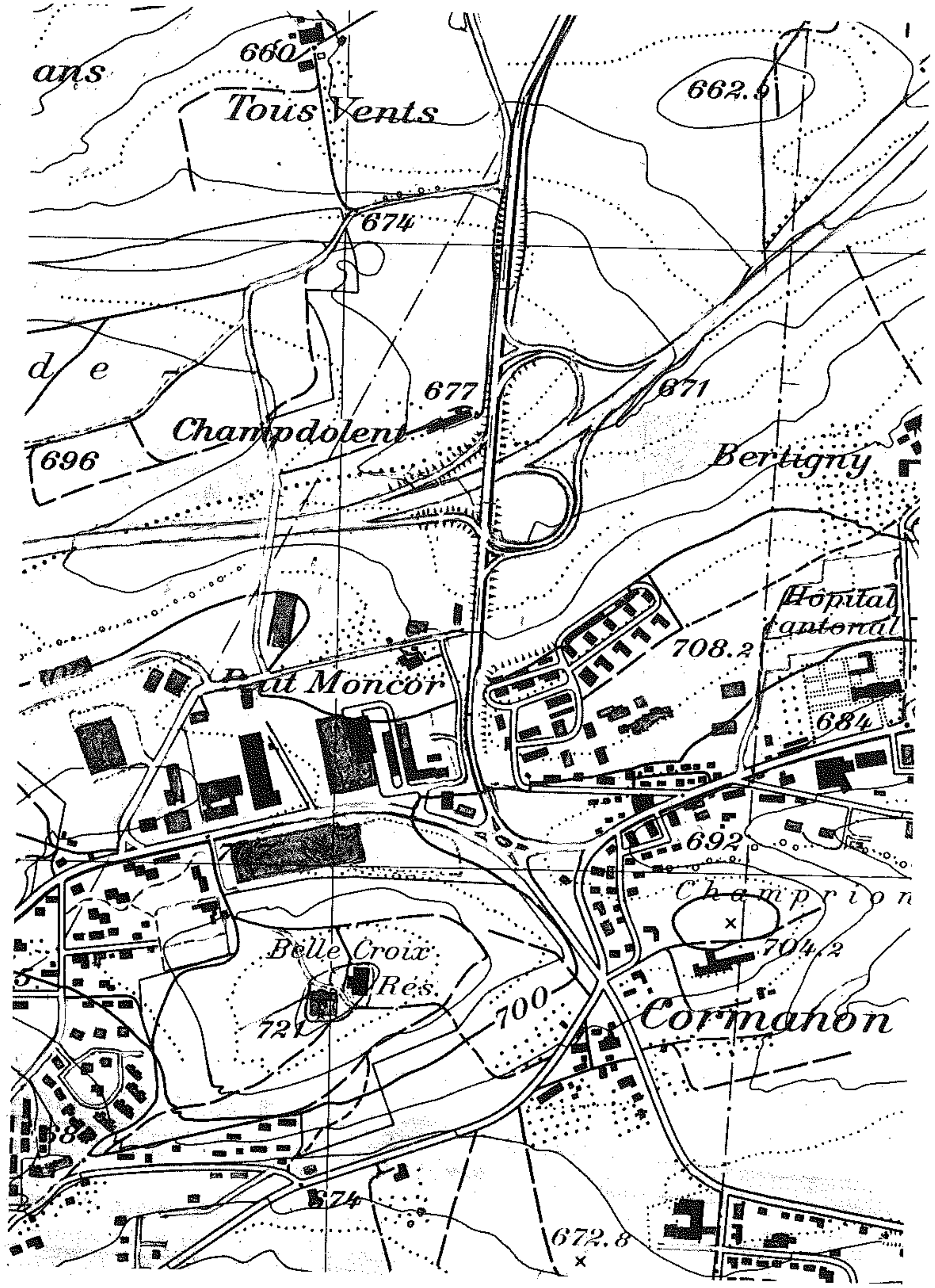


Fig. 23 : Flow diagram of the production sequence (NBS Helsinki)
National Board of Survey, Helsinki, Finland

Orthophoto or stereoplotting and drafting at 1:10 000

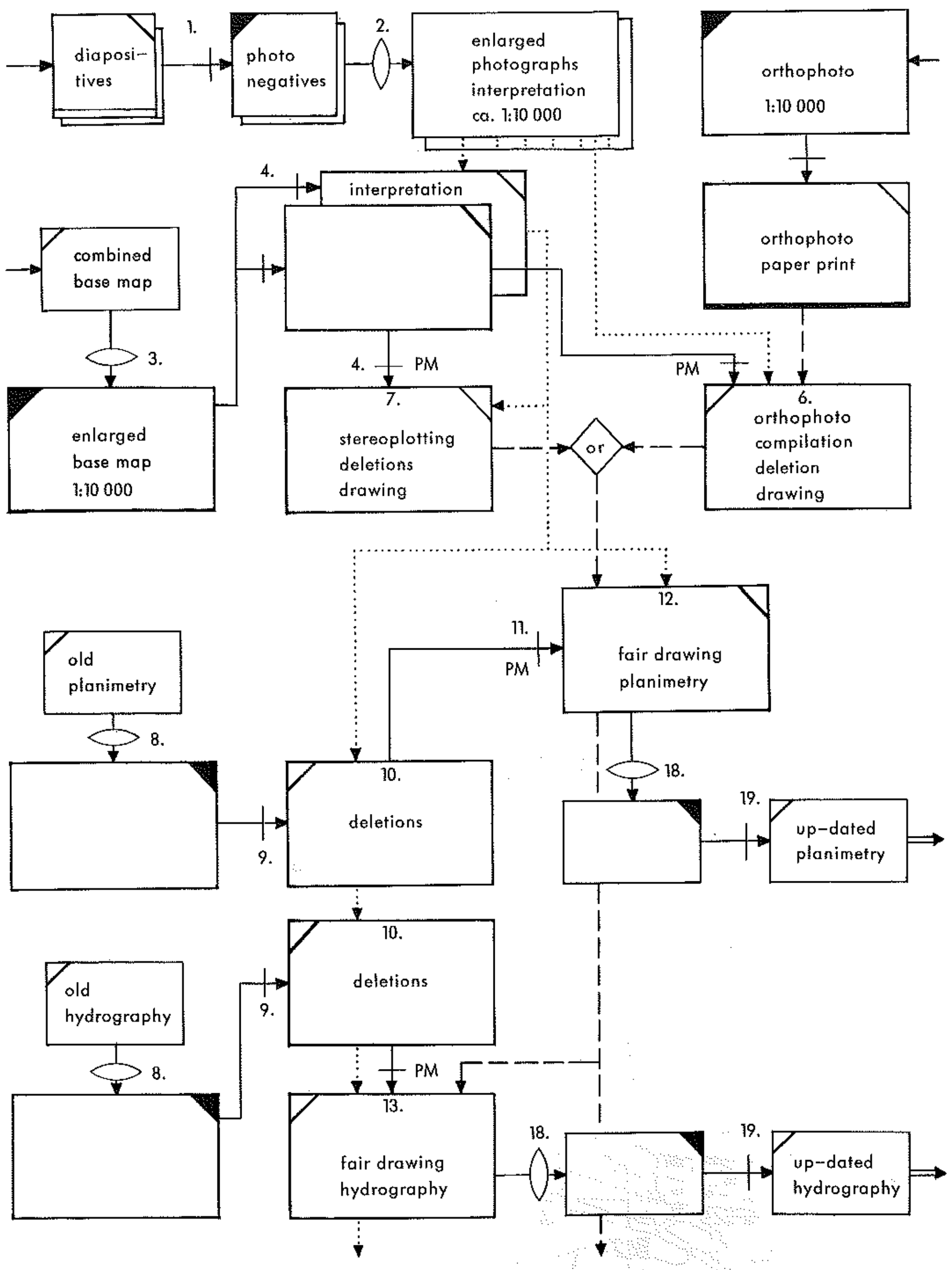
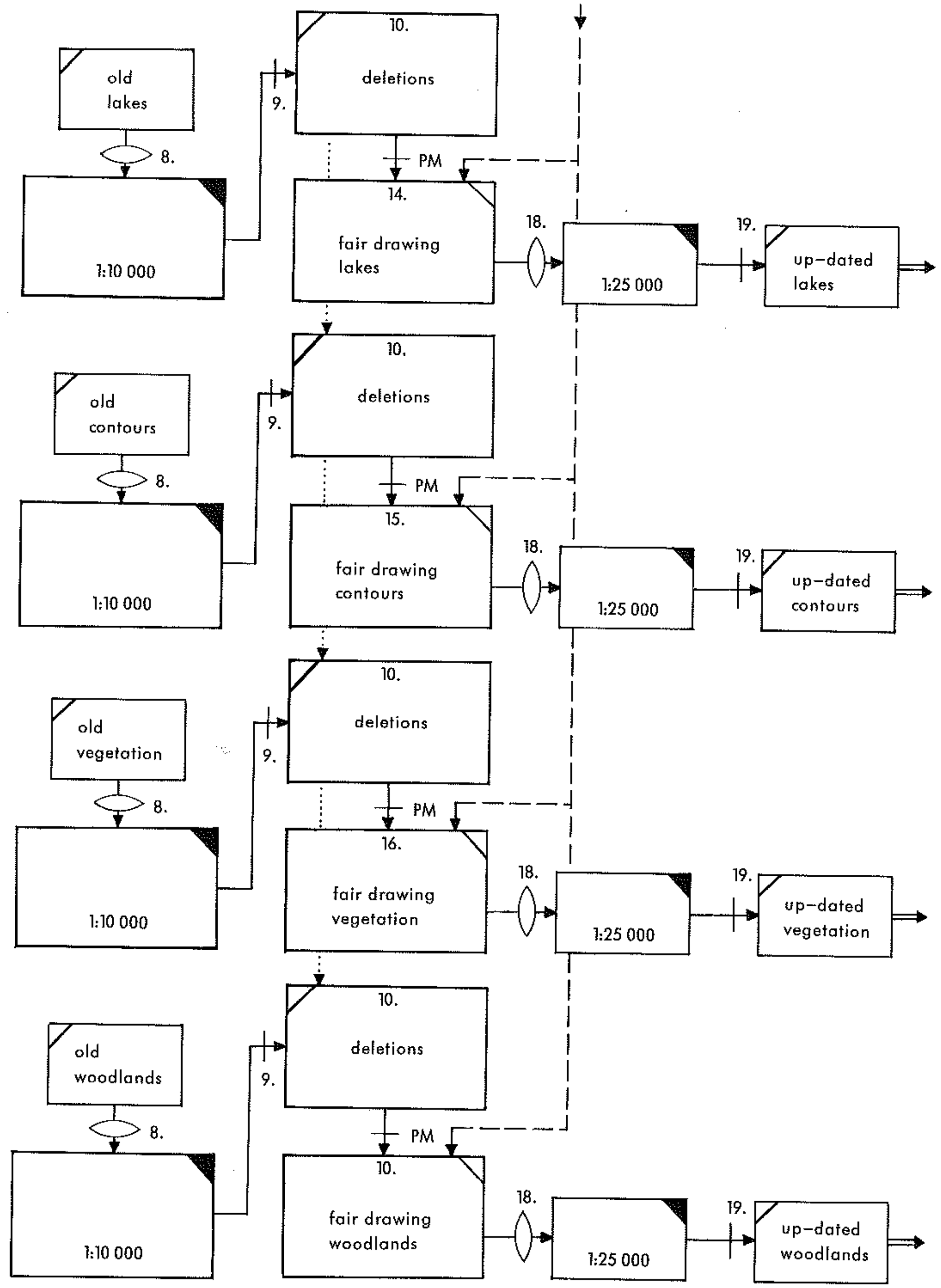


Fig. 23 (continued)



4.4. Sequence of procedures applied by the Land Survey Office Baden-Württemberg in Stuttgart, Federal Republic of Germany (LVA)

In this test, starting from the image scale 1:30 000, the orthophoto method was used in combination with ink draughting at the scale 1:10 000 for the revision of the test base map. The sequence of steps was as follows:

1. For the orthophoto production, negatives of images nos.2335, 2337 and 2339 at the scale 1:30 000 were chosen, with the central picture for the projection. On these negatives, 5 control points (C-points) were identified and marked for registering and checking in the orthophoto-projector.

2. The first model was oriented numerically in the ZEISS PLANIMAT D2 plotter. The model scale chosen was 1:20 000. 6 ground control points were used for the absolute orientation. The remaining discrepancies were of the order of 0,1 mm as a maximum for distances and 0,2 metres and less for elevations.

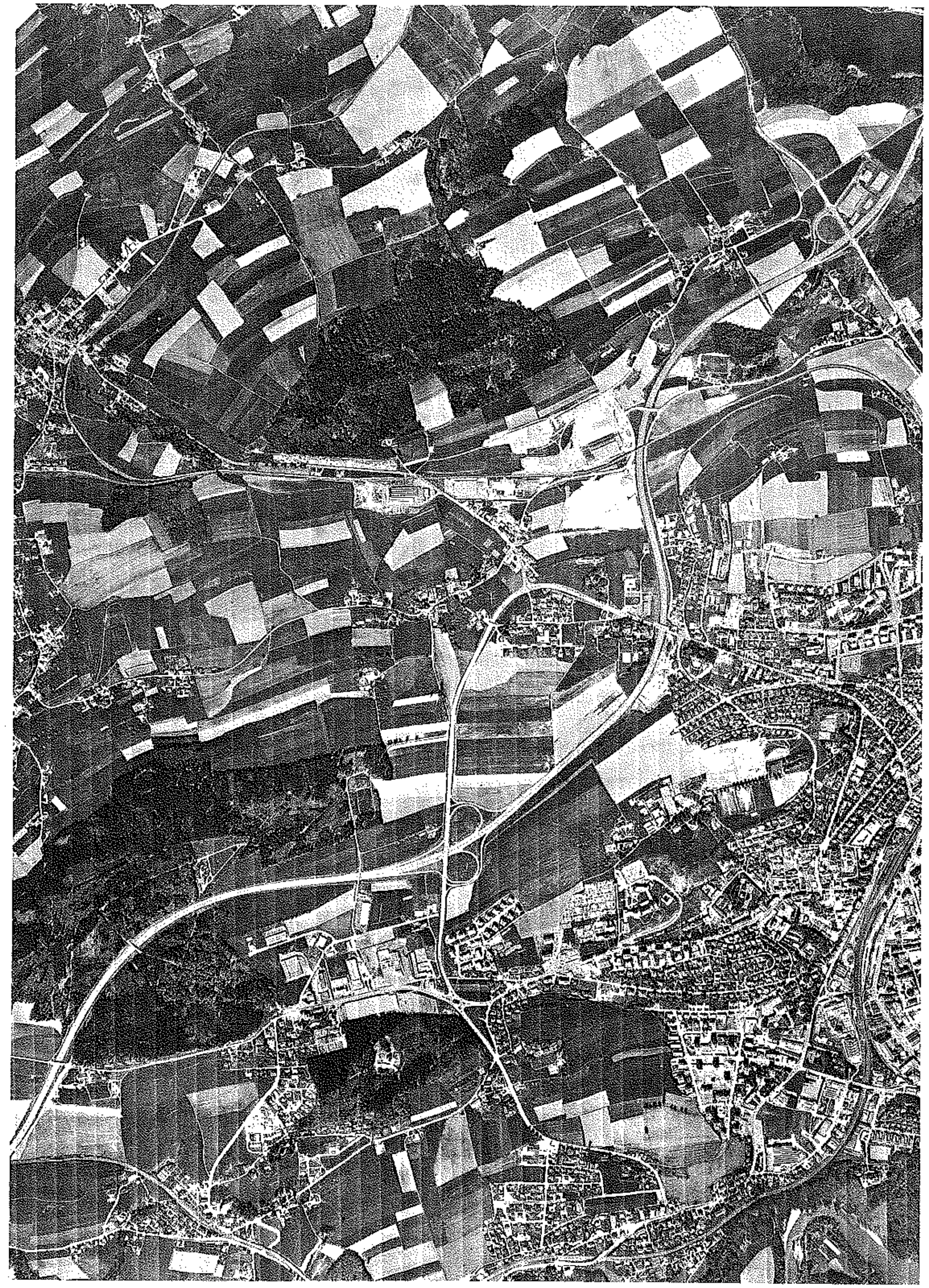
3. Then the ZEISS SG1 storage device was coupled and the profiles for this model scanned with a profile interval of 4 mm and recorded on the GRAVO-Z storage plate.

4. The second model was now oriented to the first, and two additional control points were used for the orientation. The remaining differences were of the same order of magnitude as in the first model.

   This second model was then scanned and stored on the same storage plate. The total scanning time was slightly less than two hours.

5. For the production of the orthophoto positive at the scale 1:10 000, the negative of the central picture was oriented in the orthoprojector ZEISS GZ1, using the determined orientation elements. The coordinates of the 5 C-points were checked and then the LG1 reading device was coupled to the projector. The time for recording the image at 1:10 000 on DU PONT CC S7 film with the corresponding 8 mm slit length was 1 hour 20 minutes, developing and drying of film exclusive. The projection system was equipped with the ZEISS optical interpolator "O-Int" (fig.24).

Fig. 24 : Orthophoto 1 : 10 000 used in the test by the LVA Stuttgart, reduced here to 1 : 25 000



6. A contact negative on photographic film was produced from the original combined base map positive at the scale 1:25 000.

7. This negative was then enlarged in a KLIMSCH SUPER AUTHORIKA KT 101 reproduction camera to the scale 1:10 000 and a right-reading AFGA-HDU film positive produced.

8. This combined image was copied photomechanically and inked-in in blue on the back of a sheet of POKALON, a 0,14 mm polycarbonate film, serving as a guide copy for tracing from the orthophoto. POKALON is used because of its pliability and ease of handling as compared with ASTRALON.

9. Tracing of all new items was done directly as the final fair draught, separately by colour, on the matt side of the POKALON sheet with a blue guide copy for black, on separate overlay sheets of the same material for each of the other colours. Drawing was done with a ROTRING-FOLIOGRAPH reservoir ink pen over a light table. Register marks were drawn on all sheets. The guide copy was fitted to the orthophoto over a light-table. New roads and buildings were identified using the underlying transparent orthophoto, and contact prints of the aerial photographs, (not stereoscopically), and the field identification elements, received from the pilot centre. The new roads and other items were fair drawn. Houses were in part added by the rub-on technique (fig.25).

10. All details to be deleted were opaqued with a STAEDLER LUMOCOLOR red fibretip pen on a separate overlay sheet, used as a hold-out mask later on (fig.26).

11. The fair drawing of all identified new details of the blue plate was done on a separate sheet.

12. Again a corresponding hold-out mask for blue items for deletion was prepared.

13. Independently from the orthophoto production, the same models were oriented once again in the same plotter used for the plotting of heights. Again 1:20 000 was the model scale.

    The changes in topography were carried out, especially in those areas showing considerable changes in planimetry. This is not, however, common practice in the Landesvermessungsamt. Necessary adaptions are normally made after a field check or on the basis of construction plans.

    The new contour lines and hachures, mainly along new roads, were plotted in pencil on a matt POKALON sheet at the scale 1:10 000.

14. On a separate sheet of POKALON all new contour lines were traced from the respective plot and fair drawn in relation to the new planimetry.

15. The hachures were produced with rub-on symbols on a separate sheet.

16. The accompanying hold-out mask for the brown plate was opaqued.

17. The new line and tint elements of the vegetation were drawn on separate sheets of POKALON.

18. The two corresponding hold-out masks were prepared.

19. All fair drawings and hold-out masks at 1:10 000 were reduced in the reproduction camera to wrong-reading AGFA-HDU film negatives at the scale 1:25 000.

20. The negatives of the fair drawings were copied in contact to right-reading film positives of the same make.

21. The hold-out mask negatives were provided with register marks.

22. The original wrong-reading base map positives were copied in contact as right-reading positives on 0,25 mm ASTRALON sheets by the FOS-process, with a second exposure with the above hold-out negatives before development and dyeing up in black.

23. On this base, the right-reading film positives at 1:25 000 of the new details were mounted on a sheet of ASTRALON, clear on both sides, and provided with register marks. (It can be necessary to cut and mount the films in pieces in order to provide a better match to the existing map base). Following this, each mounted sheet assembly was copied in contact on 0,25 mm ASTRALON by the photomechanical FOS-process, resulting in wrong-reading ASTRALONS with the new details.

24. Each of the dyed-up ASTRALONS (22) was coated once more and exposed with the corresponding positive of the new details. These second FOS-copies were dyed-up in red.

25. The remaining map elements in black and new ones in red were matched on these ASTRALONS by retouching with ROTRING plastic ink and fine drawing pens. The contrast colours black and red facilitate matching old and new elements.

Fig. 25: Section of the final fair draught at 1:10 000 on a blue guide copy of the base map (LVA Stuttgart)

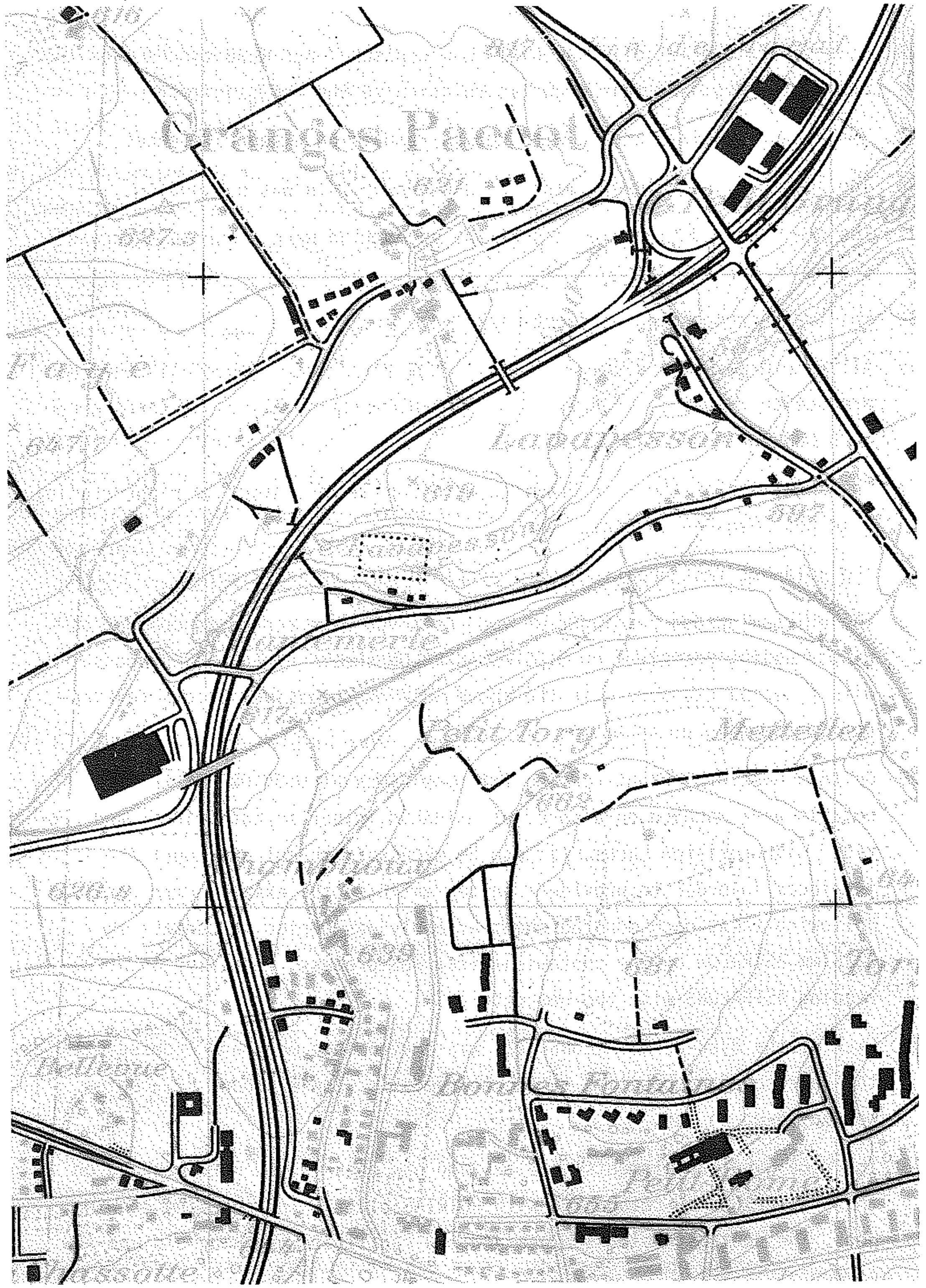
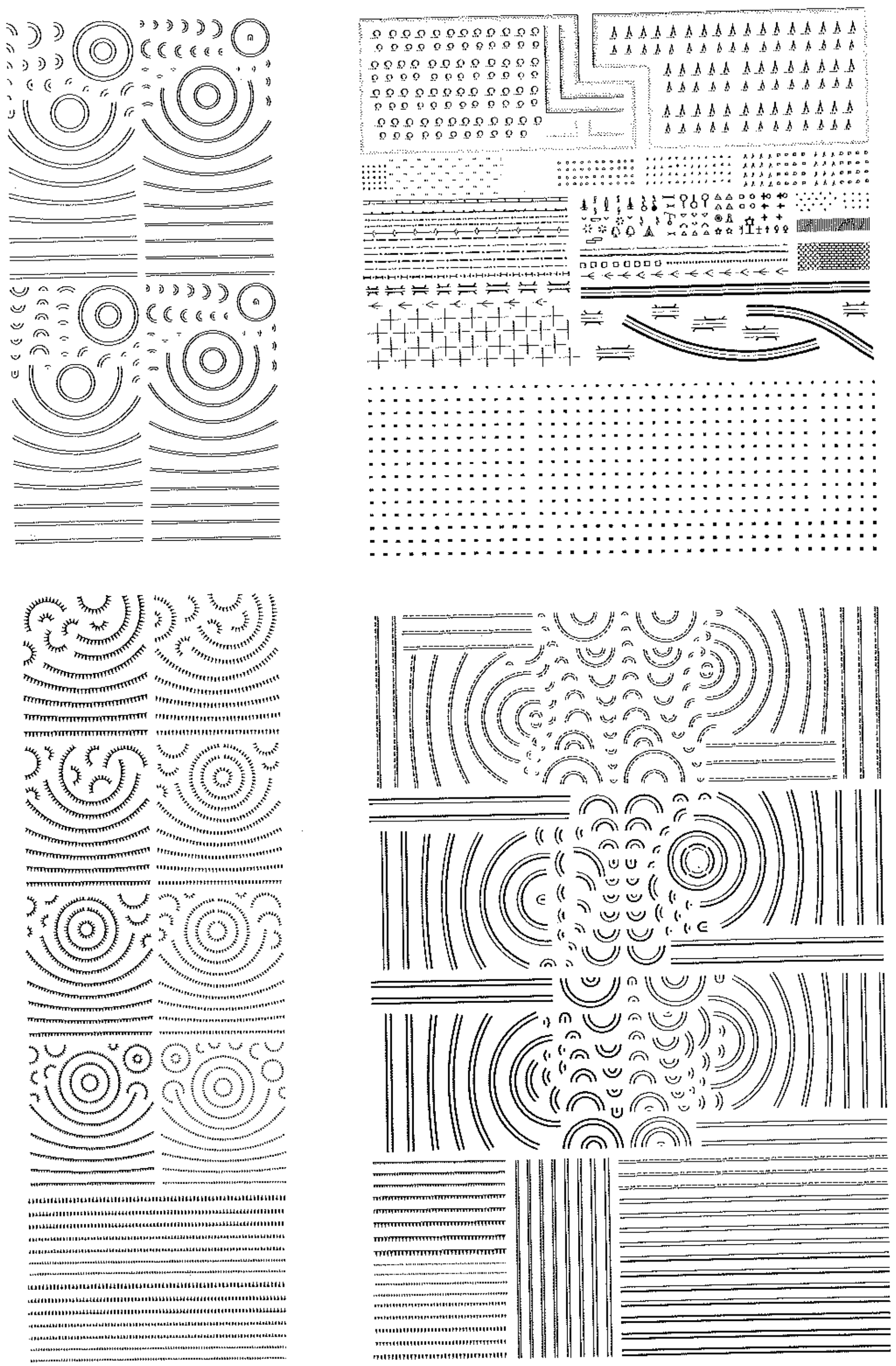


Fig. 26: Corresponding section of the hold-out mask for all details to be deleted (LVA-Stuttgart)

Fig. 28 : Rub-on symbols used in draughting at the scale 1 : 10 000, reduced here to the publication scale 1 : 25 000



26. A multi-colour FOS-copy with each plate in its corresponding colour was prepared from the two-colour ASTRALONS.

27. This proof copy was used for checking. Corrections were made on the final ASTRALONS, ready for printing after reversal to wrong-reading positives.

In common practice stages 6 and 7 are unnecessary, because there is always an enlargement of the combined base map at the scale 1:10 000 on hand. Tracing from the orthophoto is carried out with the help of photo enlargements at the scale 1:10 000. These enlargements bear the results of a preceding field-investigation of in particular road classification; embankments; special house types; hydrography; high-tension lines and recently afforested areas. Pen drawing rather than scribing from orthophotos has been implemented in current practice in order to split up the entire workload between several draughtsmen, without the need of photogrammetric equipment, and because in line drawing it is easier to adapt line widths to the minor irregularities occuring in the basic line image as a result of repeated reproduction through time.

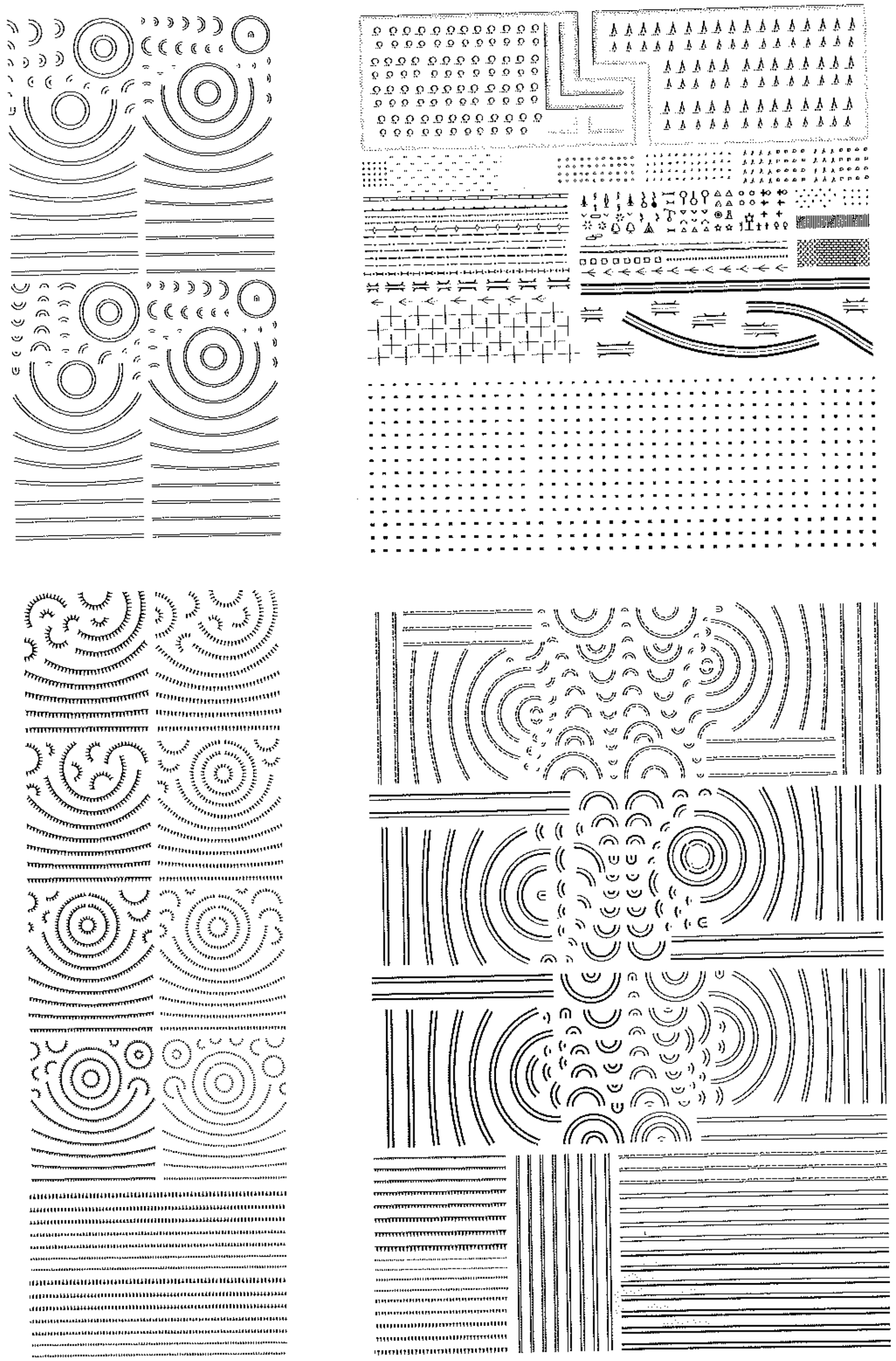
Also in normal practice, the Landesvermessungsamt uses only two sheets in current revision of the 1:25 000 maps, namely

- the blue guide copy with changes in the blue plate in red and all other new planimetric details in black (vegetation symbols also are black in the German 1:25 000 topographic map)
- and one hold-out mask for all planimetric elements in red.

Corrections of contour lines and hydrography are normally drawn in the original colour separation plates 1:25 000, so the reproduction processes normally comprise only the first block of those used for the test and shown in the following flow diagram. For the fair drawing, the rub-on-technique is more widely used, because most symbols, including double line roads, are available on a special ALFAC rub-on sheet. Therefore the time needed for drawing is reduced in normal practice considerably.

Fig.28 is an illustration of the rub-on symbols used at 1:10 000, but reduced there to 1:25 000.

Fig. 28 : Rub-on symbols used in draughting at the scale 1 : 10 000, reduced here to the publication scale 1 : 25 000



26. A multi-colour FOS-copy with each plate in its corresponding colour was prepared from the two-colour ASTRALONS.

27. This proof copy was used for checking. Corrections were made on the final ASTRALONS, ready for printing after reversal to wrong-reading positives.

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Fig.28 is an illustration of the rub-on symbols used at 1:10 000, but reduced there to 1:25 000.

Fig. 27 : Land Survey Office Baden-Württemberg, Stuttgart FRG
State Survey of Baden-Würtemberg, Stuttgart, FRG
Orthophoto production and draughting at 1:10 000

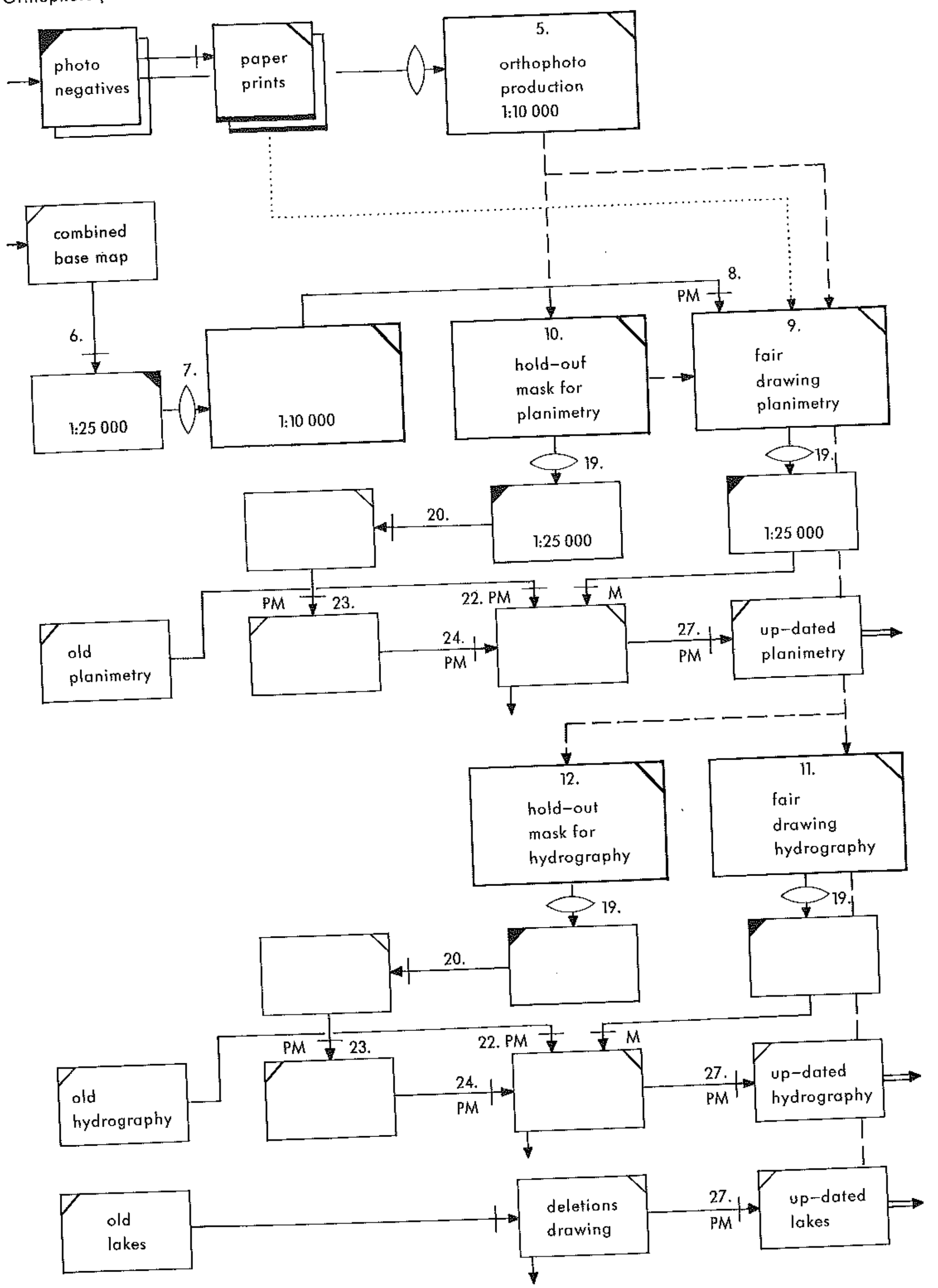
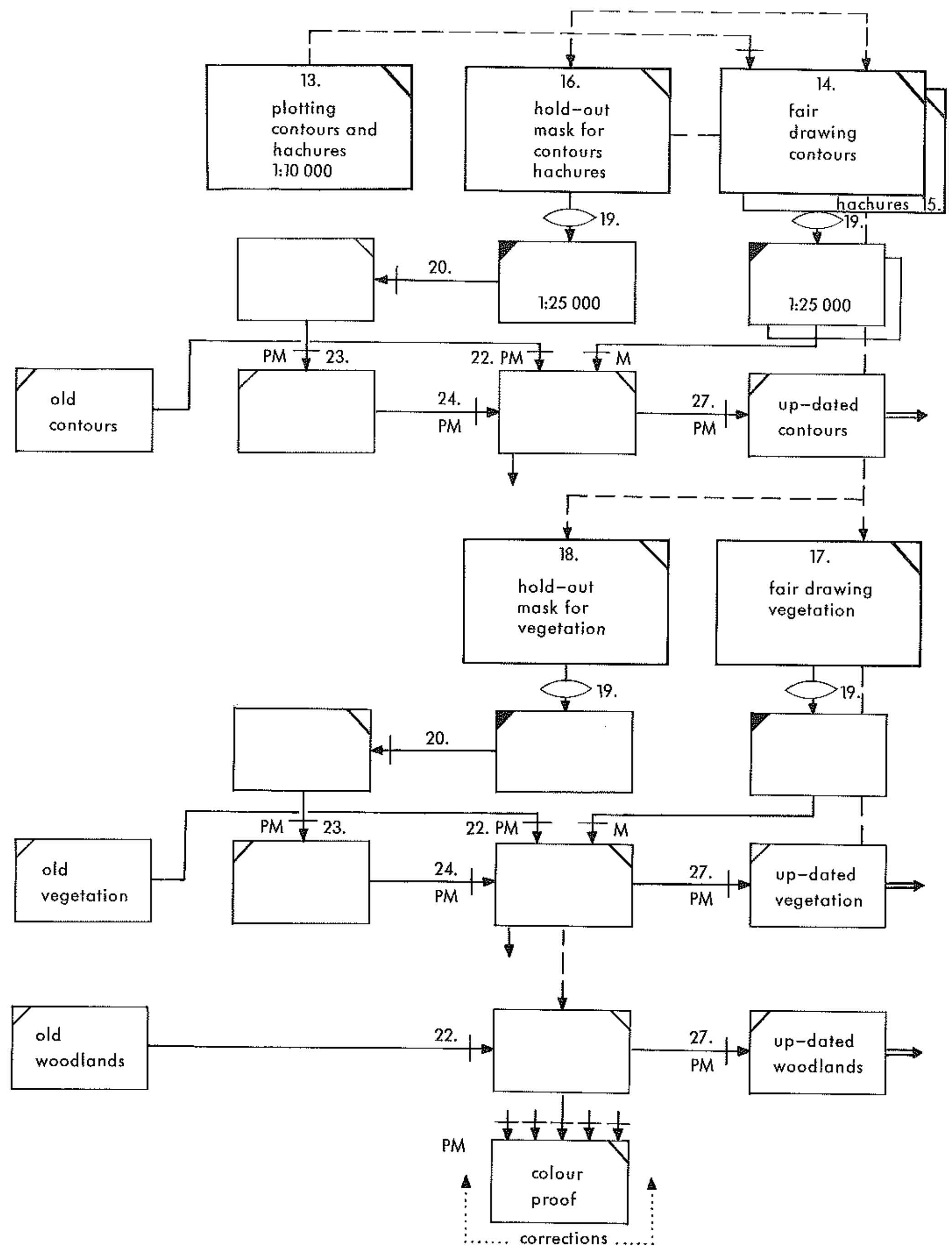


Fig. 27 (continued)



4.5 Sequence of procedures applied by the Institute for Applied Geodesy in Frankfurt a.M., Federal Republic of Germany (IfAG)

A flow diagram of the different steps is given in figure 30. The image scale 1:30 000 was used as the base for revision work. An orthophoto at the scale 1:10 000 was prepared on the AVIOPLAN OR-1 by the WILD company in Heerbrugg. The model 2336/38 was oriented with the same control points received by other participants. The image used for image projection was photograph no.2336. The scanned profiles were stored on magnetic tape and only used for the scanning process; this data is therefore no longer available. Scanning was performed with a slit aperture of 3 mm at an orthophoto scale of 1:10 000. The participant obtained a right-reading continuous-tone photographic film positive at the same scale. The subsequent production steps are as follows:

1. A right-reading halftone film was copied in contact from the orthophoto continuous-tone film.
2. The film, with the combined base map and the one with planimetry, were enlarged in a KLIMSCH COMMODORE reproduction camera to the scale 1:10 000.
3. From the wrong-reading negative (combined base map) and the right-reading negative (planimetry), wrong-reading positives were contact printed on photographic film.
4. On an ASTRALON sheet, a right-reading guide copy in two blue tones was prepared by photomechanical process from the two following positives:
   - the screened orthophoto in a medium blue tone
   - the combined base map as a line image in a blueish-green
5. On this draught manuscript, all changes were sketched up in ink on a light-table using the photographic prints and a mirror stereoscope. A wrong-reading contact negative of this drawing was then prepared. All details to be deleted were erased with scraper from a contact positive of the enlarged planimetry.
6. A guide copy was applied onto a sheet of STABILENE rust scribe coat by diazo and comprised the two following images:
   - a copy of the draught manuscript in black
   - a copy of the remaining details in dark brown

   On this scribe sheet, all new planimetric details were scribed. A wrong-reading positive was copied from this negative and retouched.

7. The positive of the revised planimetry was mounted on the positive with the new detail and reduced in the camera to the scale 1:25 000, giving a right-reading positive.
8. This positive was reversed to wrong-reading ready for printing.
9. All contour lines and hachures were plotted from images 2336/38 on a ZEISS PLANIMAT. The model was numerically oriented; calculations being made on an OLIVETTI 601.

   Plotting was done in pencil on 2 SAPHIR-draughting films at the scale 1:20 000. The manuscript was also subsequently fair drawn in pencil (fig.29).
10. From the contour and from the hachure manuscripts, enlarged negatives at 1:10 000 scale were produced in the camera on photographic film.
11. The negative bearing the hachures was overlayed by a red scribe coat on which all new slopes were scribed at 1:10 000.
12. This scribed negative was reduced in the camera to a right-reading positive at the scale 1:25 000 and reversed by contact to a negative.
13. From the other original map elements, namely
    - hydrography
    - lakes
    - vegetation and
    - woodland

    right-reading contact positives were made on photographic film.
14. On these bases, the necessary deletions were scraped away and the few new items inked in. From these positives, wrong-reading negatives were printed on film.
15. The negatives of the remaining and the new topographic linework were combined by successive exposure giving a contact positive.
16. All the other negatives were reversed to right-reading positives.
17. After a final reversal to wrong-reading positives by contact, the films were ready for the preparation of a proof copy. The CROMALIN process was adopted for this purpose and the colour combination used for proof-reading. Corrections were made directly on the final positives, which were then ready for printing.

Fig. 30 : Flow diagram of the production sequence (IfAG Frankfurt)
Institute for Applied Geodesy, Frankfurt/M, FRG
Orthophoto 1:10 000 and scribing at 1:10 000

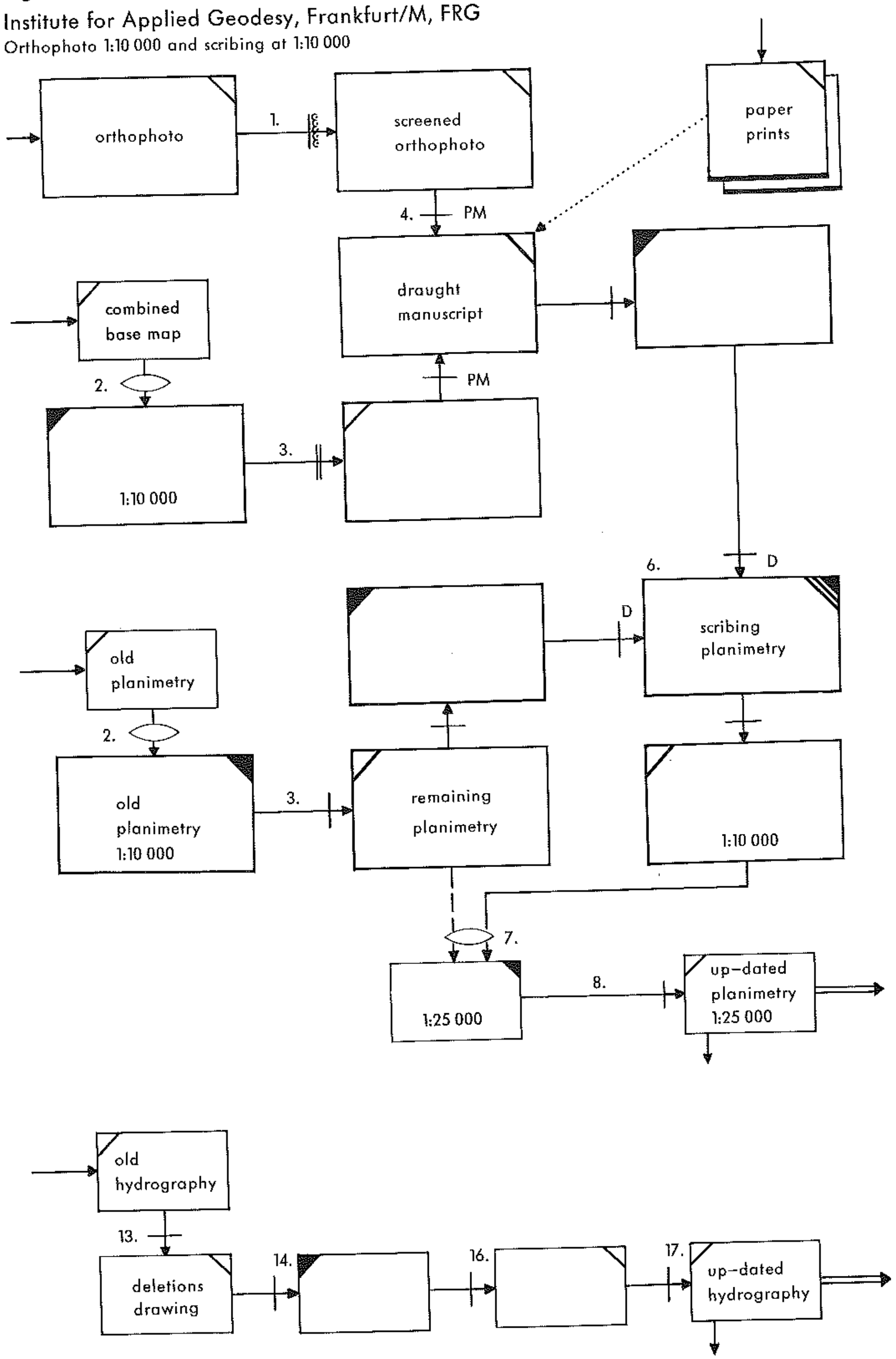
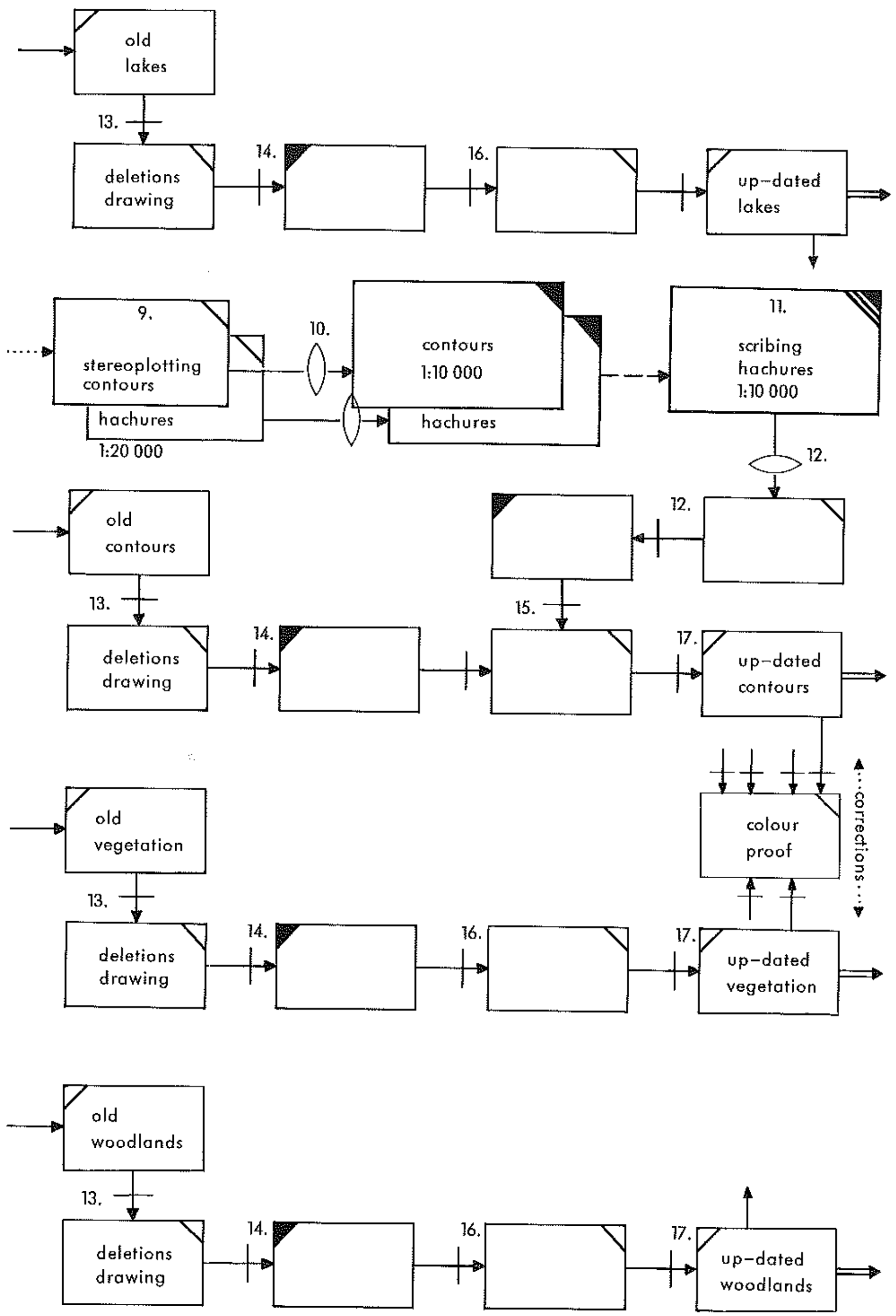
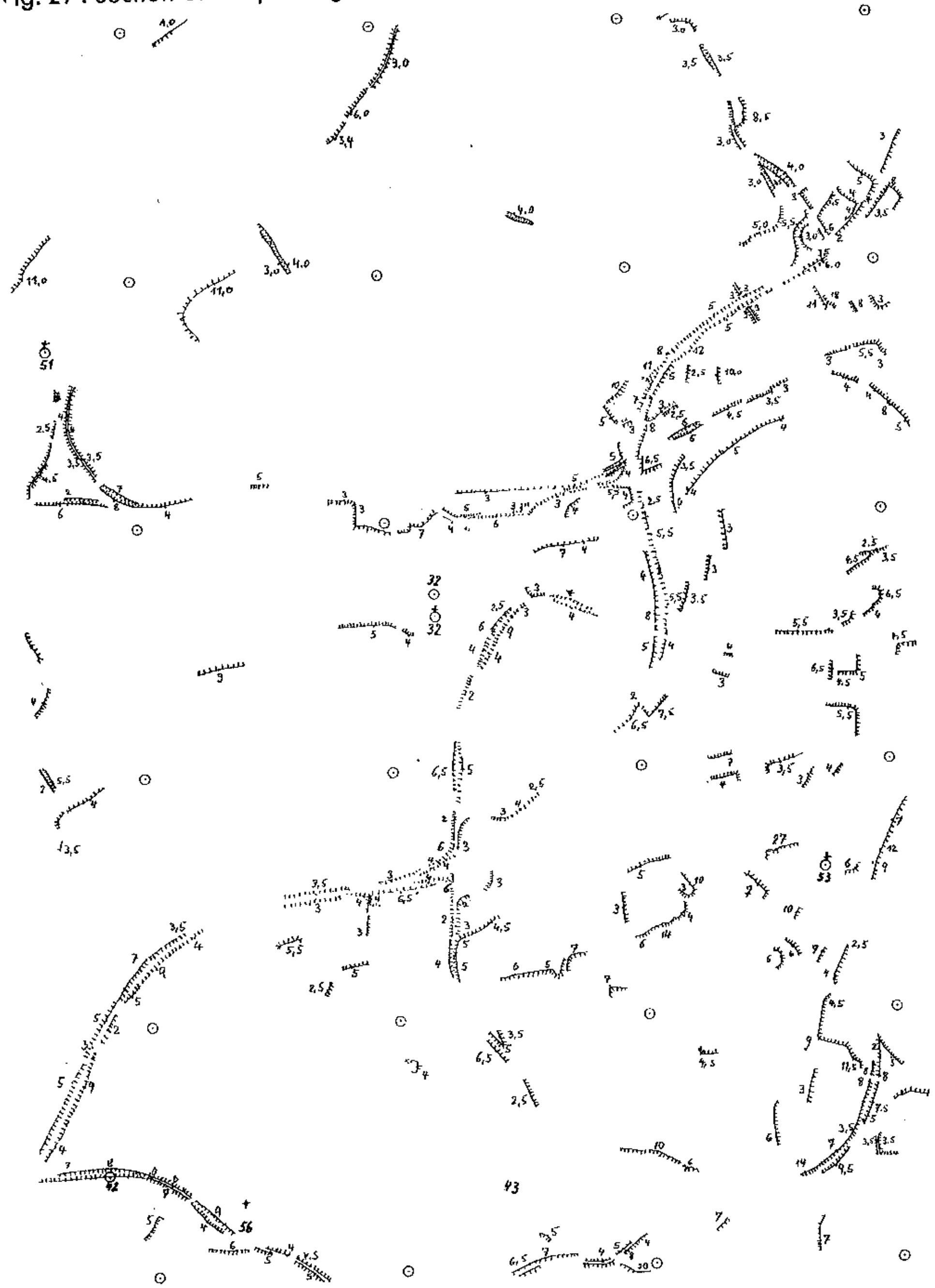


Fig. 30 (continued)



The participants from the IfAG emphasise that they have no practical experience with topographic line maps at the scale 1:25 000, their main activity being in **small-scale mapping.**

Fig. 29 : Section of the plotting manuscript for slope hachures (IfAG Frankfurt)



4.6. Sequence of procedures applied by the Topographic Service of the Netherlands in Delft (TD)

This centre applied the orthophoto method for the revision of the test base map, using photographs 2336 and 2338 at the image scale 1:30 000. The different steps were as follows:

1. From the two original aerial diapositives, continuous-tone contact negatives were produced by exposing AGFA GEVAERT N-31 P film in a vacuum frame.

2. From the above negatives at 1:30 000, enlargements were made on photo paper to the scale 1:10 000 in a DURST-LABORATOR photoenlarger. Each enlargement was cut into 4 parts, this base being used for photointerpretation.

3. On each of the seven original base map colour-separation films, register marks were plotted in the 4 corners of the test area with a HAAG-STREIT coordinatograph.

4. From these original 1:25 000 films, enlargements were made to 1:15 000 in a KLIMSCH COMMODORE reproduction camera, on KODALITH film, producing wrong-reading negatives.

5. Using the coordinatograph, the register crosses at the corners of the test area were plotted at 1:15 000 on polyester mounting film.

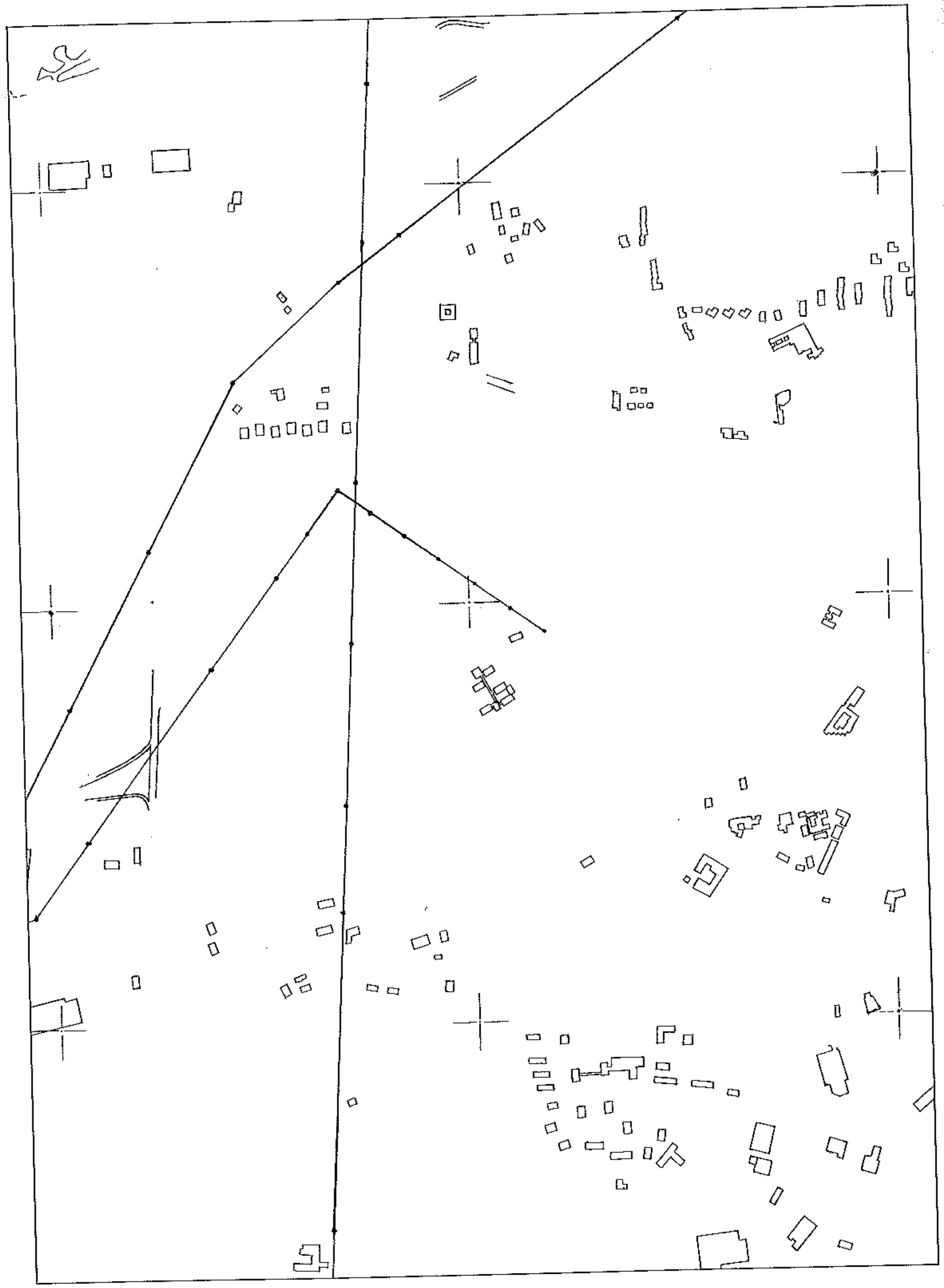
6. This film and all the negatives at the scale 1:15 000 were punched simultaneously on a punching machine of house design.

7. Photo-interpretation was carried out with a mirror stereoscope WILD ST-4 with a 4x magnification on the enlargements of the original aerial photographs. New details were marked on the photos, the obsolete details being marked on a special "delete model", a paper contact copy of the negative with the combined base map.

8. Four artificial points were marked with the point transfer device WILD PUG on aerial negative no.2336. These would subsequently be used to bring the orthophoto into exact register with the colour-separated films.

9. For the photogrammetric stereoplotting (contours only) a WILD A8 instrument with a coordinate recording device EK5a was used. The model 2336/38 was oriented and levelled with the help of 6 spot heights at road junctions derived from the initial base map 1:25 000 and given in metres. The remaining discrepancies in height were no larger than 0,5 mm . The model

Fig. 31: Plotting manuscript with high buildings and viaducts (TD Delft)



scale chosen was 1:20 000.

10. The model coordinates of the four marked pass points and of 5 non-signalised trigonometric points were registered.

11. Originally 12 terrain points with good visibility on both map and photograph were selected. Rectangular national coordinates of these points were derived from the combined base map positive, using the precision coordinatograph. These 12 points were measured with the A8. However, the results from the transformation of the model coordinates showed, on average, discrepancies of ± 4 metres. Because this was considered unacceptable, 5 non-signalised control points were finally used for the transformation of model coordinates to national coordinates. The mean of the remaining discrepancies was reduced in this way to ± 0,46 metres. These calculations were made on an OLIVETTI desk computer. In this manner the x-, y-coordinates of the 4 pass points were determined.

12. Now absolute orientation was accomplished.

13. The 40 spot heights requested for the test were registered.

14. The wrong-reading orthophoto positive was produced on the A8 with the orthophoto device PPO-8. Scanning was done at variable speed with the minimum slit length available of 4 mm. The film positive was simultaneously produced at the scale 1:15 000. An optical interpolation between adjacent scanning strips was not possible. This resulted in fairly large discrepancies between the strips in some areas. The panchromatic film used, GEVAERT P-23p, was given 5 minute development in G-5c developer.

15. From the original contour line negative, a CRONAFLEX contact positive was produced in the vacuum frame.

16. This film positive was contact-copied by diazo onto a pre-punched STABILENE no.45-3047 yellow scribe coat as guide copy for the plotting of the new contours.

17. The new contour lines were plotted in pencil on the drawing table of the A8 on this scribe coat, and sections to be deleted from the contour plate were marked.

18. Some high buildings and viaducts were plotted at 1:15 000 with pencil on a sheet of ASTRAFOIL (fig.31).

19. From this sheet a KODALITH contact negative was produced in the vacuum frame.

20. The 4 pass points were plotted with the coordinatograph on a pre-punched mounting sheet at 1:15 000.

21. The orthophoto positive was mounted on this sheet using the 4 pass points.

22. The 1:15 000 colour separation negatives were opaqued on a light table with reference to the deletion key and new contour plot.

23. The combined guide copy printed in contact by diazo onto a STABILENE scribe coat comprised (fig.32):

    - a positive image of the orthophoto in black plus additional exposures from
    -- the opaqued negative of the remaining planimetry
    -- and the negative containing the new high buildings,

    leaving yellow lines in the orthophoto image.

24. The new planimetric detail was scribed on this sheet, fitted to the remaining parts of the black plate, with constant reference to the photo-interpretation manuscript.

25. Another pre-punched scribe coat was then prepared with the following guide copy:

    - a positive image of the orthophoto positive with additional exposures from negatives of
    -- the scribed new planimetry
    -- the remaining planimetry
    -- the opaqued blue line image,

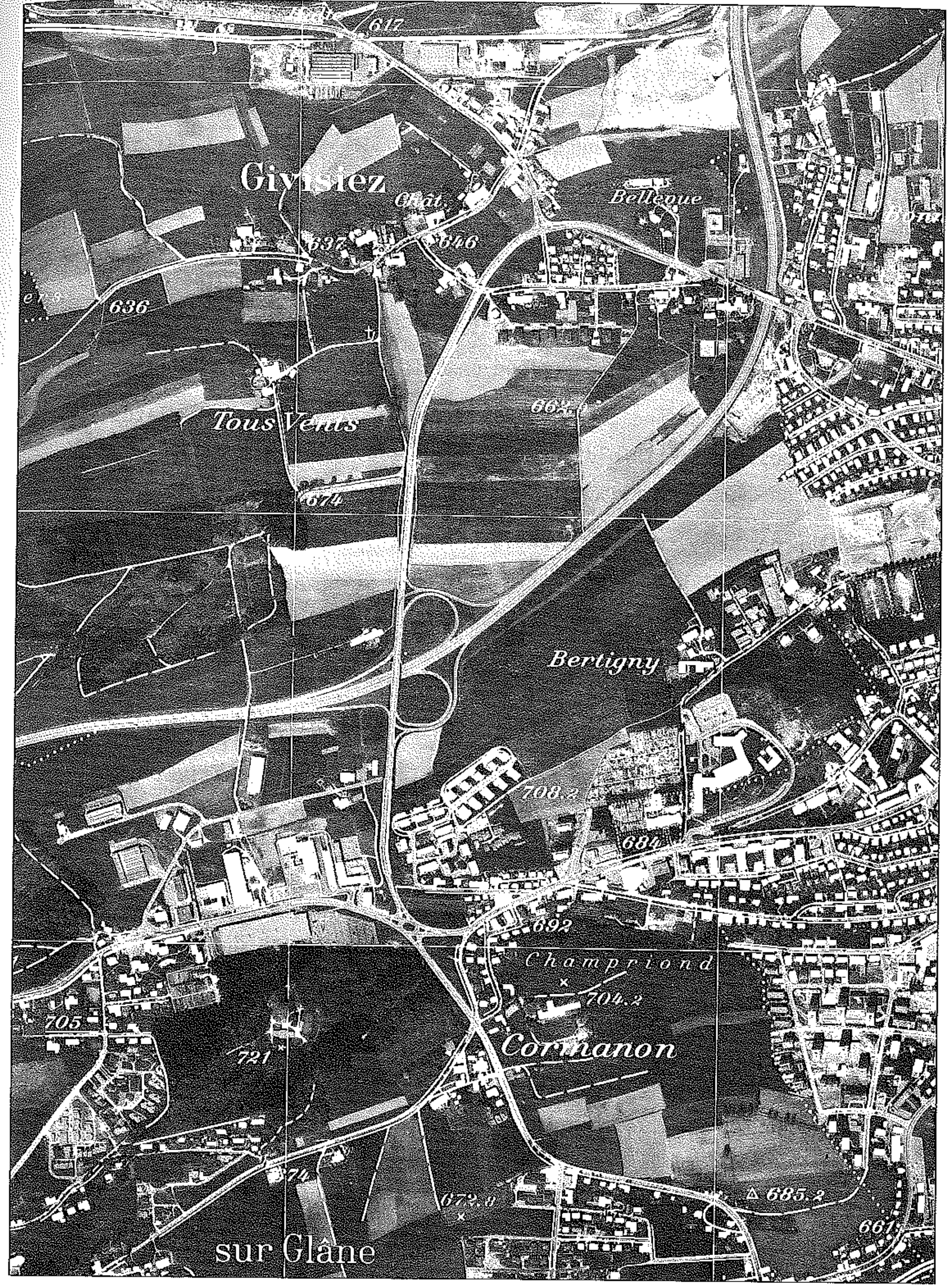
    leaving yellow lines in the orthophoto image.

26. On this sheet, the new blue lines were scribed, fitted to the remaining blue lines and to all elements of the black plate.

27. A further pre-punched scribe coat was produced with a guide copy of

    - the orthophoto positive with additional exposures from the negatives of
    -- the scribed new planimetric detail
    -- the remaining planimetry
    -- the scribed new blue lines

Fig. 32 : Principle of the guide image copied onto the scribe coat (TD Delft)



-- the remaining blue lines

-- the remaining green lines

28. On this base, the new vegetation elements of the green line plate were scribed in register with all black and blue lines and with reference to the photointerpretation manuscript.

29. The new contour lines, plotted in pencil on a sheet of scribe coat, were then scribed.

30. On the next pre-punched scribe coat, with the orthophoto guide copy, additional exposures were made with all line drawings already prepared.

31. The new slope-hachures were scribed on this sheet.

32. For the black, blue and green line and the brown contour line plates, combined positives with old and new elements at the scale 1:15 000 were produced on CRONAFLEX film.

33. A first proof copy to control register and completeness was prepared on a KROMEKOTE sheet using the DU PONT CROMALIN process.

34. This copy served for proof reading.

35. As a result, corrections were made where necessary to all final components.

36. The corrected negatives were contact-copied onto CRONAFLEX film.

37. These positives were used to prepare combined CROMALIN positives on KROMEKOTE with remaining elements in black and new ones in red.

    These two steps are superfluous in normal practice.

38. Wrong-reading combined negatives of the black, blue, green and brown lines were copied on KODAK DUPLICATING film at the scale 1:15 000.

39. These negatives were finally reduced to 1:25 000 in the reproduction camera, giving wrong-reading positives on CRONAFLEX film ready for printing.

40. In this case, due to the very small number of changes required, the two tint plates for woodland and lakes were corrected directly on the original base map films. In Delft, the normal practice is to make new strip masks for tint plates in map-revision work. The time requirement for the revision of old plates has been shown to be almost the same as that required in the preparation of new peel coats.

41. A full CROMALIN colour proof was made on KROMEKOTE from all final positives.

Scribing has been carried out in this test at the scale 1:15 000 for the following reasons: to attain higher accuracy; for the convenience of easier scribing at the larger scale; and because the scale 1:25 000 is rather small to determine all necessary details in the orthophoto.

In the current revision procedure of the Topographic Service in Delft the monochrome photogrammetric base map at 1:12 500 is revised first, using orthophotos and rectified photographs. The multicoloured maps at 1:25 000 are thereafter revised on this base.

Fig. 33 : Flow diagram of the production sequence (TD Delft)
Topographic Service of the Netherland, Delft
Orthophoto production and scribing at 1:15 000

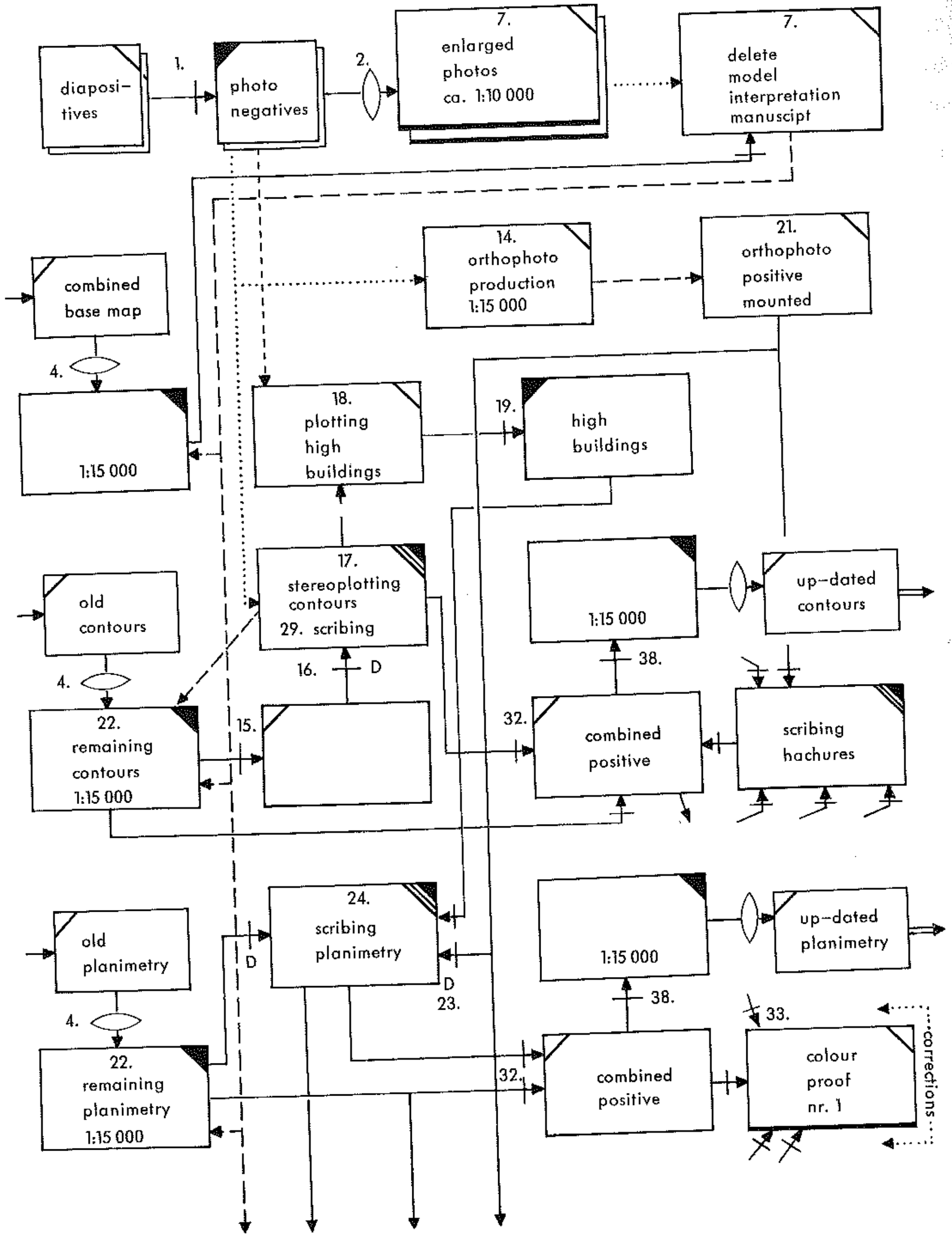
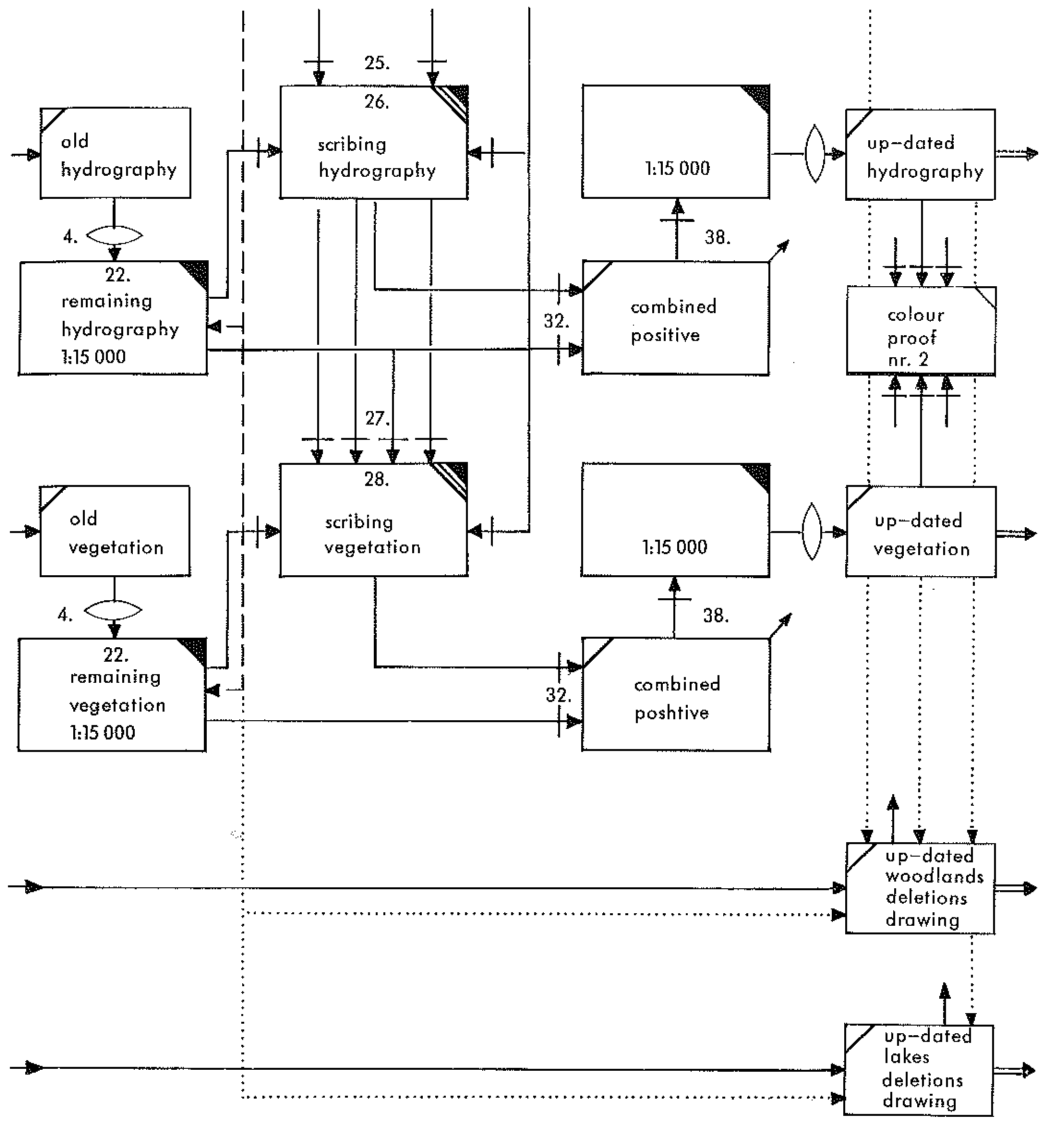


Fig. 33 (continued)



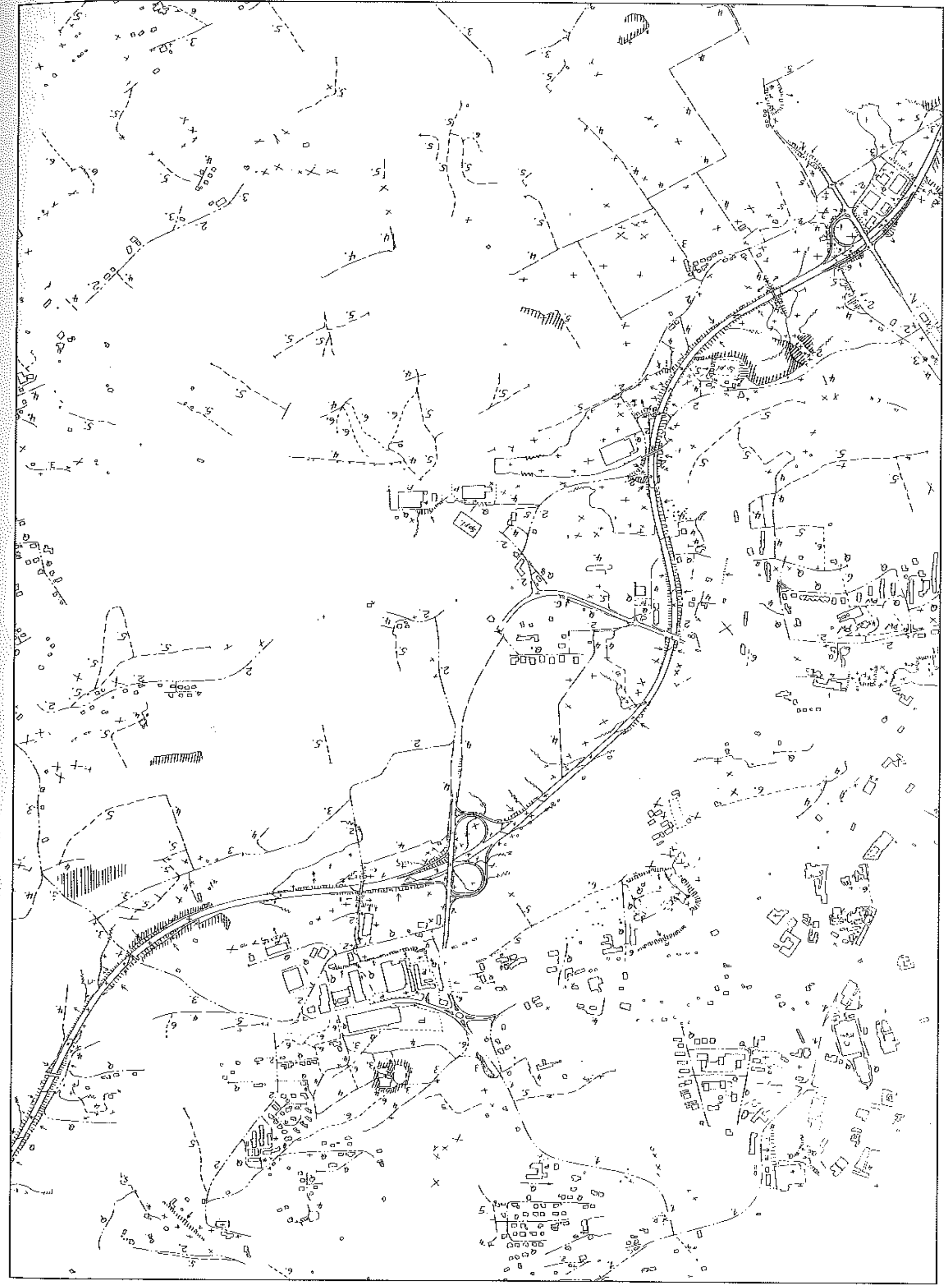
4.7 Sequence of procedures applied by the Federal Office of Topography in Wabern, Switzerland (LT)

This centre had already finished its total revision work for this map with images from 1975, when new photographs were flown in 1976 for this test. Therefore it seemed inappropriate to undergo the whole procedure once more a year later. The statistical data of the complete 1975 map revision serves as a basis for comparisons.

However, another stereorestitution was carried out with the 1976 imagery, but no cartographic procedures were followed. This description therefore gives details of the production sequence for the revised map of 1975. It pays attention to the restricted conditions of the test. All processes that are to do with lettering are therefore ommitted.

1. A glass negative of the combined base map was copied by diazo process in contact onto a lacquered glass plate. Then the plate was covered with a transparent red scribe coat. Register marks and church towers were plotted on the coordinatograph.
2. The two images nos.2337 and 2338 with 80% overlap were oriented in the stereoplotter (WILD A8). All new detail was plotted by direct scribing on the scribe-coated glass mentioned above. No pre-interpretation was made, but the identification of new details and of those to be deleted was facilitated by a device that projects optically the map image to be revised into the visual field of the operator. This allows a continuous check on the progress of work and on the accuracy of base map details.
3. From this scribe coat a wrong-reading negative was photomechanically copied on glass and a wrong-reading positive on photographic film (fig.34).
4. This plotting manuscript positive was copied and dyed up in a light red onto a glass plate with the combined base map in blue. Normally this plate is used first for the placing of new names. Then all planimetric details to be deleted were opaqued with ink on this combination.
5. This image was then photomechanically copied onto a coated glass plate prepared in house. After etching, the negative was not dyed up, but used directly as a hold-out mask in the next step.
6. The plotting manuscript negative on glass was copied by diazo process in dark grey on a lacquered glass plate. In a second step, the combined base

Fig. 34 : Plotting manuscript scribed at 1: 25 000 (LT Wabern)



map negative was copied onto the plate in a light grey, and in a third stage, the plate coated with a green scribe coat. The old planimetry positive was then photomechanically copied onto this coat. Before etching it into the coat, a second exposure was made with the above hold-out mask (5). This way those elements to be deleted were hardened in the light-sensitive coat and therefore not etched.

7. Into this scribe coat, the new planimetric details were scribed.

8. This scribed image was then reversed to a wrong-reading negative on glass that served as a guide for the other scribe coats.

9. The few details to be deleted on the blue plate were erased on the glass positive of the hydrography, before a negative was produced.

10. On another glass plate, the negative of the up-dated planimetry was then copied in black, the plotting manuscript negative in a dark grey and the combined base map in a light grey. These copies were then covered with a green scribe coat. The old hydrography was etched into this coat.

11. In this scribe coat, the new hydrography was scribed.

12. This scribe coat was then reversed to a wrong-reading negative on glass, to be used as guide copy on the other scribe coats.

13. The ink on the hold-out mask (5) was washed off and contour line details to be deleted in the brown plate were opaqued on the red-blue guide image. The hold-out mask negative was copied photomechanically from the above positive on glass.

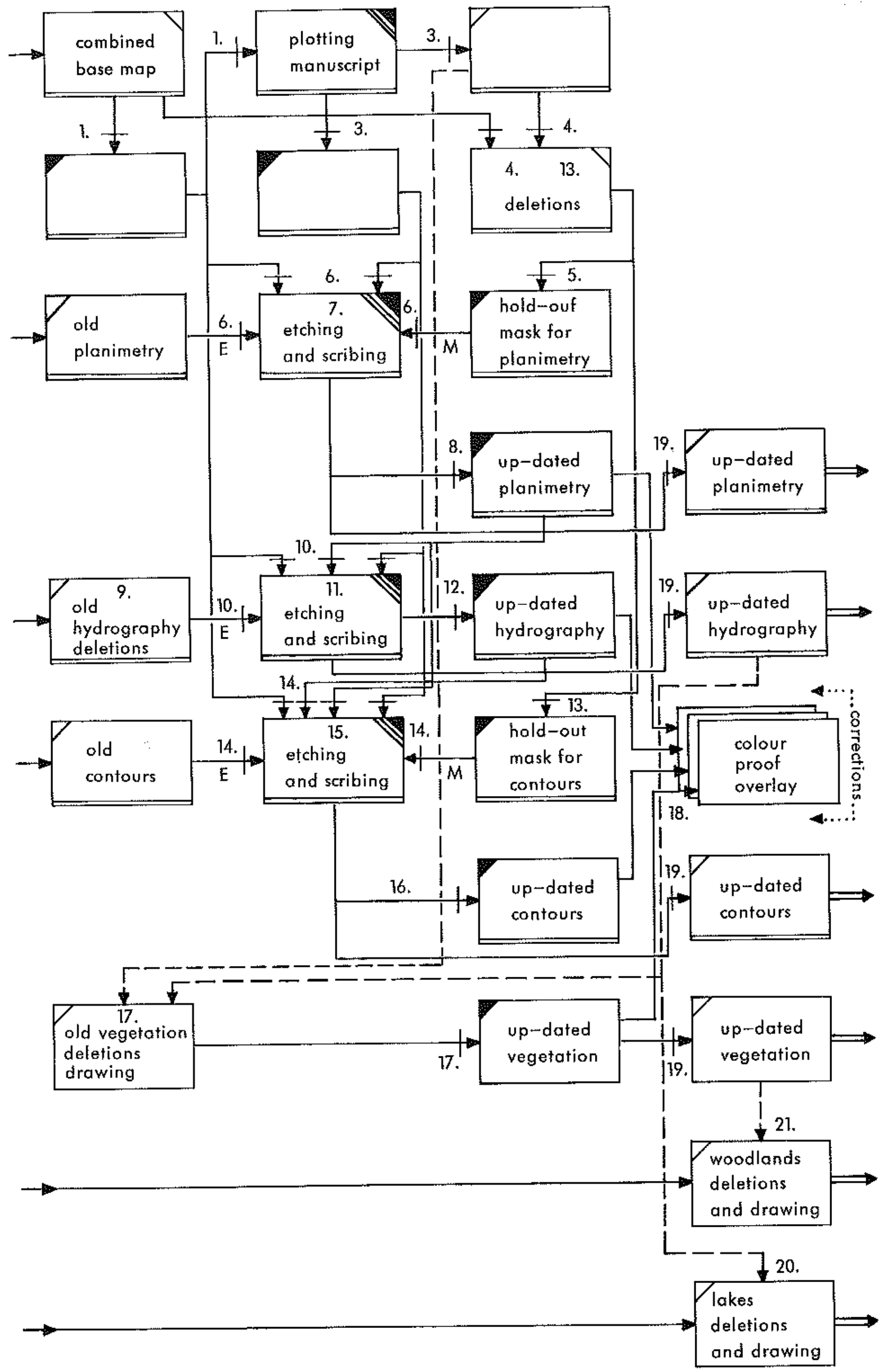
14. Another scribing plate was prepared with diazo copies from the up-dated planimetry and hydrography negatives in black and the plotting manuscript negative in dark grey. Again, this combination was covered by the green scribe coat. The old contour line positive was then copied onto this coat. Before etching a second exposure was made with the above hold-out mask negative (13).

15. The new contours were scribed on this plate.

16. This scribing was reversed to a wrong-reading negative on glass for further guide copies.

17. The few amendments to the vegetation plate would have been erased or inked in directly on the original positive for the purpose ot this test. Again, a negative was needed for the next step.

Fig. 35 : Flow diagram of the production sequence (LT Wabern)
Federal Office for Topography, Wabern, Switzerland
Stereoplotting from 1:30 000 imagery and scribing on glass at 1:25 000



18. The contact negatives of all four up-dated line plates were used to produce a COLOR-KEY (3M) positive in each of the four colours. This set of overlays was used for checking and corrections applied directly on their respective scribe coats.

19. Once all scribe coats were corrected, a final contact positive on a photographic dry plate was copied, from each of them.

20. The positive film of the old lakes was laid over the up-dated hydrography positive and changes inked or erased.

21. The positive film of the woodland areas was corrected in the same manner.

5. Test evaluation and verification methods

5.1 Terms, definitions and designations used

A considerable part of the test results is of quantitative nature. In order to clarify the terms and designations used we give the definitions used in this test in advance:

Positional error: ε_v

Deviation of the position of a point in a map or map manuscript (A) from its position in the verification basis (B) (see fig.36).

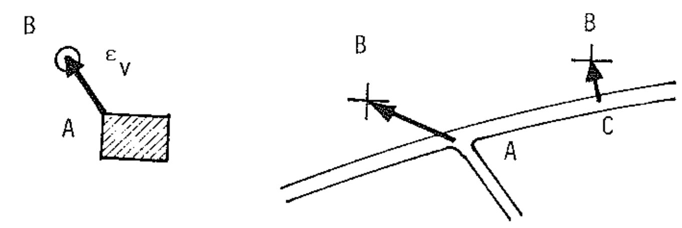


Fig.36 Positional errors

In case of a line this deviation is determined as distance between verification point (B) and nearest map point (C) of this line. The direction of the arrow indicates the necessary correction. The positional error may be expressed also with respect to the two grid coordinate axes x and y (fig.37) by the two components ε_x and ε_y,

whereas $$\varepsilon_v^2 = \varepsilon_x^2 + \varepsilon_y^2$$

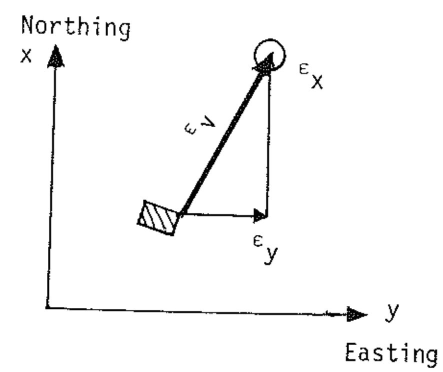


Fig.37 Grid definition ot the Swiss National Map Series

Height error: ε or ε_H

Deviation ot the height indicated in a map by a spot height number or a contour line from the height of this point in the verification base. ε is calculated as height indicated in map (H) minus height of the same point in the verification base (H_e):

$$\varepsilon = H - H_e$$

Therefore, if ε is positive the height number in the map would have to be reduced.

Residual errors:

In fact all errors are residual errors here, because in this kind of verification true values are not known at all, but only positions or heights of the verification base or a mean value that is supposed to be of considerable higher accuracy.

Mean error: $\bar{\varepsilon} = \frac{[\varepsilon]}{n}$

Arithmetic mean of a number of errors.

Standard deviation:

The standard deviation of errors, usually denotated by m or δ

is defined as follows

$$m = \pm\sqrt{\frac{[\varepsilon^2]}{n-1}}$$

It represents a confidence level of 68% that the given errors remain within the interval + m to -m.

5.2 General remarks on the evaluation

An overall evaluation of a number of more or less equivalent map samples can enable rather general statements to be made regarding quality and appearance. A less discerning map-user might be quite satisfied from his first general impression. In order to assess various mapping techniques however, it was necessary to formulate more detailed criteria. Unfortunately there is no commom quality standard for topographic mapping. Each country has established its own requirements, which more often than not, are rather lacking in refinement. For the Swiss base map revised here, there are, for example, two tolerances only, a root mean square error of $\pm$ 1 m for the spot heights and another of $\pm$ 0,3 mm for positional accuracy. Whenever a detected error is found to be greater than this tolerance, it is corrected, although theory allows for 32% of all observations to deviate in excess of the mean error.

In the absence of a common denominator, the policy was to analyse the test samples in as much detail as possible. Four major areas for quality evaluation were distinguished, namely

- completeness
- correctness
- positional and height accuracy
- line quality

A variety of criteria were applied in order to enlighten the problems from several sides. Thus not only were the mean errors computed, but also maximal ones. The whole error distribution was analysed and compared.

For mapping organisations, the quality of the map as a whole seems to be of primary importance. Does a certain procedure based on practical experience and on economic considerations provide an acceptable result? The answer to this question must have first priority. Refinements can always be made at a later stage. In any case, there are often a number of constraints that can seriously restrict freedom in the choice of procedure. In light of this, the main emphasis in the assessment was placed on the final product. Where appropriate and of interest, individual procedures were also evaluated and compared. The main purpose in doing this was to identify problems that have a considerable influence on the general result. The participants as well as the pilot centre could hardly have devoted more time for experimenting with all kinds of alternatives without abandoning the straight-forward approach that typifies production practices.

The other major interest in this test was the time and cost involved in a revision process. In this respect, the experiment was designed so that intermediate processes could be timed and compared with each other. One of the handicaps in this case was that only a portion of a whole map sheet could be treated. There is certainly a considerable difference between the time needed for a first model and the average for a number of sequential models. There is no ideal solution to overcome this disadvantage. In order to obtain results that could be easily compared to typical production units, it was decided to multiply the hours needed for the test area of 18 km^2 to an area of 100 km^2 by a factor of 5,5. It is clear however that the time needed for a reproduction process may be practically identical for a small excerpt as for a whole map. In this case the multiplication factor was not applied.

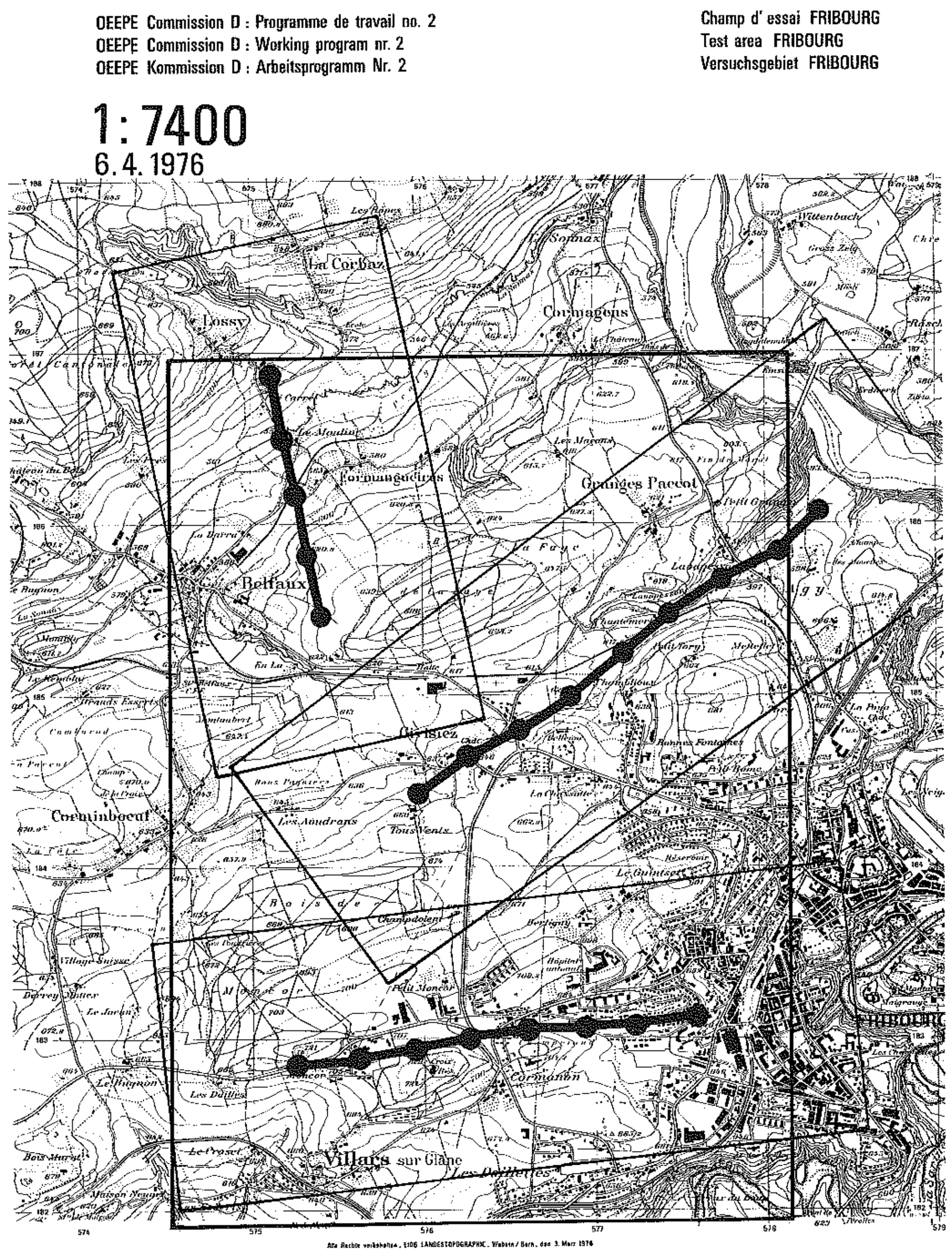
5.3 The basis for the verification

As mentioned above, a number of different aspects were to be evaluated. For this purpose, an up-dated large scale reference map at 1:2 500 was prepared. It had to serve a number of purposes and was used for checking accuracy, completeness, correctness and effects due to generalisation.

Two of the three sheets of this verification reference map were assembled from 16 topographic plans at the scale 1:1 000. These plans belong in part to the plan series "Grand Fribourg" and in part to a series of plans prepared for the motorway construction. Reductions of all these plans were produced to the scale 1:2 500 and assembled. Two large film positives were used for stereoplotting. All the plans were very detailed including one-metre contours. The data was however in many parts obsolete. Before they could be used for verification they also had to be revised. The revisions for these verification maps were plotted from the 1:7 400 photographs also flown on May 6th 1976, thus sharing the same situation as the test material. Figure 38 shows the pictures taken along the three flight lines.

Additional control points were signalised to assure correct levelling and scaling of all models. One of the three plans (Belfaux) is a completely new restitution executed by the Department of Photogrammetry at the Ecole Polytechnique Fédérale de Lausanne. The two other plans were stereoplotted by the commission chairman at the corresponding department of the Eidg. Technische Hochschule Zurich. These manuscripts were produced in pencil. The model-coordinates of all points needed for verification were recorded and later transformed to

Fig. 38 : Flight lines for verification purposes, image scale 1:7400



National-coordinates. In the Belfaux plan, these points were pricked on the manuscript and National-coordinates derived by digitisation. The estimated standard deviation of the positional errors of these verification points is 0,2 mm at 1:2 500 or 0,02 mm at the map scale 1:25 000. Such up-dated large scale plans were prepared for 13 km^2 of the 18,4 km^2 test area. Besides the planimetry, those contours that also appear at the scale 1:25 000 were plotted together with the 40 spot heights selected for evaluation as well as those in the base map. The root mean square error of these elevations is estimated to be ± 0,2 metres and is therefore sufficiently small in relation to the errors to be expected from the measurements in the 1:18 000 and 1:30 000 images.

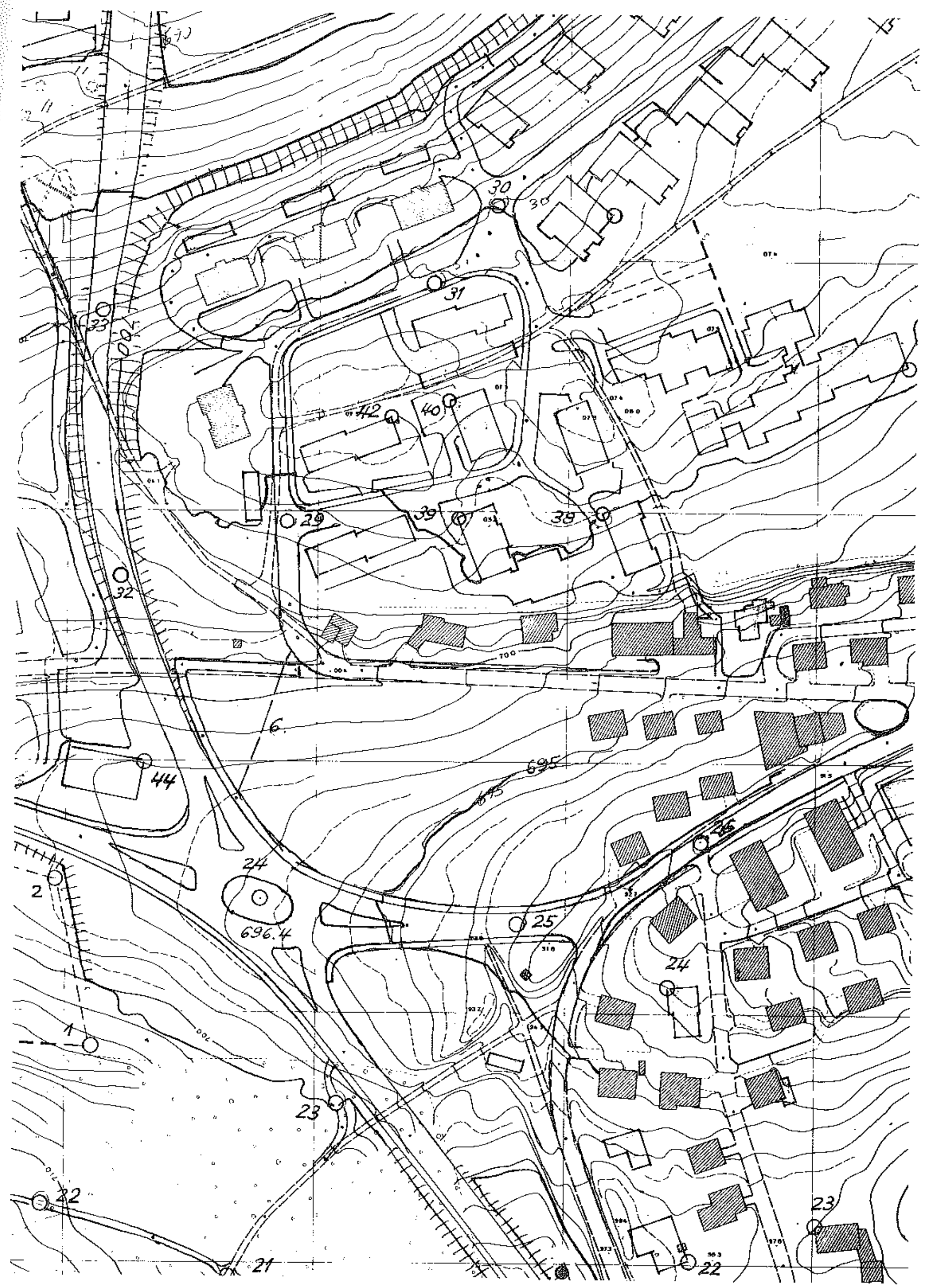
In order to substantiate these restitutions, a detailed field identification was carried out by the chairman himself two weeks after the photographic runs. Two full days were necessary for this purpose. All changes to be made on the base map were recorded on enlarged photographs. Special representation problems were indicated as well. These field manuscripts were also consulted subsequently during the completeness and shape check.

Some parts of the verification plans were drawn at 1:2 500 and reduced to the scale 1:25 000 for direct visual comparison (see figure 39). Similarly, all contour lines were drawn, reduced and assembled. The contour plates were verified in this way (see figures 77 to 87).

5.4 Methods used for the verification of accuracy

The idea was to measure a hundred or more clearly definable points in each final test sample; and to analyse the residual errors according to various criteria. The coordinates of these were established and made available from the large scale restitutions. Two verification methods were examined by the pilot centre to measure these points on the final 1:25 000 films; the first on a digitiser, the second in a stereocomparator. After a number of trials, the measurements were finally carried out with the WILD Stereocomparator STKI. The latter proved to be easier and more comfortable to use in exact positioning onto the verification points in the final films than with the digitiser. Furthermore, no problem of internal accuracy was posed in using the stereocomparator, whereas sadly, the digitiser measurements were disturbed by an eccentricity error in the particular tracing cursor used.

Fig. 39 : Section of the verification plan 1 : 2500



The following procedure was therefore adopted: The measurements were carried out on the final positives of each test sample. Where only negatives or large formats were available, contact positives were produced from them. The verification points were arranged in 'runs' , strung along a polygonal line and plotted as a small circle. A blueline contact copy of each run was prepared after all points had been numbered. The blue guide image was mounted on the corresponding film positive and this combination introduced into the stereocomparator. All measurements were recorded on punch cards, the four grid corners at the beginning as well as at the end of a run. Each verification point was measured only once in order to keep the whole verification work within certains limits. All other grid corners within the test area were also recorded to enable an analysis of map deformations in reproduction processing.

All comparator coordinates were transformed to National-coordinates using the four grid corners. A 'Helmert-transformation' (translation, rotation, and scaling) was calculated on the basis of these 4 grid points and then applied to all other recorded points. For each test sample all x- and y-coordinate differences between transformed comparator-coordinates and verification-coordinates and all residual error vectors v were calculated. These errors were statistically analysed.

The internal accuracy of this procedure could be derived from the grid points measured several times. The standard deviation in recording a grid intersection in the map was calculated to be smaller than 0,01 mm or 0,18 metres on the ground. It was certainly more difficult to get an exact fix on other map elements. House corners were often very much rounded, so that the point had to be taken at the intersection of two house edges. Another problem was the determination of the deviation of the road axes. In contrast to verification of well-defined house corners, it is impossible to establish the deviation from the verification point. Therefore the nearest point on the road axis to the verification point cross was chosen. In case of road junctions there was no ambiguity.

The plotting manuscript from the stereo facet plotter at the scale 1:10 000 was the only once measured on the digitiser, using an enlarged plot of the verification run. A four point calibration and transformation was applied to obtain National-coordinates of these verification points.

5.5 Evaluation of the base map

Of utmost importance in every map revision is the quality of the base map. If it is not sufficiently accurate, a number of problems will hinder a straightforward revision. Every uncertainty implies an interruption in the plotting process and often it is difficult to decide where to start and finish with corrections in the base map. The situation can be so hopeless that a completely new restitution becomes the only solution.

The intention of the Commission was to revise a base map that was of good quality and lent itself well therefore to revision. This requirement guided the selection of the map.

In order to get a quantitative evaluation of the quality of this base map, the tests were applied to it in its pre-revision form. The following root mean square errors were determined:

			at 1:25 000
19 grid intersections	m_v =	± 0.3 m	0.01 mm
42 house corners	m_v =	± 3.8 m	0.15 mm
	v_{max} =	6.3 m	0.25 mm
98 points on road and railway axes	m_v =	± 3.8 m	0.15 mm
	v_{max} =	13.1 m	0.5 mm
5 trigonometric points	m_v =	± 2.2 m	0.09 mm
11 points on rivers	m_v =	± 3.9 m	0.15 mm
20 points along high tension lines	m_v =	± 2.4 m	0.1 mm

For the error distribution figure 40 may also be consulted.

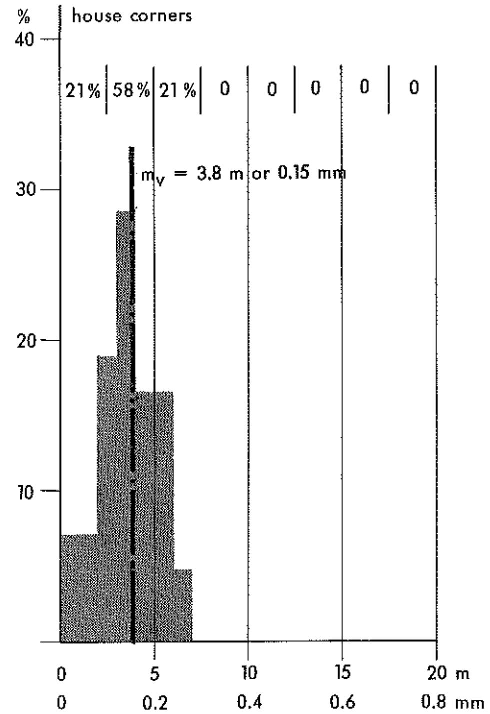
The checked points were also split into those existing already in the first edition of 1957 and those added in the first revision of 1968. The result is as follows:

78 points on road axes (1957)	± 3.9 m	0.15 mm
20 points on road axes (1968)	± 3.2 m	0.13 mm
14 points on high tension lines (1957)	± 2.8 m	0.11 mm
6 points on high tension lines (1968)	± 0.6 m	0.03 mm

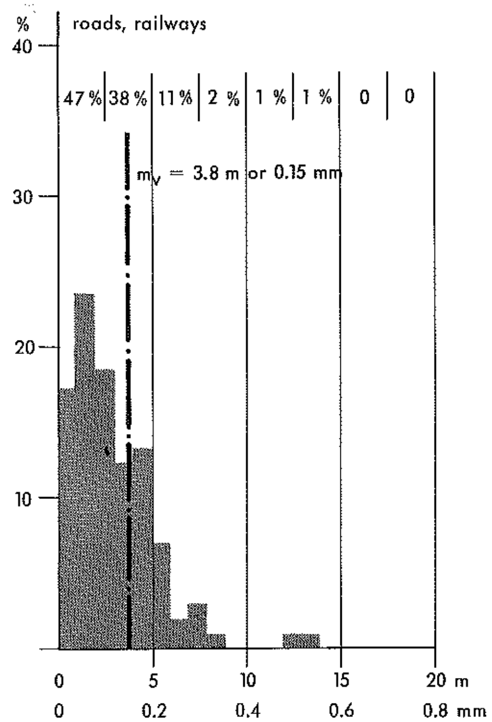
Table 3: Verification of the accuracy of the spot heights existing on the base map which was to be revised in the test

No.	Height in the base map	Effective height	Diff. v	vv
1	570	570.5	- 0.5	0.25
2	556	556.3	- 0.3	0.09
3	585	586.1	- 1.1	1.21
4	580	580.0	0	0
5	589	589.4	- 0.4	0.16
6	588	588.0	0	0
7	583	584.7	- 1.7	2.89
8	622	621.7	+ 0.3	0.09
9	620	620.6	- 0.6	0.36
10	617	616.7	+ 0.3	0.09
11	615	614.6	+ 0.4	0.16
12	613	613.0	0	0
13	637	637.0	0	0
14	646	646.0	0	0
15	660	660.8	- 0.8	0.64
16	631	629.9	+ 1.1	1.21
17	621	621.9	- 0.9	0.81
18	619	619.0	0	0
19	597	596.8	+ 0.2	0.04
20	662	661.9	+ 0.1	0.01
21	646	645.5	+ 0.5	0.25
22	681	680.8	+ 0.2	0.04
23	639	638.7	+ 0.3	0.09
24	644	644.7	- 0.7	0.49
25	642	642.2	- 0.2	0.04
26	690	690.6	- 0.6	0.36
27	691	690.9	+ 0.1	0.01
28	698	698.3	- 0.3	0.09
29	642	642.3	- 0.3	0.09
30	684	683.1	+ 0.9	0.81
31	674	674.6	- 0.6	0.36
32	677	677.6	- 0.6	0.36
33	696	695.6	+ 0.4	0.16
34	703	703.2	- 0.2	0.04
35	721	721.7	- 0.7	0.49
36	705	707.2	- 2.2	4.84
37	707	706.5	+ 0.5	0.25
38	684	683.6	+ 0.4	0.16
39	660	660.0	0	0
40	674	674.0	0	0
41	640	640.2	- 0.2	0.04
42	638	637.9	+ 0.1	0.01
43	656	657.0	- 1	1
44	661	662.3	- 1.3	1.69
45	648	648.0	0	0
46	646	645.2	+ 0.8	0.64
47	661	662.3	- 1.3	1.69
			(v) = - 9.9	(vv) = 22.01
			$\frac{(v)}{n}$ = - 0.2	$\sqrt{\frac{(vv)}{n}}$ = ±0.69 m

Fig. 40 : Distribution of residual positional errors



LT Wabern, base map



It can be concluded therefore from the result of the accuracy test of the base map, that the first edition showed a root mean square positional error of 0.15 mm or less and those elements added in the first revision were even more accurate, at 0.13 mm. Only 5 of the 177 points deviated more than 0.3 mm corresponding to 3%. 15% of all points showed residual errors greater than 0.2 mm.

All 47 spot heights on the base map, that could be verified by large scale plotting or by field measurement, dated back to the first edition of 1957. They are given in the map only to the nearest metre. Therefore allowance should be given for the rounding-up error, when the following result of the comparison is considered, as given in the table

standard deviation of a spot height 1597 = $\pm$ 0.69 m

This value is well within the tolerance of $\pm$ 1 metre. There was one elevation that deviated 2.2 metres (P. 705 in Moncor). There is a possibility that this spot height was chosen by the Topografische Dienst Delft for levelling the stereo model. This would explain most of the large discrepancies discovered in the spot heigt test in this corner.

In general it can certainly be said that the base map was of a very high standard, homogeneous and precise. It is little wonder that the participants stated that revising a map of this quality was no problem at all.

6. Quantitative and qualitative results of the test

6.1 General remarks on positional accuracy

The problems of positional accuracies of graphical photogrammetric output and of maps are manifold. An analysis of possible sources for positional errors in the whole mapping process results in a rather tedious undertaking. However in order to improve overall accuracy of the result of a map revision it would be essential to get more insight into errors caused by certain subprocesses.

As a first step, therefore, an attempt is made to list up and briefly discuss error sources within the sequence of procedures applied by the participants. Then an estimate of the contribution of the errors to the final result is made. Some remarks also have to be devoted to error propagation in this very special case. They will lead finally to the arguments for the error analysis as it has been undertaken in this test.

If we follow the sequence of procedures when plotting from an orthophoto we will have to take in mind the following error sources:

a) The aerial photograph negatives used in the orthophoto preparation are third generation polyester films, prepared in two consecutive contact copying processes from the original aerial film negative. Therefore, apart from the distortions inherent in the film exposed in the air, film shrinkage and distortion may have been caused by the two developing and drying processes. The first of these two factors has been the object of numerous fundamental research projects in photogrammetry. It can be split again in a number of factors, e.g. lens distortion, flatness of film during exposure etc. Integral values for these errors have been received from test field measurements. For the camera - plane - film combination used in the FRIBOURG test however no test field data was available. On the other hand the amount of film distortions caused by development and drying are well-known from a variety of tests.

b) The next group of error sources is in connection with the orthophoto production. Relative and absolute orientation are controlled to some extent by the remaining discrepancies m_V and m_H, that were reported as follows:

	Planimetry	Heights
Delft (TD)	$m_V = \pm 0.46$ m	$m_H = \pm 0.3$ m
Stuttgart (LVA)	$m_V = \pm 1.7$ m	$m_H = \pm 0.1$ m

The scanning of the model was done in both cases with a slit width of 4 mm in the model scale 1:20 000. The projection of the orthophoto was done by TD (NL) at the scale 1:15 000 without interpolation between the two adjacient scanning strips. Fairly large discrepancies in some areas were recorded by Delft. The order of magnitude of these discrepancies along slit borders may be determined by measuring the shift of image elements that run perpendicularly across these borders.

With reference to the scale of the final map the discrepancies were occasionally as large as 5 m, but are normally well below this amount. These discrepancies are the result of the accuracy of profiling and of the terrain geometry at the slit border. Stuttgart executed the projection of the orthophoto at the scale 1:10 000 (resulting slit width 8 mm). The Zeiss orthoprojector GZ1 thereby was equipped with the optical interpolation system "O-Int", which eliminates such discrepancies. Also the WILD-Orthophotos used by NBS and IfAG have no discrepancies at adjacent strips. Of course these are not the only errors inherent in the orthophoto image, and as such are easy to detect and eliminate. Checking the positional accuracy of the orthophoto, which is an intermediate product in the whole map revision process might have been done but is also not without problems. Selecting photo detail that is identical to the one represented in the verification map is a rather subjective process. Measuring the same verification points as in the final map samples would have caused even more uncertainty, because quite a number of them are hidden corners in the orthophoto. Therefore the interpretation errors could not be separated from the geometric errors of the orthophoto.

c) Another source of errors is registering the orthophoto onto the old planimetry, including the selection and plotting of eventually necessary pass points. How often such a solid register was abandoned in order to achieve a better match with the existing planimetry by slightly shifting the sheet, has not been reported. But it is often considered as one of the advantages of this technique, especially in revision of old maps, where the geometry of the planimetry is not in all parts exact enough. Only a detailed analysis of the error vectors over the whole sheet would clarify this point. Whether a more accurate absolute position of the new items is an advantage over greater relative accuracy to remaining old elements, that have a small offset to their true position, is another question. In other words, what is more preferable; a more consistent planimetry with greater absolute discrepancies or a more accurate but heterogeneous revised map?

d) In the case when a compilation manuscript is prepared before fair drawing interpretation and also a compilation error have to be taken in account. IfAG was the only participant to use this procedure. Three other participants produced their fair drawings directly from the orthophoto.

e) The drawing error is the deviation from the compilation manuscript in fair drawing or scribing. If this final draughting happens directly on the base of the underlaid orthophoto, it includes an interpretation error as well.

f) Due to the fact that fair drawing has been performed by all participants in scales larger than 1:25 000, an enlargement of the base map and a reduction in the camera are necessary. These two steps are also not free from errors, especially from lens and film distortions.

If the stereoplotting procedure is used, the above error sources are largely the same, with the exception however of items b) and c). Item f) would not apply if all plotting is done at publication scale.

g) The following residual errors of the relative and absolute orientation for subsequent stereoplotting have been reported:

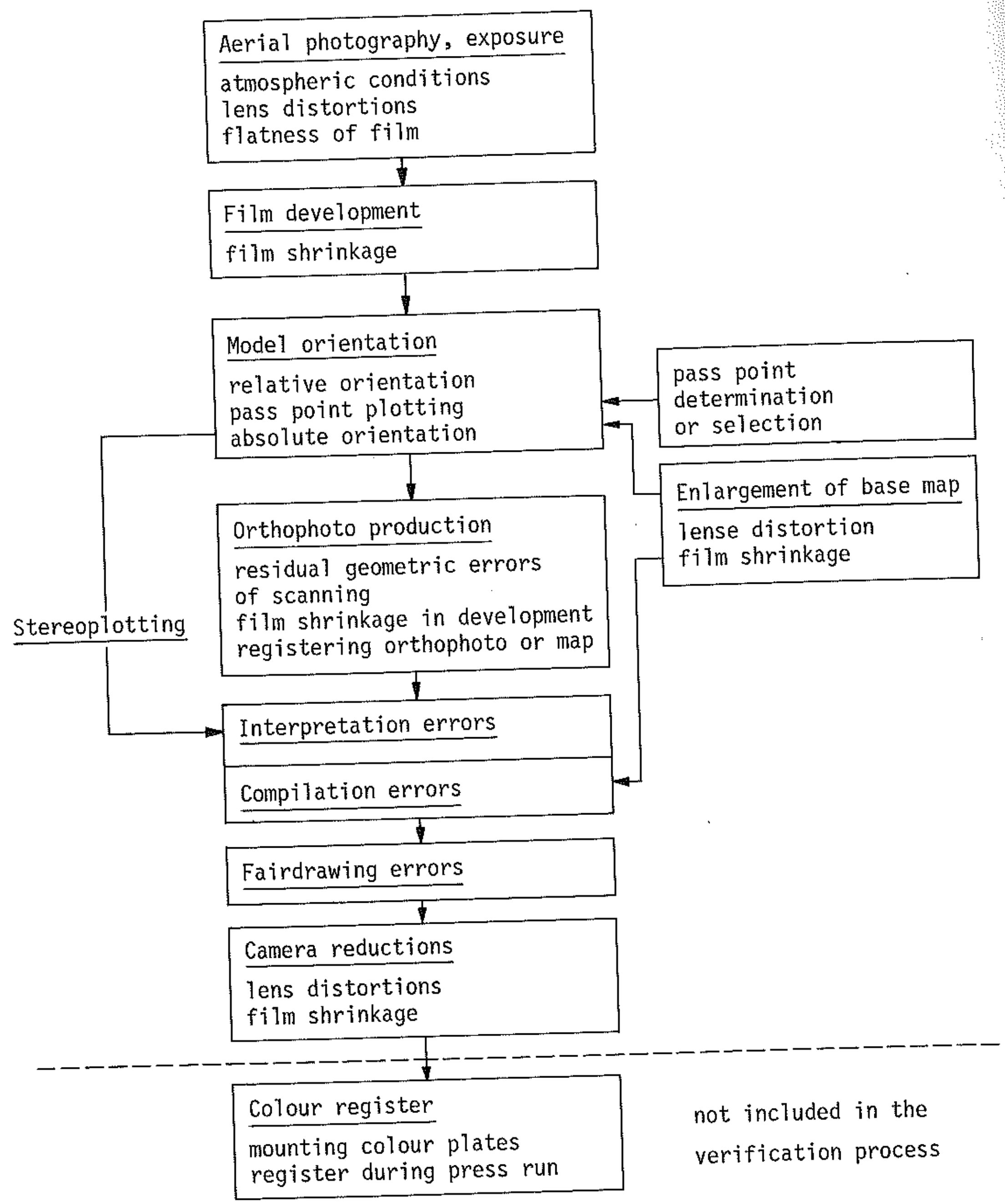
Frankfurt (IfAG)	$m_V = \pm 0.12$ m	$m_H = \pm 0.15$ m
Brussels (IGN)		
- images 1:30 000		± 1.8 m
- images 1:18 000		± 0.6 m

Not all of the errors listed above can be completely separated. Many of them are correlated. Others are compensated to a considerable degree by subsequent processes in revision work. A symmetric scale distortion caused by film shrinkage e.g. may be compensated in the phase of reduction with the reproduction camera.

Such errors have to be considered as systematic errors following some defined function and usually suitable for correction.

Or, to mention another possibility, accidental compilation errors are reduced in some cases in the fair drawing process, quivering lines etc. Therefore it is scarcely possible to combine all these individual errors by simply applying an error propagation law as is usually done with random errors. On the other hand, having the goal of the test work in mind, it is not very satisfactory

Table 4: Error sources in the whole revision process



to measure an integral positional error of the whole revision work, when one would like to draw conclusions on the suitability of individual subprocesses. Fortunately however, the results were very encouraging from the point of view of accuracy. As long as this is true, there is no need to look for inappropriate subprocesses that ought to be eliminated.

The error discussion of the test result treats for these reasons three kinds of problems:

- Evaluation of the overall accuracy of the whole sequence of procedures
- Estimations of the magnitude of errors of some selected subprocesses
- Error analysis that concentrates on specific individual errors

Table 4 is a synopsis of the sources of positional errors in the whole revision process. With the exception of colour register in printing all these errors are included in the values m_v, v and v_{max} of table 5, giving the results of the verification for positional accuracy. For each participating centre the number of controlled points is listed for each category of features together with the values in metres for the standard deviation of all check points that showed an error smaller than 0.6 mm in the map or 15 m in natural units. Errors larger than 0.6 mm were enumerated, but considered as blunders and not included for the calculation of the standard deviation.

Means were calculated for all examples in each of the two main methods and scales applied, for orthophoto and for stereoplotting. The results of the two test samples that reached only the map manuscript stage, stereoplotting by the Federal Office of Topography and the stereo facet plotter application by the National Board of Surveys in Helsinki were included in the list as well. Table 5 on the other side gives the numerical details about the series of histograms (figures 41 to 48).

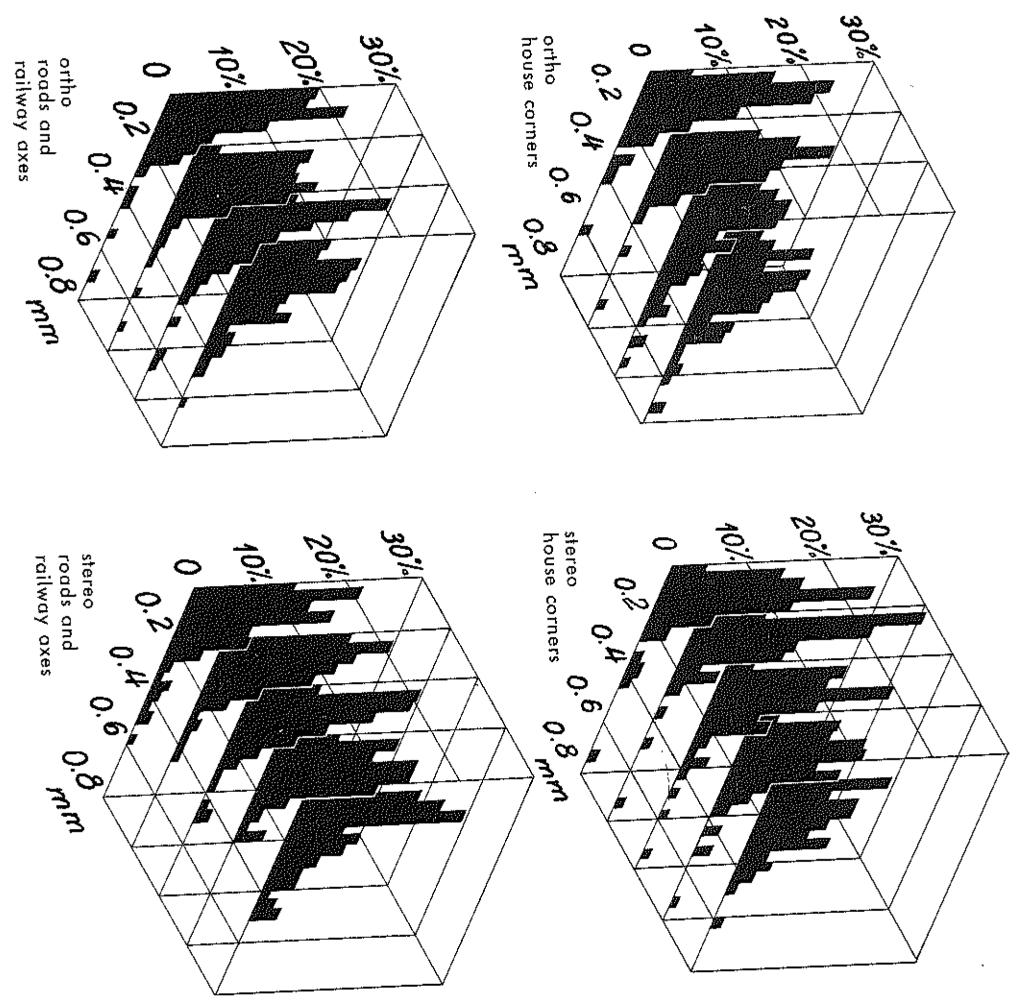


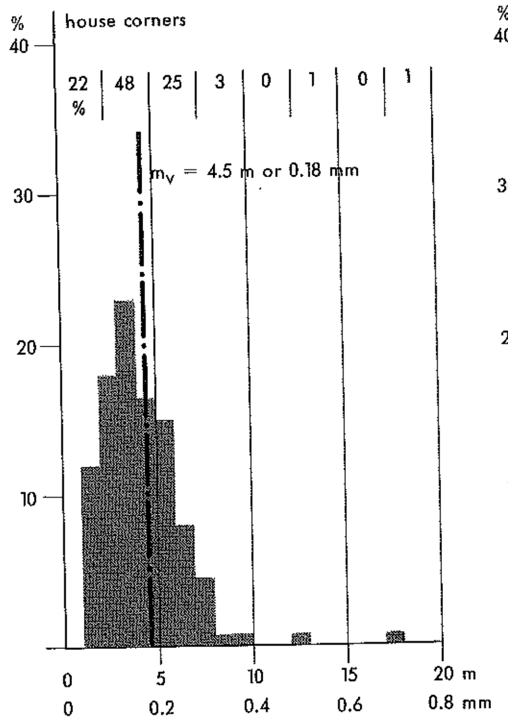
Fig. 41: Histograms comparing positional accuracies of house corners, roads and railway axes in the test samples up-dated by the orthophoto and by the stereoplotting method

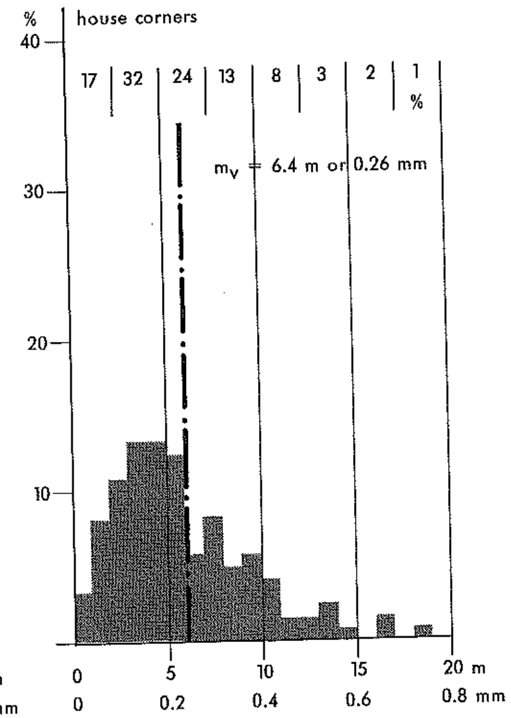
Table 5: Results of the verification for positional accuracy in metres

3) Stereo Facet Plotter

root mean square error m_v = / maximal error v_{max} = (in metres)	LT 1968 Base Map	LVA D	IfAG D	TDN NL	NBS SF	Ortho photo mean	NBS SF	IGN B	NGO N	Stereo plotting mean	IGN B	NGO N	Stereo plotting mean	LT 1975	LT 1976	NBS SF
Image scale 1:	30 000						30 000				18 000			27000	30000	30000
Compilation method	diff.	Orthophoto					Stereoplotting				Stereoplotting					3)
Plotting and cartography at 1:		10000	10000	15000	10000		10000	16667	25000		16667	25000		25000	25000	10000
Drawn or scribed	scrib.	drawn	scrib.	scrib.	drawn		drawn	scrib.	scrib.		scrib.	scrib.		scrib.	manus only	manus only
Grid m_v = ±	0.3	0.3	0.9	0.4	0.4	0.5	0.4	0.5	0.3	0.4	0.5	0.4	0.5	0.3	1.5	0.4
v_{max} =	0.6	0.5	1.6	0.6	0.8	1.6	0.7	0.8	0.6	0.8	1.4	0.6	1.4	0.6	1.9	0.6
House corners																
number of points with v > 15 m	0	2	7	1	3	3	1	1	1	1	1	1	1	2	1	1
with v < 15 m	42	132	117	134	126	127	131	130	131	131	134	132	133	118	130	116
for all points with v < 15m, m_v = ±	3.8	4.5	6.4	3.8	7.0	5.4	5.2	4.5	3.9	4.5	3.5	5.0	4.2	3.4	2.5	6.4
Roads, railways																
number of points with v > 15 m	0	1	5	3	1	2	1	0	1	1	1	0	1	0	0	0
with v < 15 m	98	177	159	171	174	170	171	166	170	169	174	170	172	163	172	168
for all points with v < 15m, m_v = ±	3.8	4.5	4.6	3.4	5.1	4.4	4.0	3.9	4.3	4.1	3.3	4.8	4.0	3.6	2.9	5.1
Rivers, high tension lines, fields																
number of points with v > 15 m	0	1	0	2	0	1	0	0	1	0	0	0	0	0	0	0
with v < 15 m	37	23	9	13	12	14	13	8	15	12	15	20	17	15	13	17
for all points with v < 15m, m_v = ±	3.0	3.9	5.0	5.8	4.2	4.7	4.4	3.9	3.7	4.0	6.3	3.0	4.6	2.9	3.0	5.1
all categories m_v = ±	3.6	4.5	5.4	3.7	5.9	4.8	4.6	4.1	4.1	4.3	3.6	4.8	4.1	3.5	2.7	5.6

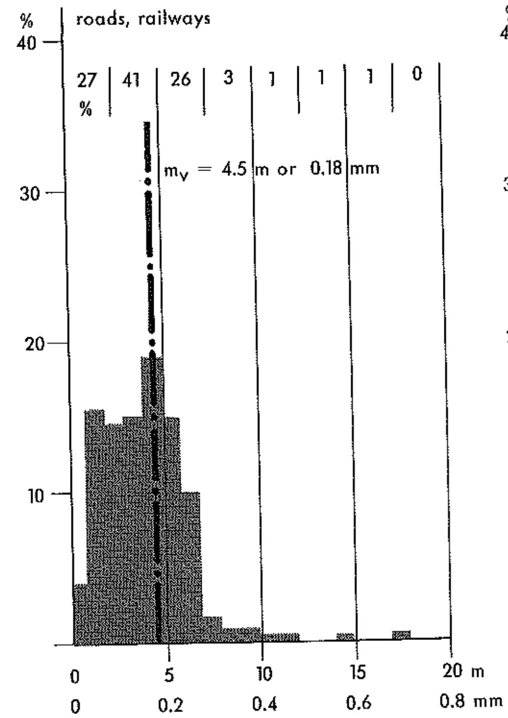
Fig. 42 : Distribution of residual positional errors





LVA Stuttgart image scale : 1 : 30000 method : orthophoto

IfAG Frankfurt image scale : 1 : 30000 method : orthophoto



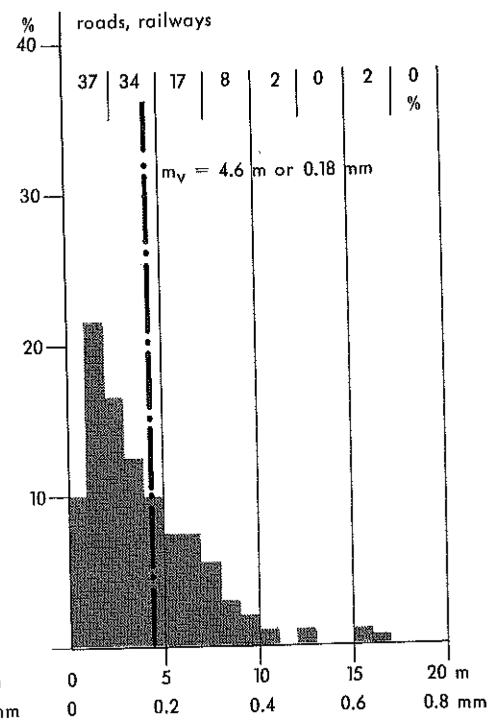
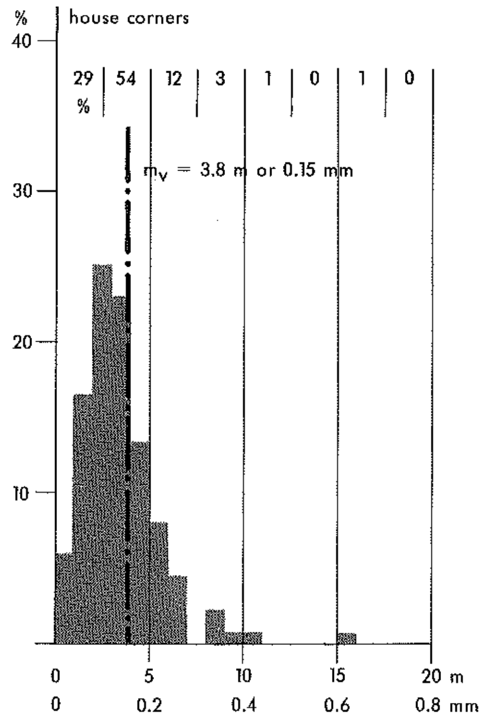
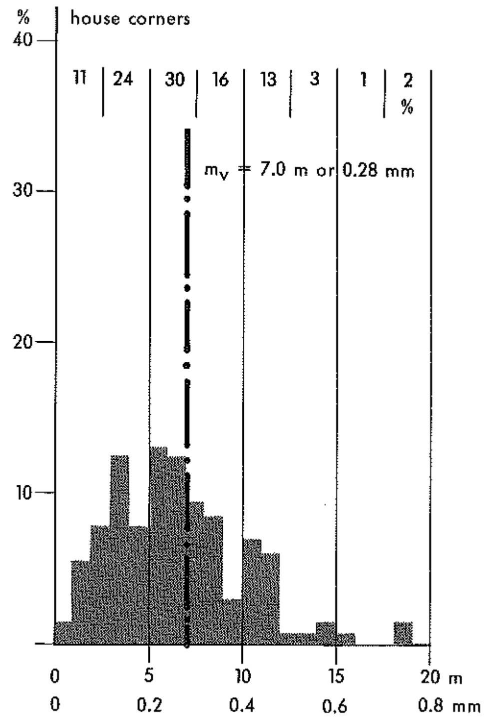


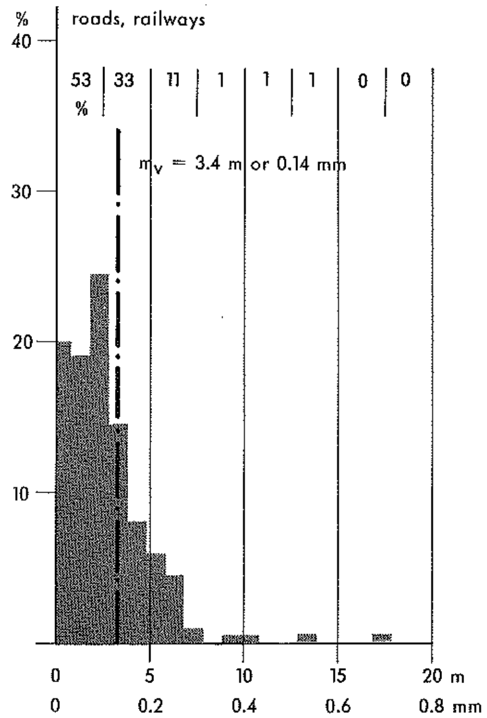
Fig. 43 : Distribution of residual positional errors





TD Delft image scale : 1 : 30000 method : orthophoto

NBS Helsinki image scale : 1 : 30000 method : orthophoto



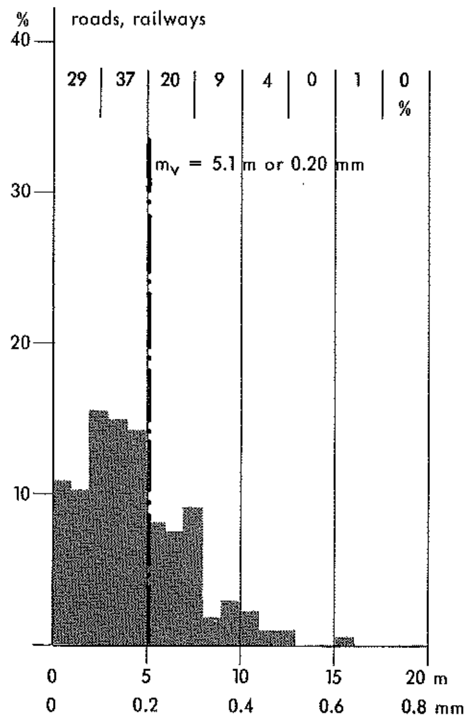


Fig. 44 : Distribution of residual positional errors

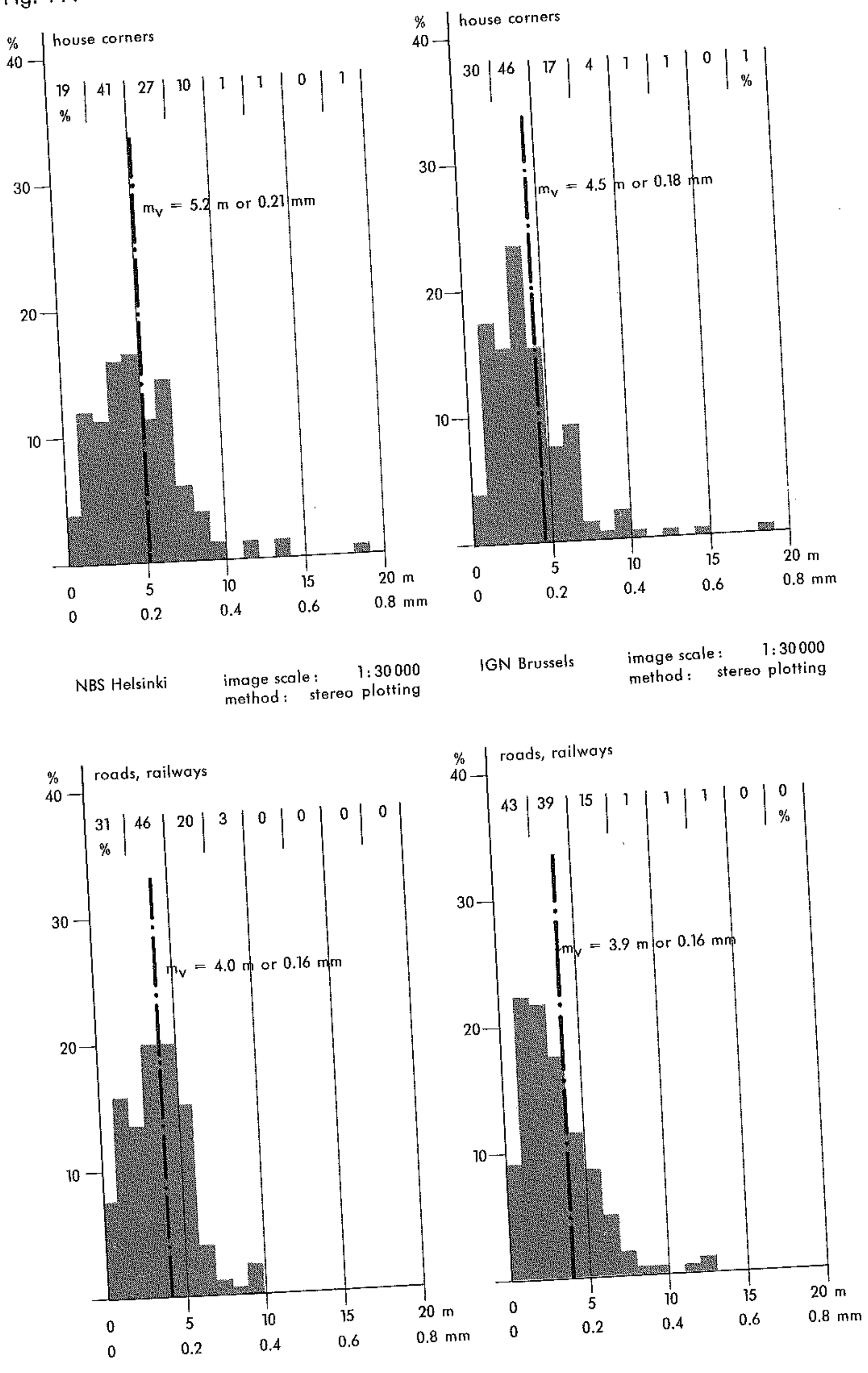


Fig. 45 : Distribution of residual positional errors

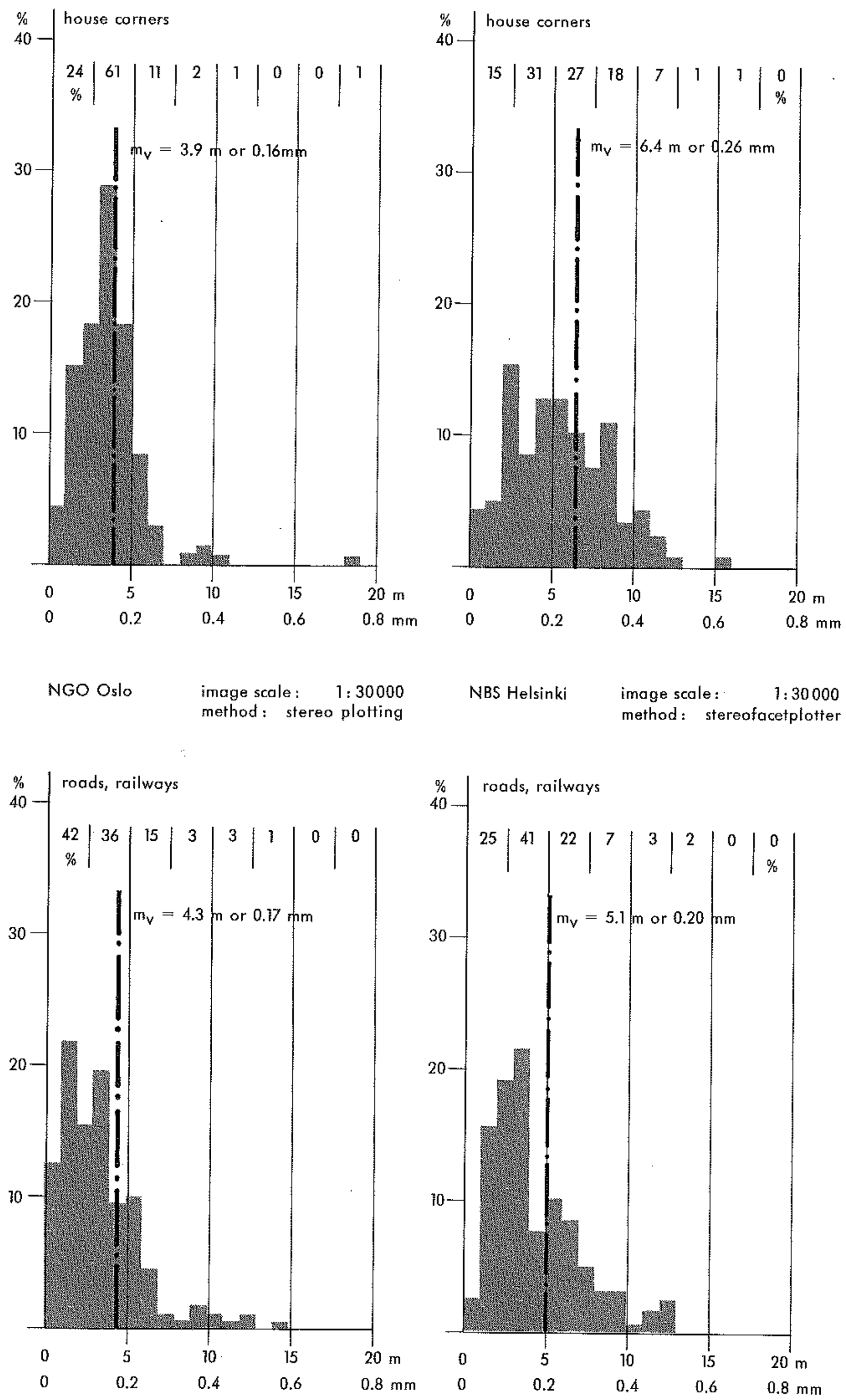
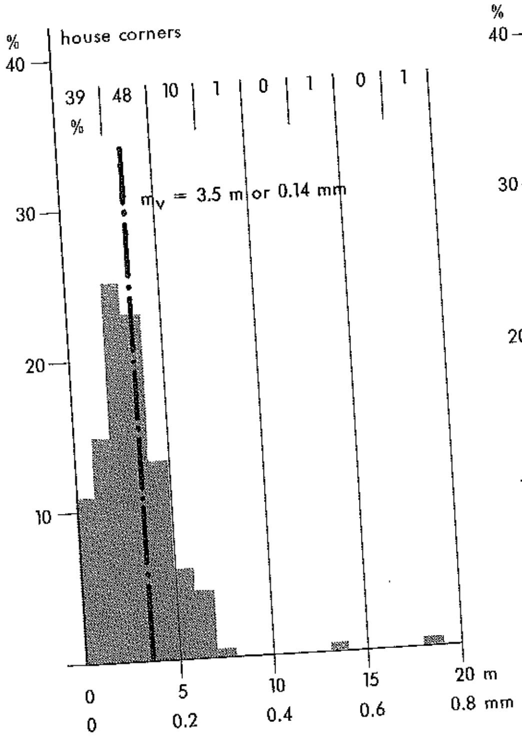
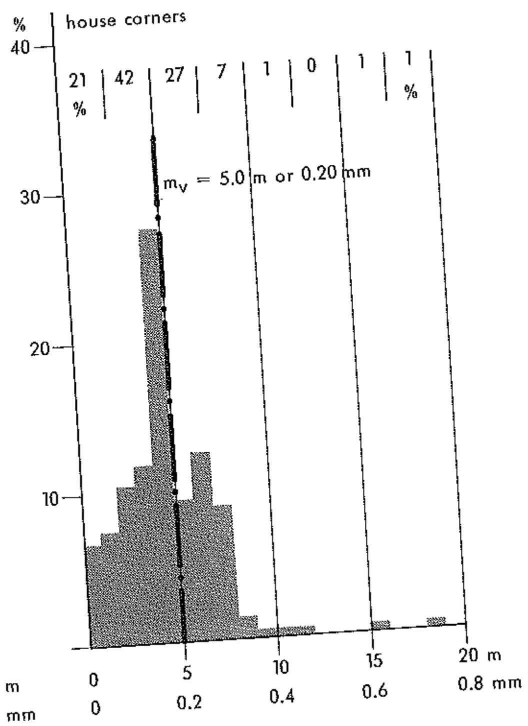


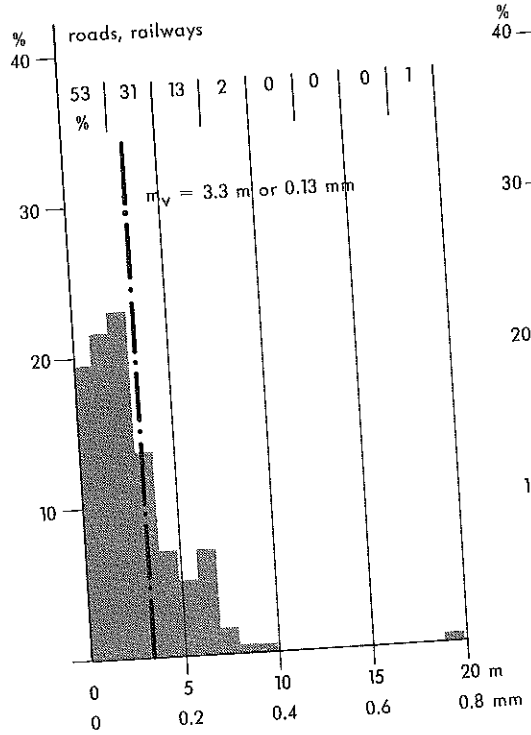
Fig. 46 : Distribution of residual positional errors



IGN Brussels image scale: 1 : 18 000 method: stereo plotting



NGO Oslo image scale: 1 : 18 000 method: stereo plotting



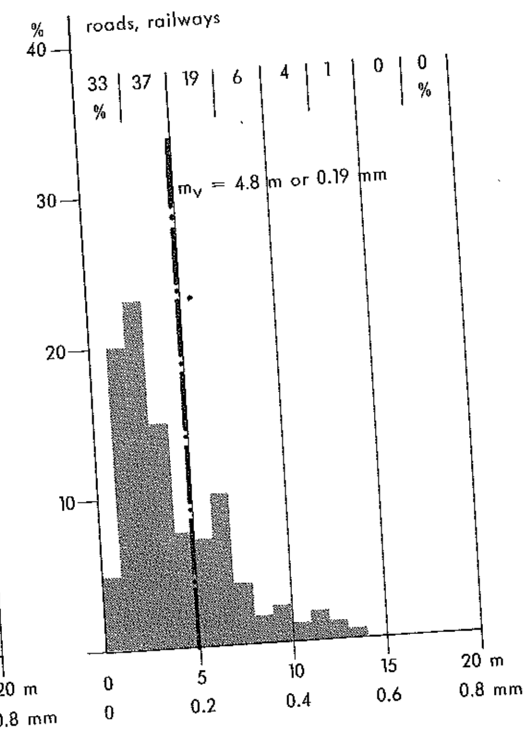
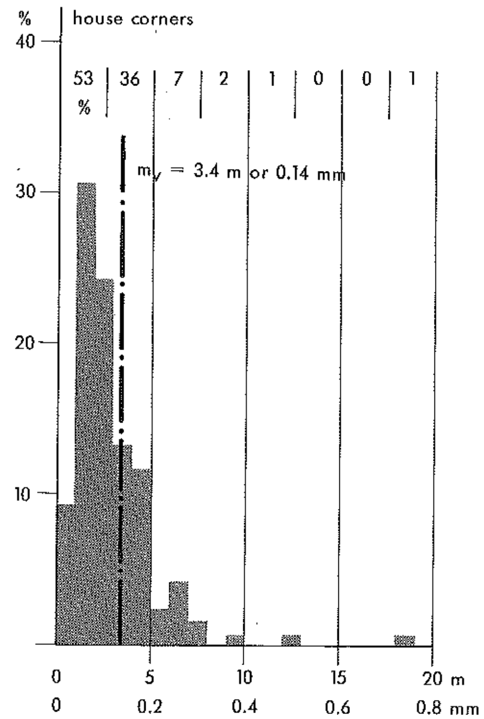
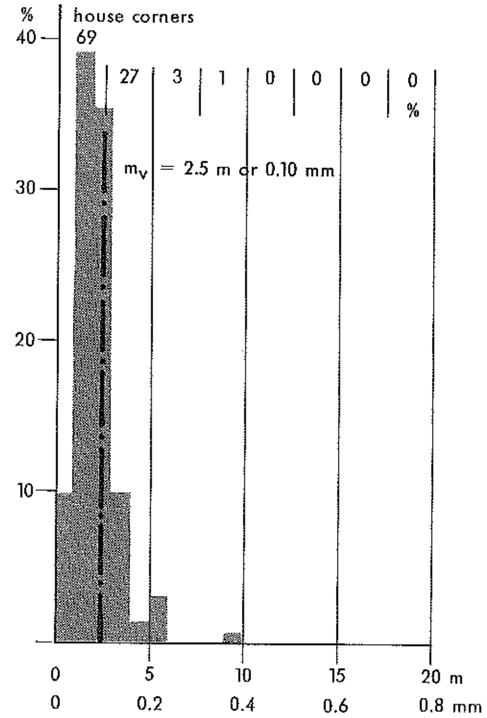


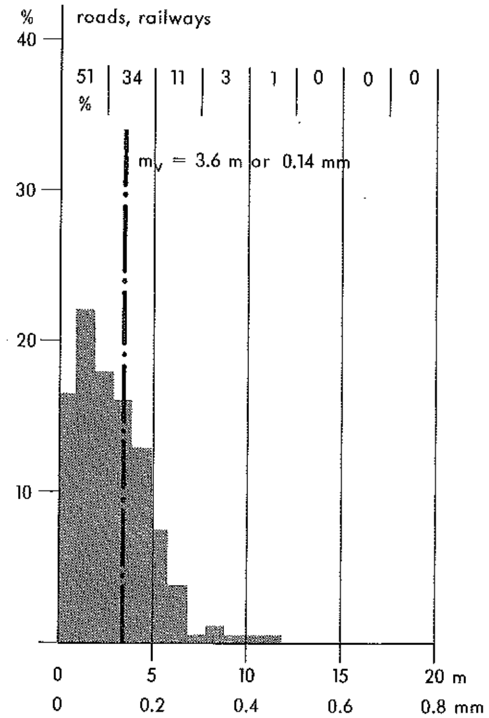
Fig. 47 : Distribution of residual positional errors



LT Wabern 1975 image scale: 1:30 000 method: stereo plotting



LT Wabern 1976 image scale: 1:30 000 method: stereo plotting manuscript only



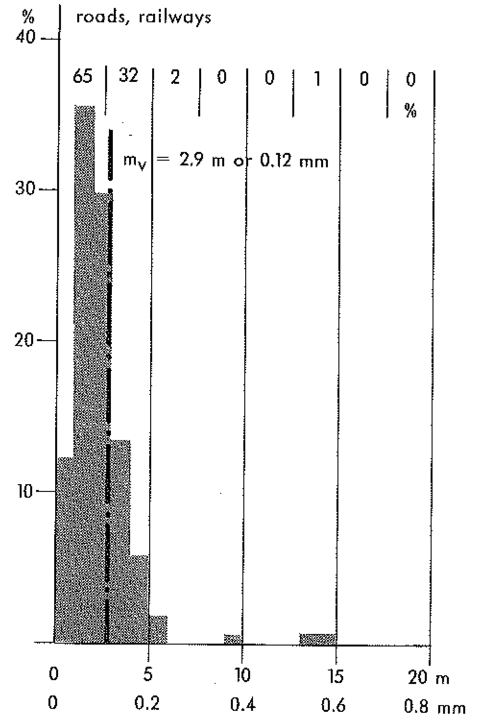


Fig. 48 : Comparison of the two methods, all tests included : distribution of residual positional errors

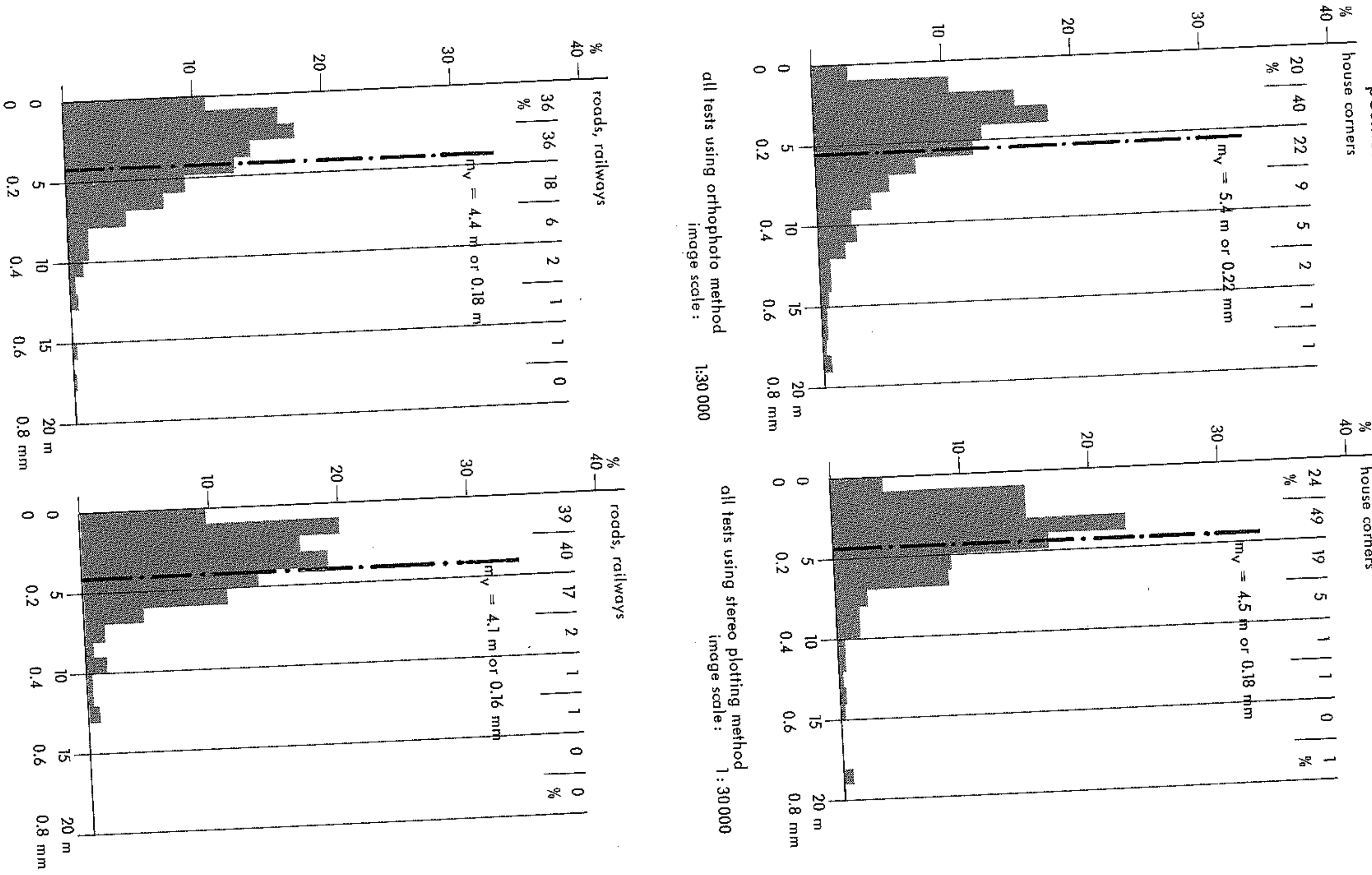


Table 6: Results of the verification for positional accuracy as % of all points

Participant		LT Base map	LVA D	IfAG D	TD NL	NBS SF	Ortho	NBS SF	IGN B	NGO N	Stereo	IGN B	NGO N	Stereo	LT 75 CH 1)	LT 76 CH	NBS SF
Image scale 1:			30 000					30 000				18 000			27000	30000	30000
Compilation method			Orthophoto					Stereoplotting				Stereoplotting					3)
Plotting and cartography at 1:			10000	10000	15000	10000		10000	16667	25000		16667	25000		25000	25000	10000
Drawn (d) or scribed (s)		s	d	s	s	d	mean	d	s	s	mean	s	s	mean	s	2)	3)
House corners: Percentage of residual errors at the scale of the map 1 : 25 000		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	< 0.1 mm	21	22	17	29	11	20	19	30	24	24	39	21	30	53	69	15
	> 0.1 mm	79	78	83	71	89	80	81	70	76	76	61	79	70	47	31	85
	> 0.2 mm	21	30	51	17	65	41	40	24	15	26	13	37	25	11	4	53
	> 0.3 mm	0	5	27	5	35	18	13	7	4	8	3	10	7	4	1	26
	> 0.4 mm	0	2	14	2	19	9	3	3	2	3	2	3	3	2	0	8
	> 0.5 mm	0	2	6	1	6	4	2	2	1	2	2	2	2	1	0	2
	> 0.6 mm	0	1	3	1	3	2	1	1	1	1	1	2	1	1	0	1
	> 0.7 mm	0	1	1	0	2	1	1	1	1	1	1	1	1	1	0	0
Roads, railways: Percentage of residual errors at the scale of the map 1 : 25 000	< 0.1 mm	47	27	37	53	29	36	31	43	42	39	53	33	43	51	65	25
	> 0.1 mm	53	73	63	47	71	64	69	57	58	61	47	67	57	49	35	75
	> 0.2 mm	15	32	29	14	34	28	23	18	22	21	16	30	23	15	3	34
	> 0.3 mm	4	6	12	3	14	9	3	3	7	4	3	11	7	4	1	12
	> 0.4 mm	2	3	4	2	5	4	0	2	4	2	1	5	3	1	1	5
	> 0.5 mm	1	2	2	1	1	2	0	1	1	1	1	1	1	0	1	2
	> 0.6 mm	0	1	2	0	1	1	0	0	0	0	1	0	0	0	0	0
	> 0.7 mm	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

1) regular revision 1975 with other photographs 2) plotting only 3) Stereo Facet Plotter manuscript only

6.2 General conclusions on positional accuracy of new items

The results of the verification of new items can be summarized by two major facts:

1. According to this test there is no significant difference between the stereoplotting and the orthophoto method.
2. The difference between stereoplotting with photography of 1:18 000 image scale and with photography of 1:30 000 is too small to be significant.

These results that could have been expected, however, should be considered in the light of the following conclusions:

3. The differences between the two scales and the two methods in terms of standard deviation are too small to be significant.
4. Stereoplotting and the orthophoto method are therefore equally well suited for the revision of maps 1:25 000.
5. There is practically no advantage of the larger image scale 1:18 000 over 1:30 000 with respect to accuracy.

In absolute terms the following general conclusions may be stated:

6. The planimetric errors of the entire revision process in up-dating a 1:25 000 map by photogrammetry are in the order of 0.2 mm.
7. The results obtained in the FRIBOURG test vary between 0.14 and 0.24 mm all categories of planimetric features included.
8. Errors larger than 0.6 mm are relatively infrequent; only about 1% of all verified new map details showed deviations exceeding 0.6 mm.

6.3 Detailed analysis of positional errors

With the overall results indicating that planimetric errors were very much under control and the overall accuracy of 0.2 mm quite acceptable and practically independent from the method used, special attention has been devoted to a detailed study of individual errors. If specific error sources could be detected, additional criteria for the choice of a method might be derived.

A good means for such a detailed analysis are the positional error vector representations in the figures 49 to 59. Millimetres of the error vectors correspond to metres on the ground. Such error vector representations have been prepared for all test samples and carefully studied for possible error sources and their influence on the positional accuracy.

Systematic positional errors

In some cases the total vector display indicates an overall systematic error, with obviously a translation in the order of 0.1 mm. For the two most evident cases the average translations were computed as follows:

	$\Delta y_{(mm)}$	$\Delta y_{(mm)}$	method
Land Survey Office Baden-Württemberg, Stuttgart	-0,10	+0,10	ortho
National Board of Survey, Helsinki	-0,09	+0,08	stereo
Topographical Service, Delft (for comparison)	+0,03	-0,05	ortho

House corners only were used to determine these shifts, because deviations of roads can be measured only perpendicularly to the axes.

These translations could be located already in the compilation manuscript in both cases.

In quite a number of other cases translations occurred more locally in certain restricted areas. There were two orthophoto tests, each of them with two areas of less than one km^2, that showed uniform displacements of the order of 0.2 mm. Practically the same observations could be made on three of the six stereoplotting tests. The areas with such systematic translations are relatively small in this method. It may well be that the operators adapted the absolute orientation to the planimetry locally. In the test performed by the Geographic Survey of Norway with three models at the image scale 1:18 000, there is obviously a slight shift of the absolute orientation between the three models, as can be deduced from the following figures:

Land Survey Office Baden–Württemberg
Orthophoto at 1 : 10 000 and draughting at 1 : 10 000

Fig. 49 : Residual error vectors of house corners, road and railway axes

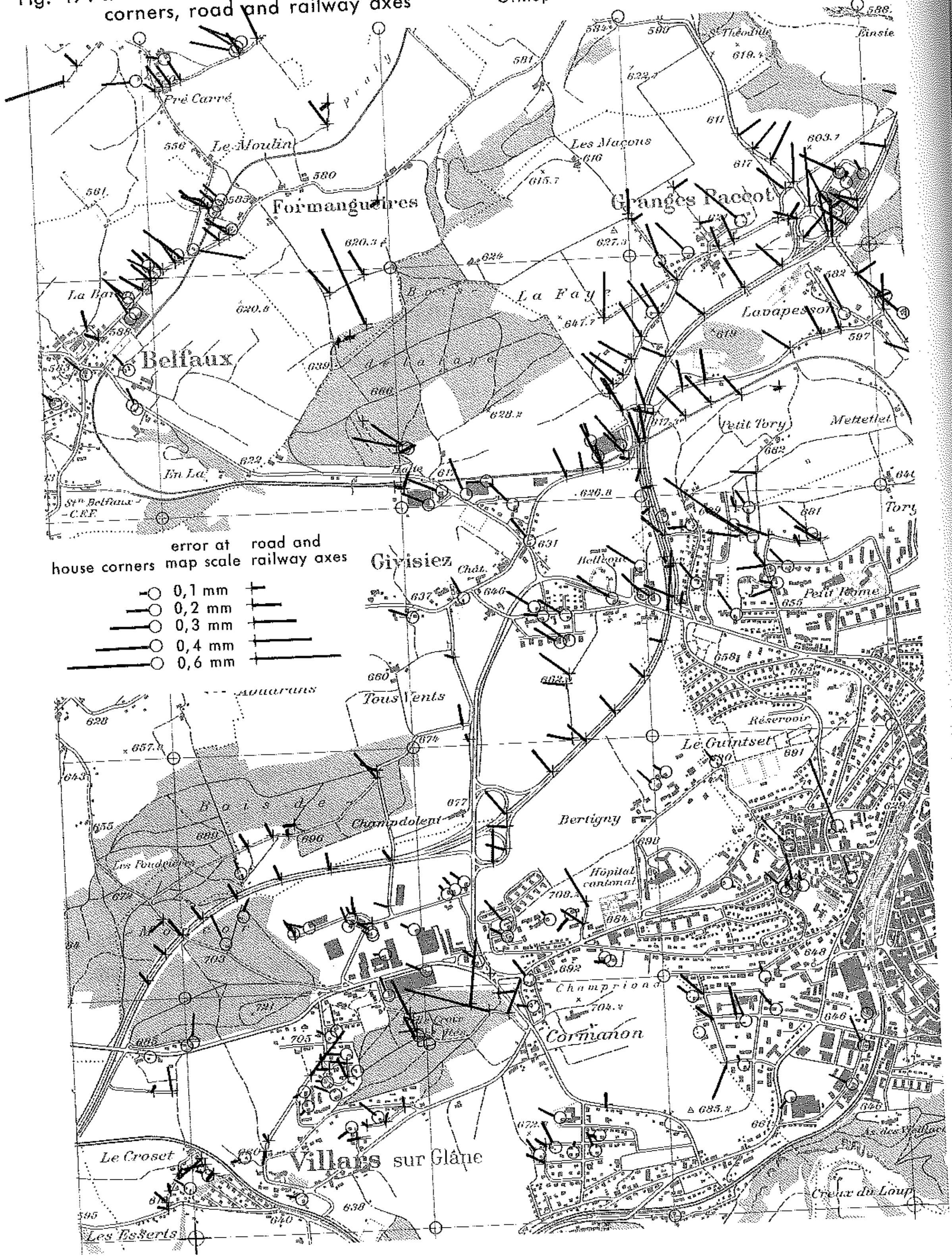


Fig. 50 : Residual error vectors of house corners, road and railway axes

Institute for Applied Geodesy, Frankfurt/M, FRG
Orthophoto 1:10 000 and scribing at 1:10 000

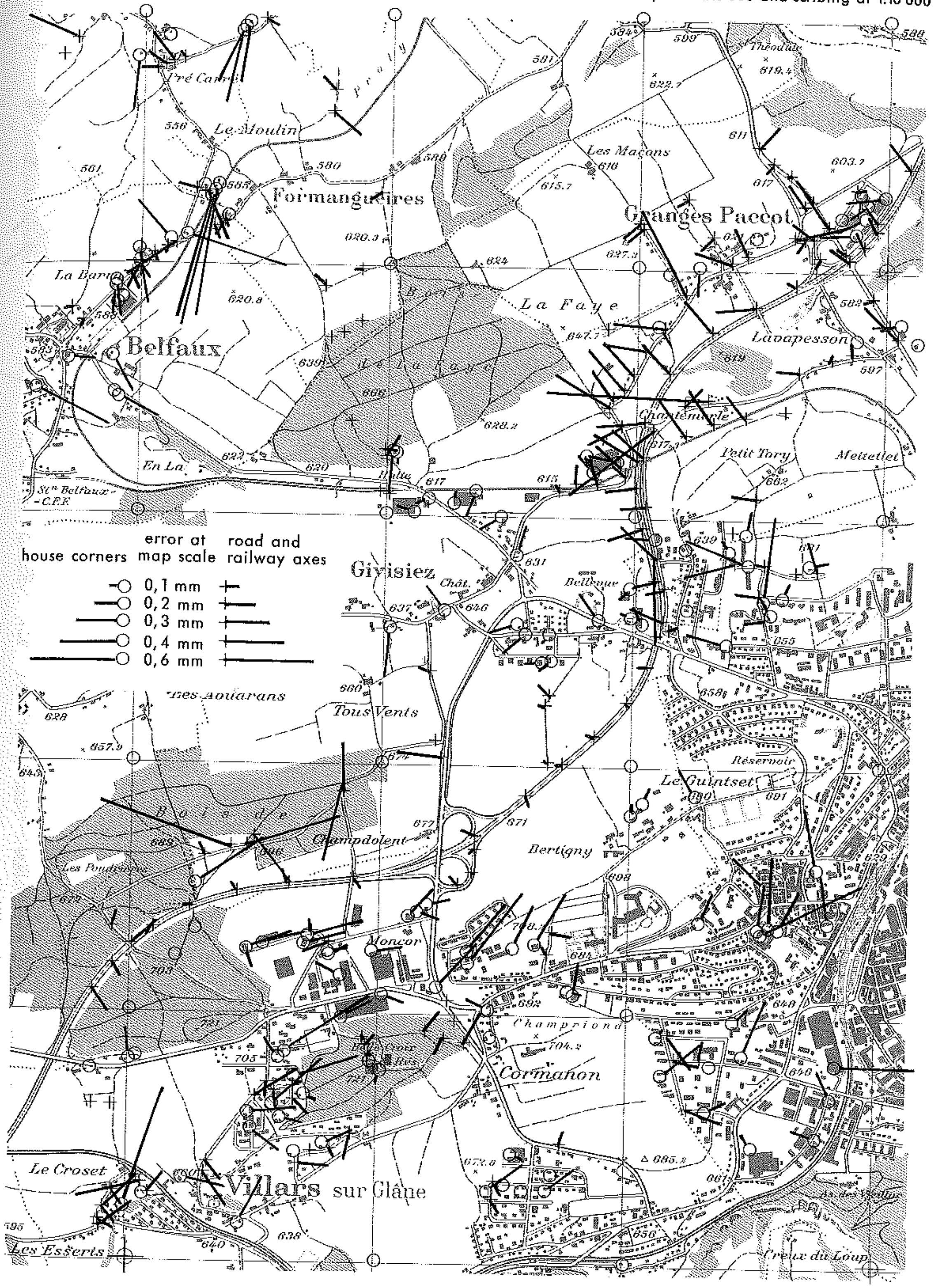


Fig. 51 : Residual error vectors of house corners, road and railway axes

Topographic Service of the Netherland, Delft
Orthophoto production and scribing at 1:15 000

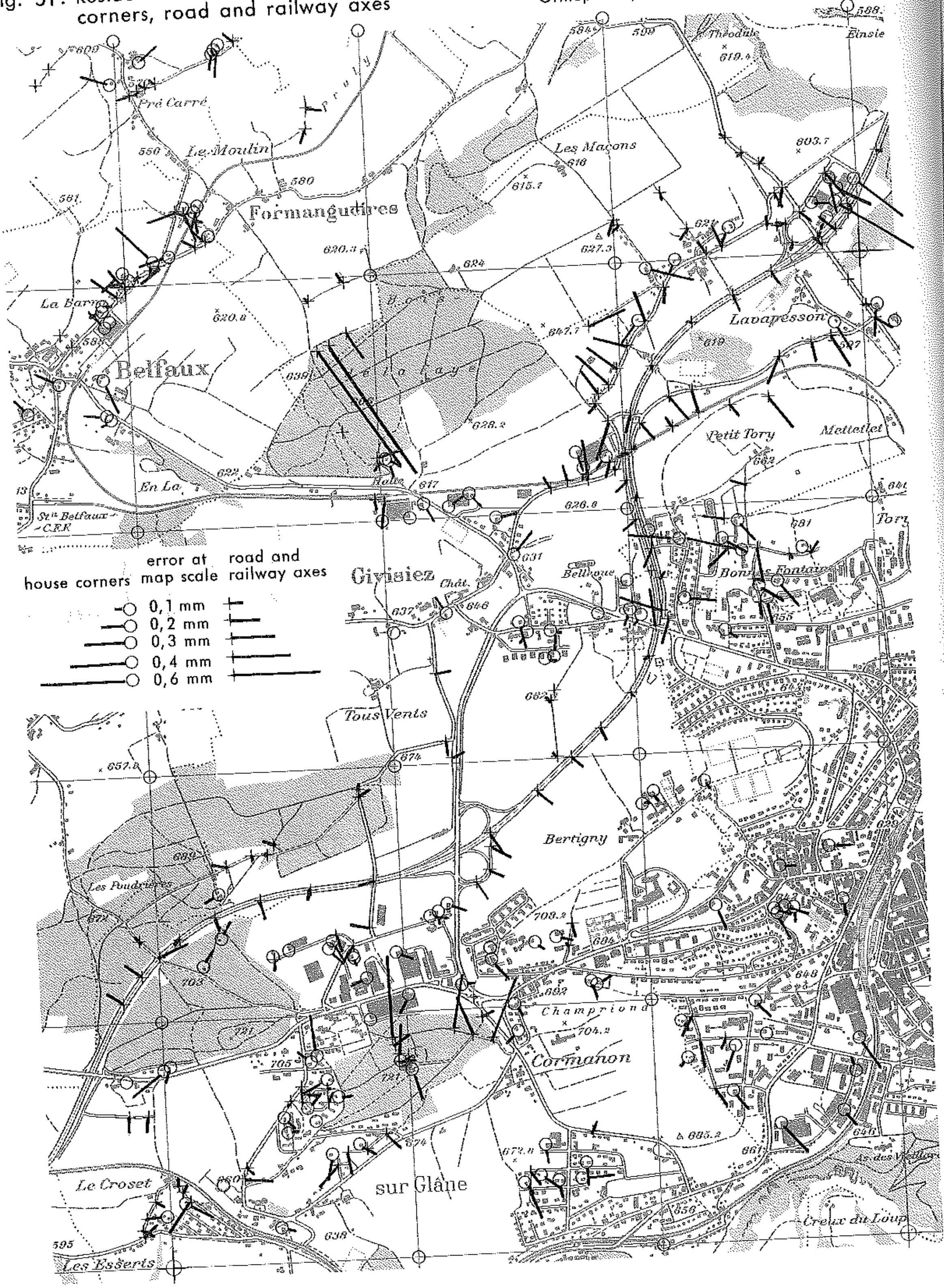


Fig. 52 : Residual error vectors of house corners, road and railway axes

National Board of Survey, Helsinki, Finland
Orthophoto 1:10 000 and draughting at 1:10 000

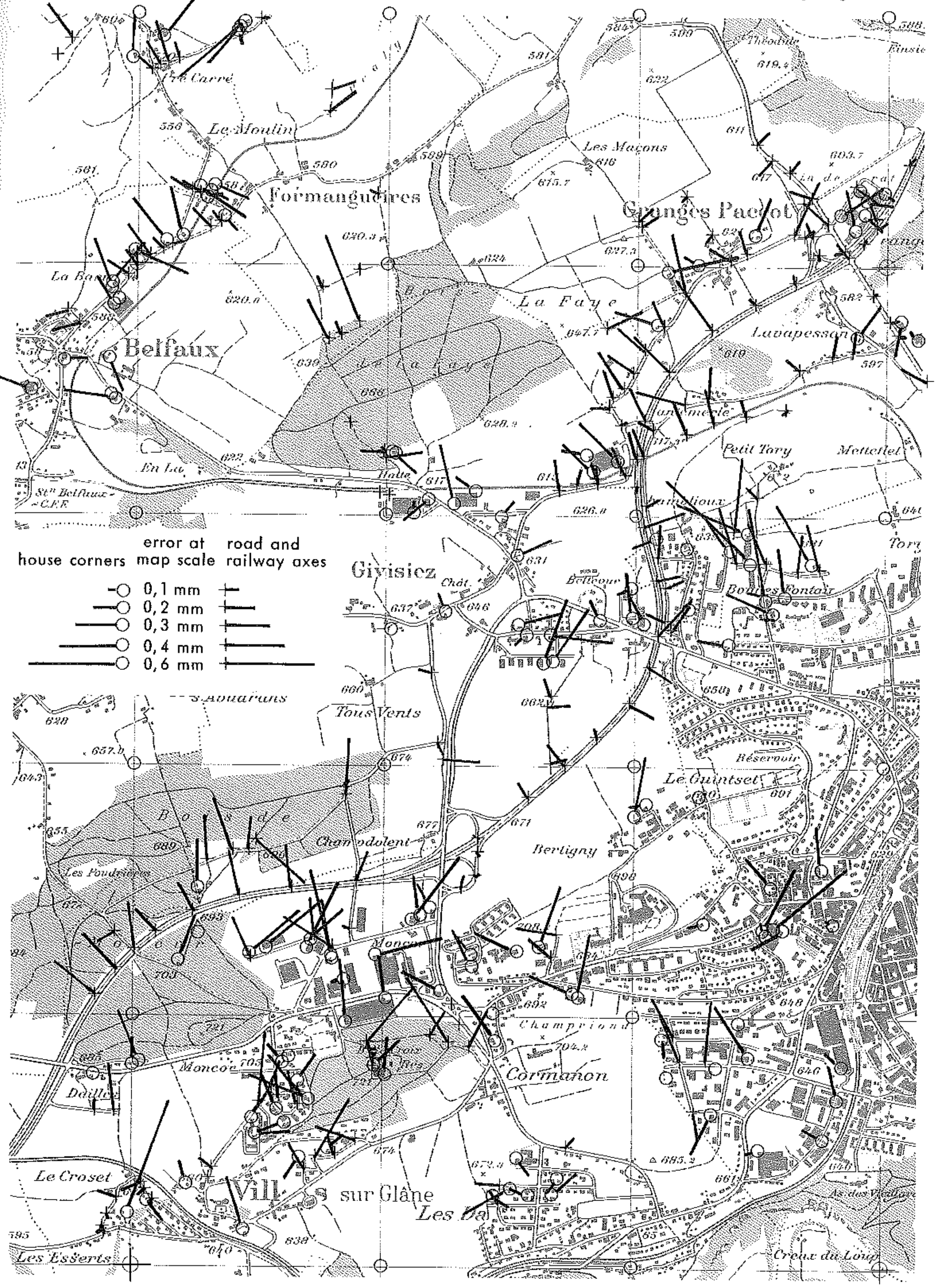


Fig. 53 : Residual error vectors of house corners, road and railway axes

National Board of Survey Helsinki, Finland

Stereoplotting from 1:30 000 imagery and draughting at 1:10 000

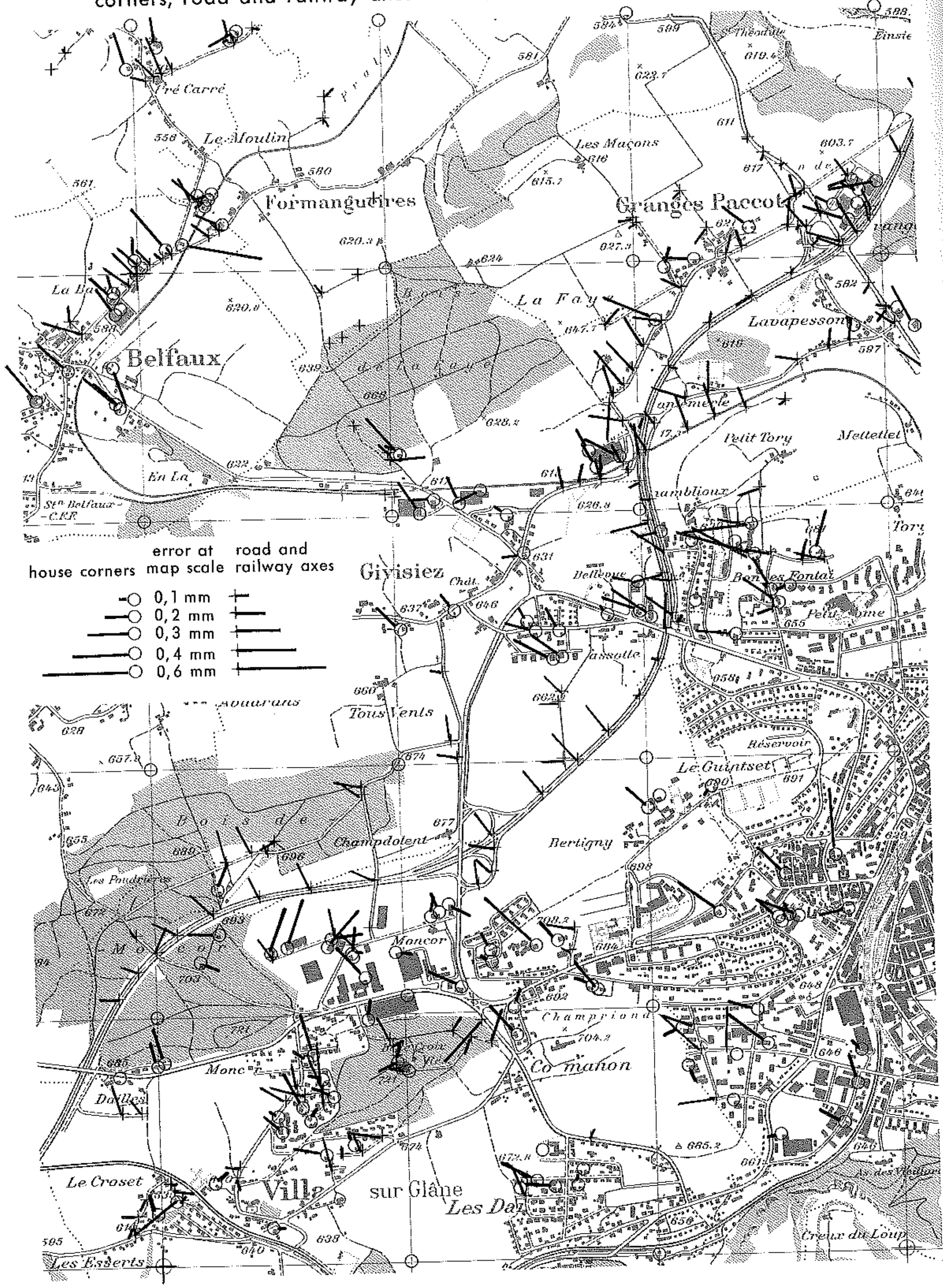


Fig. 54 : Residual error vectors of house corners, road and railway axes

National Geographic Institute of Belgium, Brussels

Stereoplotting from 1:30 000 imagery and scribing at 1:16 667

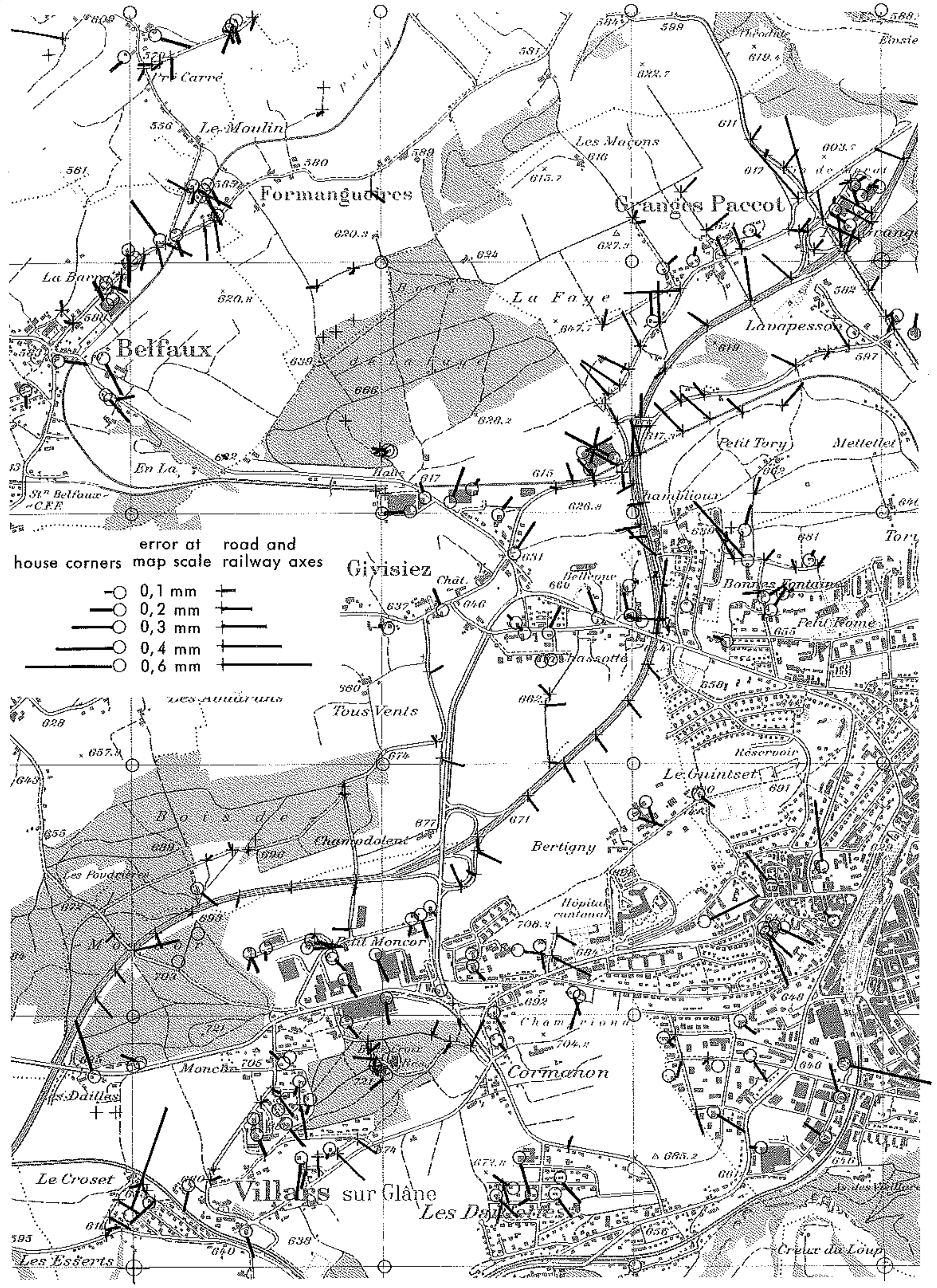


Fig. 55 : Residual error vectors of house corners, road and railway axes

Geographical Survey of Norway, Oslo
Stereoplotting from 1:30 000 imagery and scribing at 1:25 000

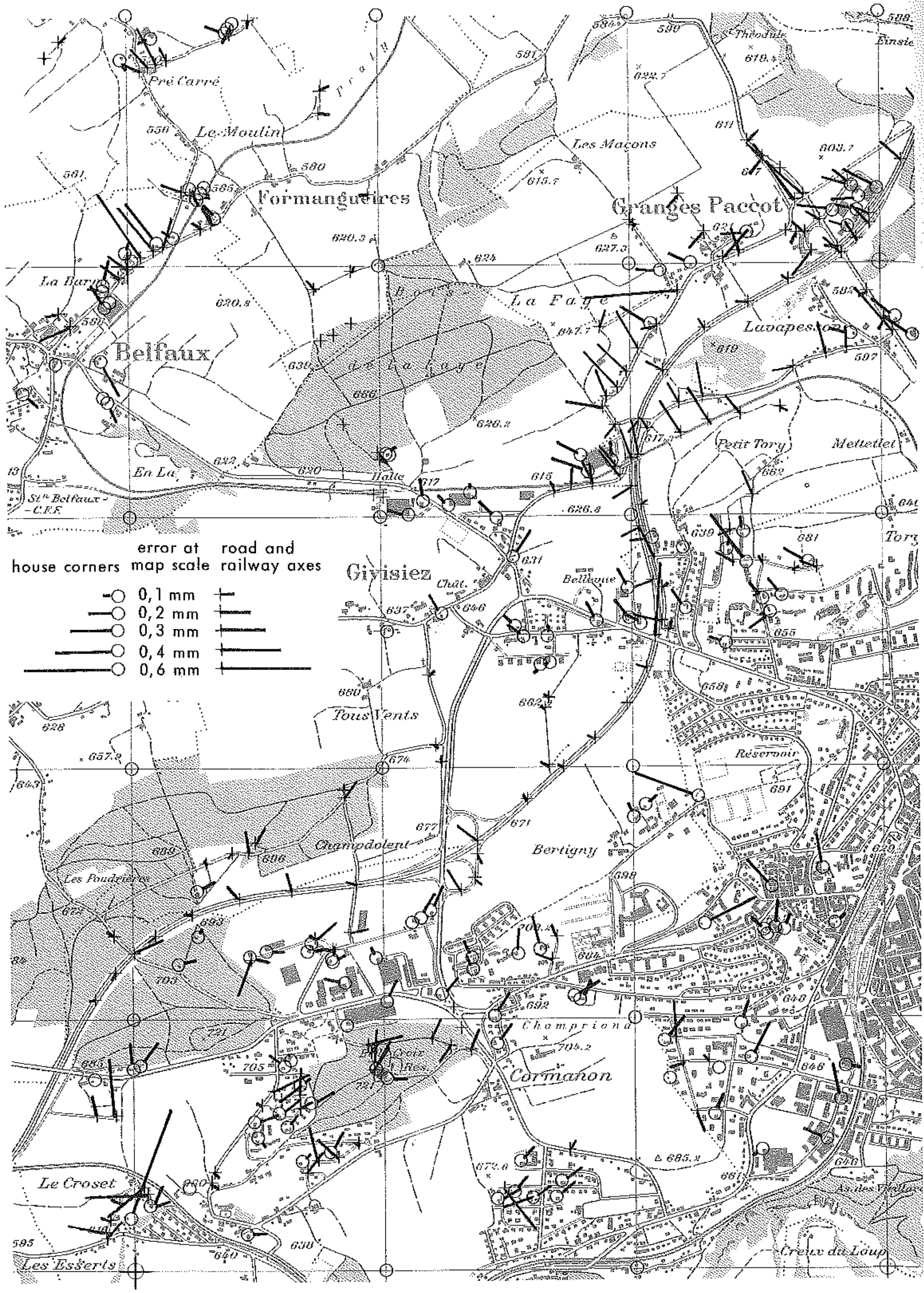


Fig. 56 : Residual error vectors of house corners, road and railway axes

National Geographic Institute of Belgium, Brussels
Stereoplotting from 1:18 000 imagery and scribing at 1:16 667

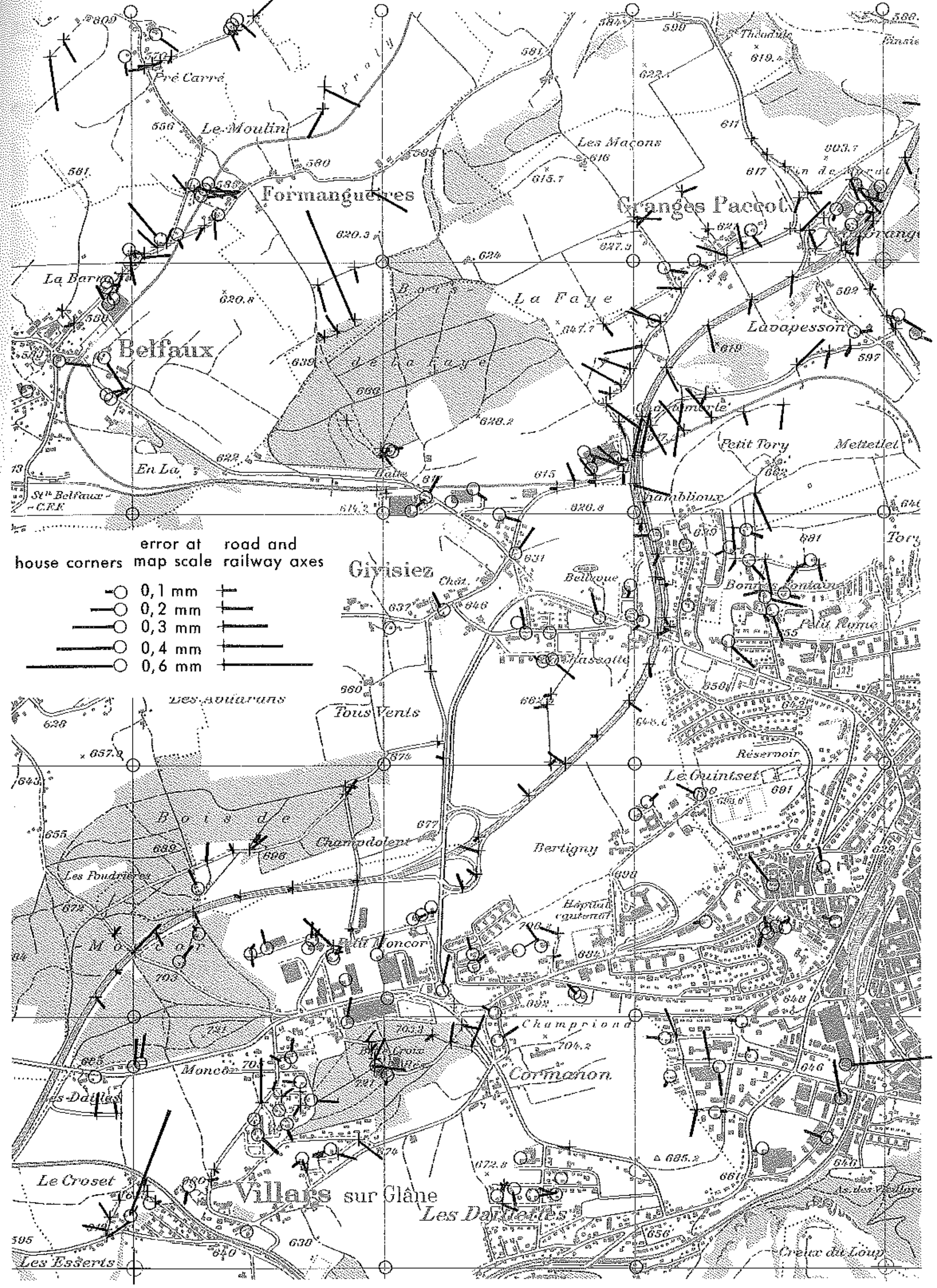


Fig. 57 : Residual error vectors of house corners, road and railway axes

Geographical Survey of Norway, Oslo
Stereoplotting from 1:18 000 imagery and scribing at 1:25 000

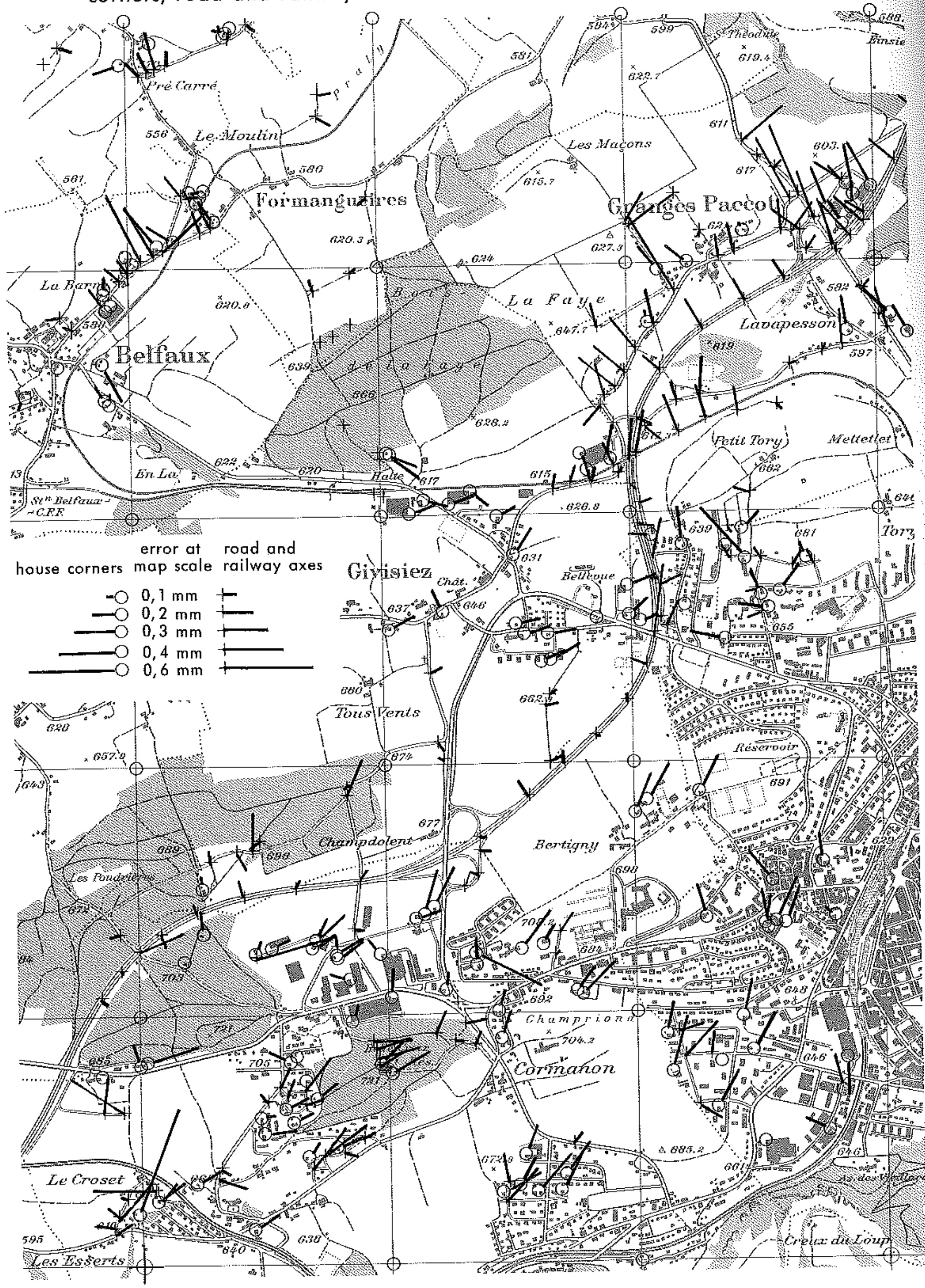


Fig. 58 : Residual error vectors of house corners, road and railway axes

Swiss Federal Office of Topography, Wabern
Stereoplotting from 1 : 27 000 and scribing at 1 : 25 000

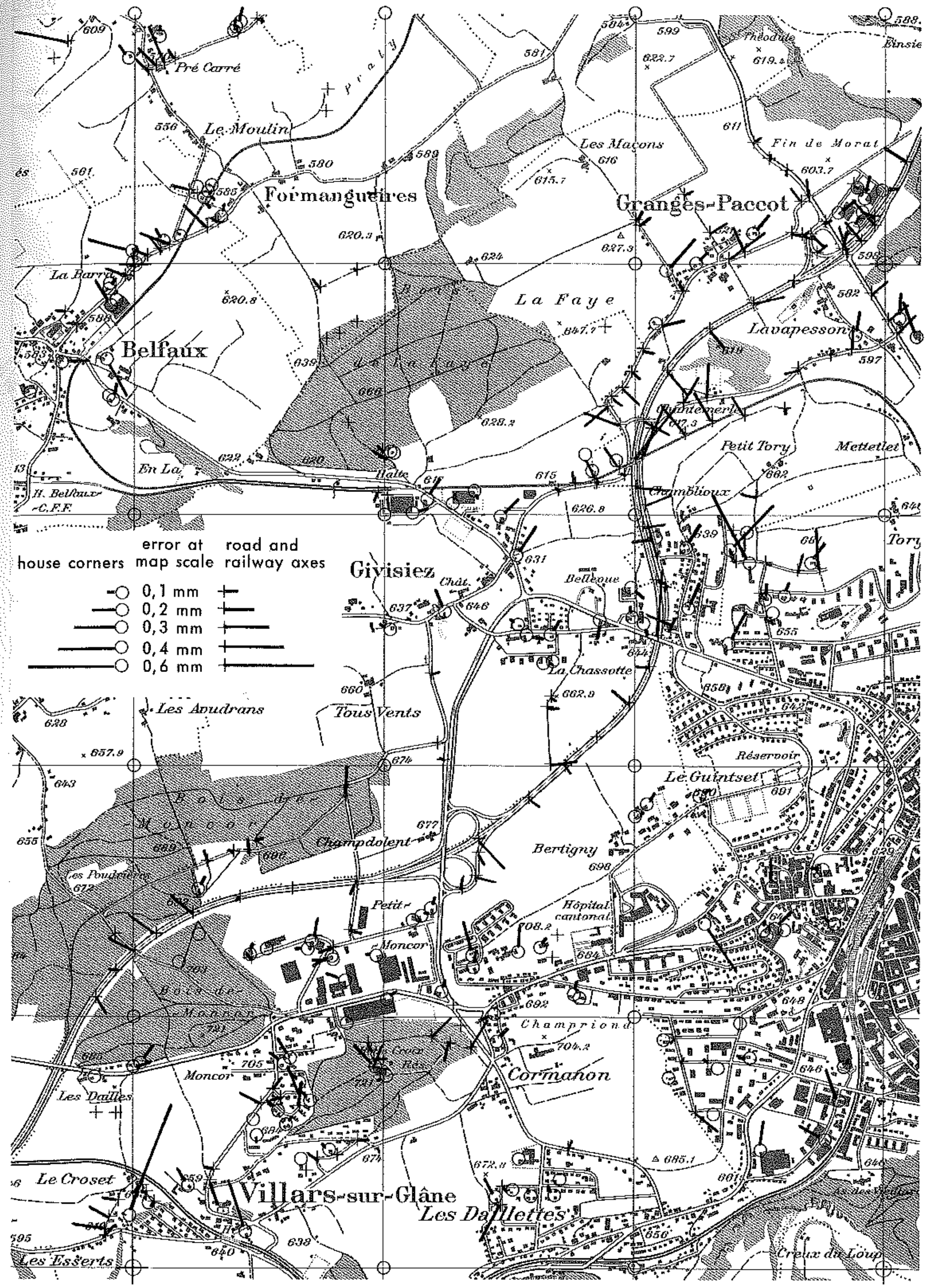
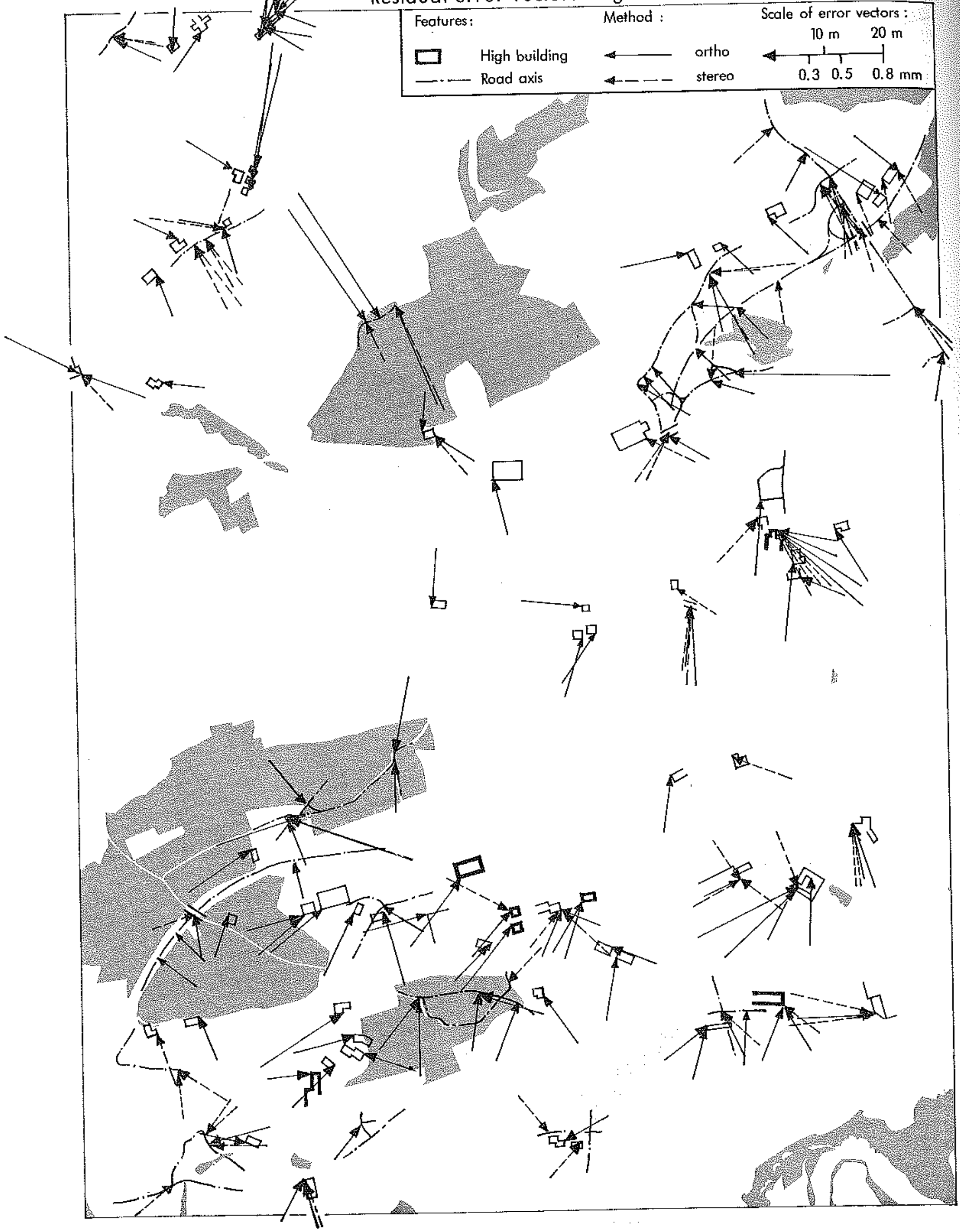


Fig. 59 :
Residual error vectors larger than 0.3 mm, all tests included



model	Δy (mm)	Δx (mm)	number of verification points
1824/26	-0,06	+0,09	34
1826/28	+0,05	+0,06	31
1828/30	+0,08	+0,13	68

Individual positional errors

In addition to this general analysis of systematic translations, some interpretation of individual errors was attempted. Only positional errors exceeding 0,3 mm, i.e. the accepted tolerance in this topographic map, have been further considered. They are plotted on figure 59, separately for the orthophoto and the stereoplotting method.

From the error statistics in table 6 it becomes evident that with reference to house corners there are slightly more errors exceeding 0,3 mm in the orthophoto method than in stereoplotting. The same is true for other categories, roads, railways etc. It is supposed that the reason for this fact lies in the advantage of the stereointerpretation. The unexpectedly good result of the orthophoto method is to a certain degree due to the enlargement of the images to 1:10 000 or 1:15 000.

The individual differences between contributions using the same method are considerable. Some of this effect is apparently due to lack of experience with the technique concerned, because some centres performed the test for their own purpose as internal experimental work using a new technique. Therefore not all contributions can be considered as the result of an experienced team.

A number of errors are due to the fact that new extensions to houses have not been detected. Both methods are equally represented in this group. Some gross errors seem to originate in different treatment of the generalisation of the outlines, although special care has been taken in the selection of the verification points to avoid generalisation problems. In 8 cases this effect may be the reason for a larger deviation.

High buildings were supposed to produce larger positional errors especially in the orthophoto compilation. The same was expected for house corners, hidden due to perspective conditions or cast shadows. There are 9 deviations of corners of high buildings exceeding 0,3 mm at map scale, all of them produced by the orthophoto method. One restitution centre (TD), having considered this effect to be a critical one in orthophoto compilation included therefore high buildings in the process of stereoplotting topographic features, avoiding this way any gross error of this kind.

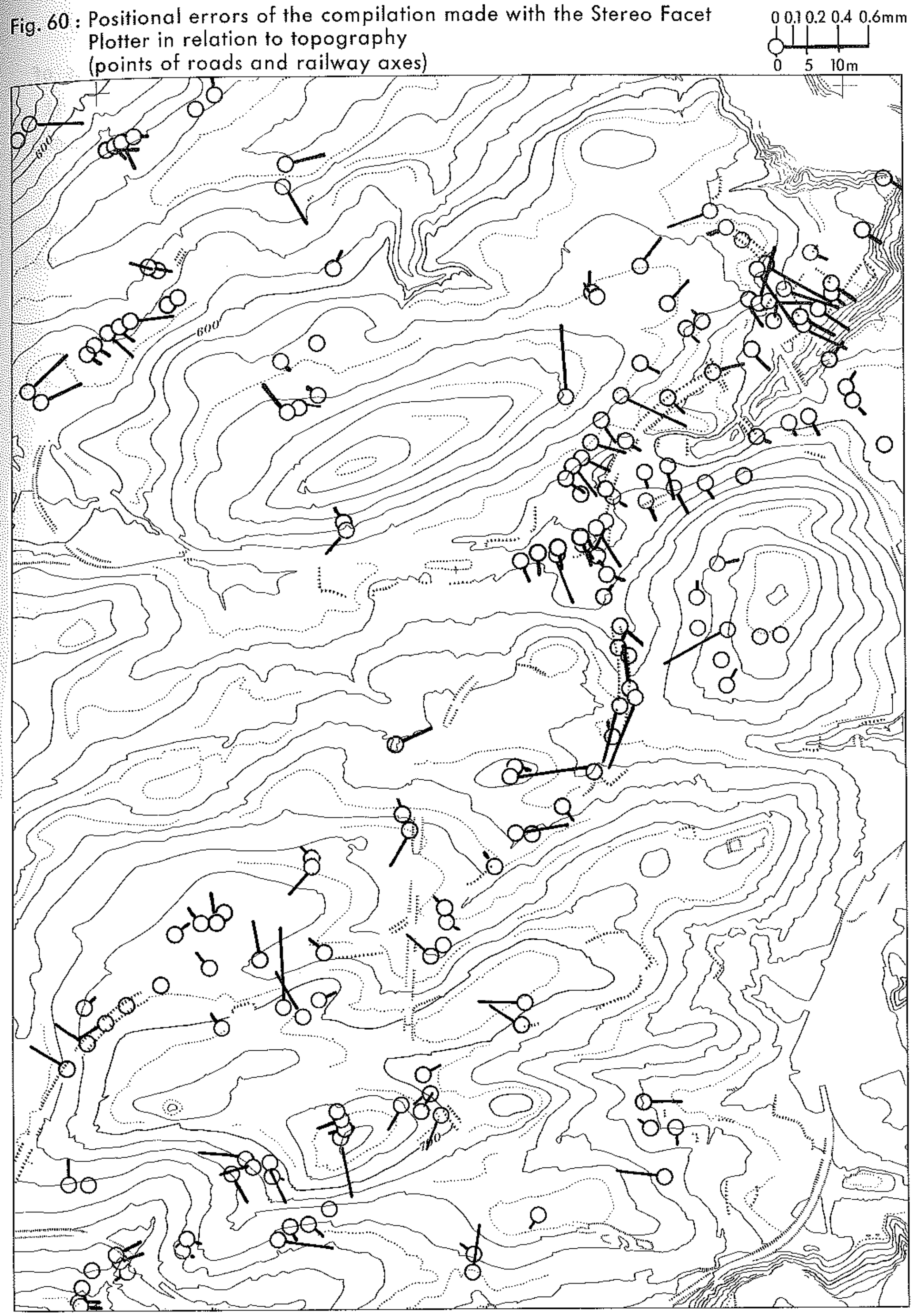
Hidden corners due to the central perspective of the photographs may be the reason for some 16 larger errors in orthophoto compilation, obviously predominantly in those test samples produced by less experienced personnel.

There are 13 verification points situated on road axes within woodland areas in which gross errors have been found. As was to be expected, they occur especially in those tests using the orthophoto method. Stereo-interpreting is certainly more accurate for new forest roads than compiling them from one photograph only.

In three cases roads had been subjected to minor corrections. These changes have all been detected by orthophoto compilation, but in stereoplotting some operators have overlooked them. A number of deviations of 0,3 mm concerned the motorway, both methods included. No specific reason can be given for these errors. Finally we might mention that bridges seem to be somehow critical with respect to positional accuracy.

A special case is the compilation that has been made in Helsinki with the Stereo Facet plotter. Again the overall accuracy computed from the errors measured in the compilation manuscript is surprisingly good. The method seems to be suited under the given conditions for a single revision. Some reservations would have to be made on whether the homogeneity of the map would not suffer in a whole series of subsequent revisions, the positional error of 0,24 mm being at the upper limit. Unfortunately the compilation itself is not documented. It was no longer possible to determine the borders of the facets, information needed when one looks for correlations to the errors detected. Fig. 60 gives the positional errors for points on road and railway axes in relation to the topography represented in contour lines. Here again there is no obvious interdependence to the steepness of the terrain.

Fig. 60 : Positional errors of the compilation made with the Stereo Facet Plotter in relation to topography (points of roads and railway axes)



6.4 Positional errors introduced by photographic reproduction

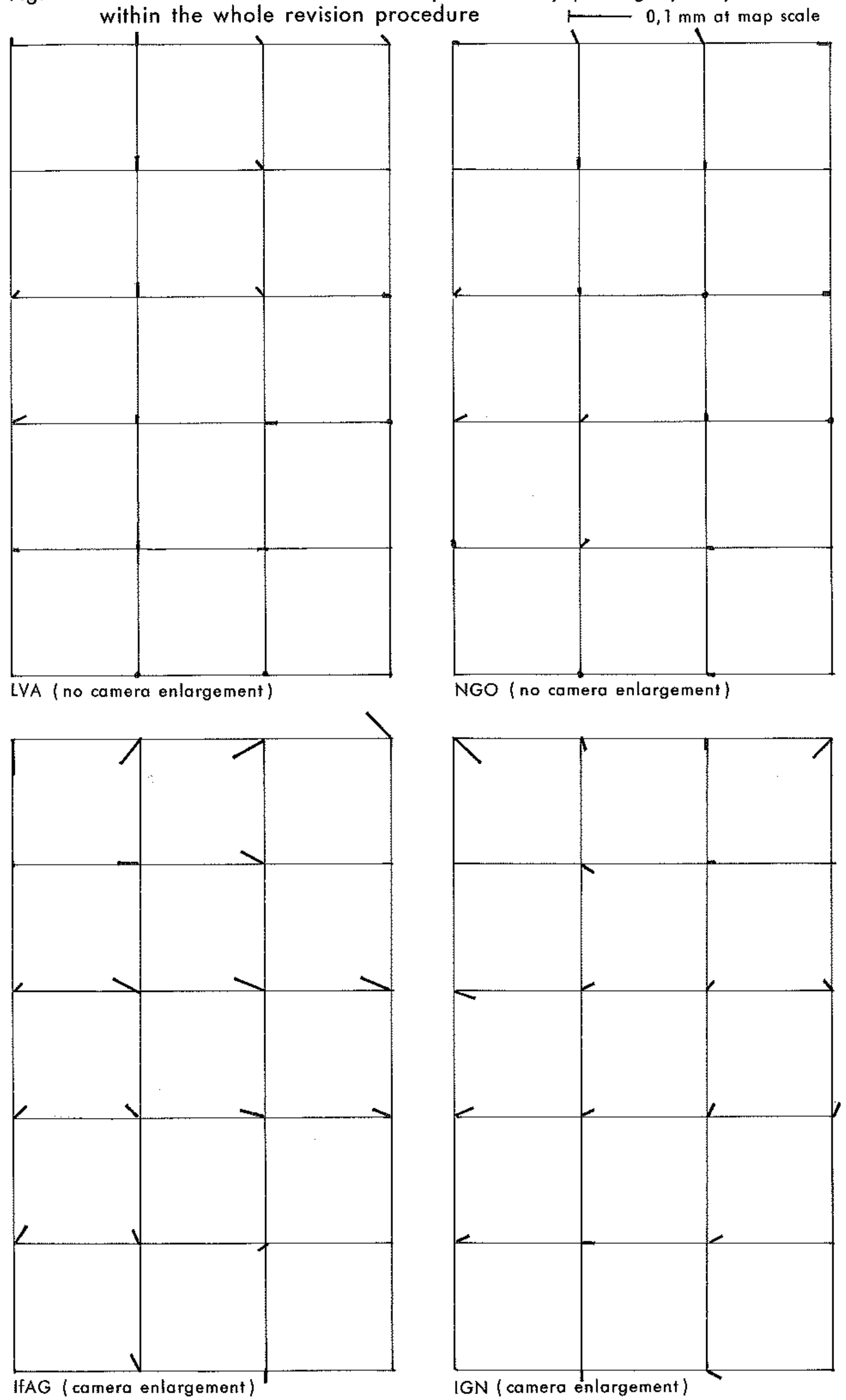
Obviously most centres make use of the reproduction camera for enlargements of the base map and for final reduction again to publication scale. Therefore it was a question of precaution to check also for possible distortions introduced by these reproduction processes.

Though all recognizable grid corners were recorded as well in the stereocomparator, the necessary data for checking the grid was also obtained. The residual error vectors were calculated after the usual transformation with four grid corners. For four samples they are plotted in figure 61.

The two upper samples show the residual deformations in two cases where no camera work was involved. The two bottom samples which show definitely larger distortions, have been enlarged and reduced again in the camera. But even here no grid corner deviates more than 0.06 mm. This evidence shows that reproduction did not introduce any significant deformations that would have affected seriously either the map result or the accuracy checks.

In view of the relatively small format of our map samples this was to be expected. In practice, where larger formats are usually handled, this aspect should not be neglected. The upper left sample also illustrates the result after two subsequent photomechanical copies on Astralon. Due to the small format again the suitability of this material cannot be assessed in this test.

Fig. 61: Residual errors of the base map caused by photographic processes within the whole revision procedure



6.5 Completeness and correctness of buildings in the revised map

The principal aim of this test was not to measure the semantic information obtainable in a map revision process using photogrammetric methods, but much more to study economic solutions to the map revision problem at this scale. However, one of the major decisions to be made is to determine the amount of field identification needed to assure a high degree of completeness and correctness in the final map.

It had been decided by the Commission beforehand that every centre should receive a field identification for the entire road network, but no information on buildings except on demand.

All types of new houses, including garages that are in part underground, had therefore to be derived solely from the aerial photos. Assistance was of course provided by the existing houses on the original base map for the test, i.e. before the year 1968. They served at least partly as a key for the way in which the new ones were to be represented.

Some verification was therefore devoted to check the completeness of buildings within the test area and on each individual map sample.

The final positives for the black plate were used for this purpose.

The buildings were grouped in 5 categories: large industrial and large residential buildings; the largest group of medium and small houses; those very small houses or huts, that are represented only exceptionally, but normally left out; and those garages in rows that are mainly underground - these can be represented by a wall symbol, if they are not shown as houses.

Initially, the actual number of buildings in each category was counted grid by grid on the original base map, 1968 edition. The actual number at the time the photographs had been taken was determined on the basis of the complete field identification done two weeks after flying the photography. The following table gives the number of buildings in each category within the test area:

Table 8: Number of buildings represented in the revised map

	image scale										field verification
	1 : 18 000		1 : 30 000								
Interpretation method (stereo s, orthophoto o, monocular m)	s	s	s	s	s	s	o	m,o	s,o	s	
number of buildings	IGN B	NGO N	NSB SF	IGN B	NGO N	NSB SF	LVA D	IFAG D	TD NL	LT CH	correct number of buildings
large industrial buildings											
new ones added	17	17	17	15	17	17	17	17	17	17	17
deleted buildings	1	1	1	0	1	1	1	1	1	-	1
old shape to correct	13	10	14	13	13	10	15	12	13	15	15
bad shape	3	0	0	1	2	0	1	3	2	0	0
large residential buildings											
new ones added	14	14	14	14	14	14	14	14	14	14	14
deleted buildings	0	0	0	0	0	0	0	0	0	-	0
old shape to correct	2	2	2	2	2	2	0	0	2	2	2
bad shape	0	0	0	0	0	0	1	0	0	0	0
medium and small size buildings											
new ones added	342	345	334	326	335	348	341	335	333	355	359
deleted buildings	72	60	59	65	61	70	80	64	69	-	90
old shape to correct	8	9	9	8	7	11	10	8	10	15	15
bad shape	23	11	42	27	11	15	5	44	13	1	0
too much added	1	0	2	1	2	1	0	1	1	3	0
too much deleted	0	0	0	0	0	0	0	1	1	-	0
Total of new buildings added	373	376	365	355	366	379	372	366	364	386	390
Total of deleted buildings	73	61	60	65	62	71	81	65	70	-	91
Total of corrected shapes	23	21	25	23	22	23	25	20	35	32	32
Total of correct operations	469	458	450	443	450	473	478	451	459	418	513
Total of all bad shapes	26	11	42	28	13	15	7	47	15	1	0

Table 7: Number of buildings in the test area

	1968	1968 - 1976			1976
	existing	con-structed	new shape	disap-peared	existing
Large industrial buildings	32	+ 17	15	- 1	48
Large residential buildings	39	+ 14	2	0	53
Medium and small size houses	1873	+ 359	15	- 90	2142
Very small houses and huts	-	+ 30	-	-	30
Underground garages	45	+ 83	2	0	128

If the very small houses and huts are to be ignored, a total of 596 changes had to be made with regard to buildings in the test area. This implies that as much as 30% of the settlement situation had in some way been altered in the 8-year period since 1968.

The realisation of these changes was checked grid by grid, all ten stereorestitutions in parallel. Every change was also evaluated in terms of shape. If the form of the building deviated too much from the one in the large scale plans 1:1 000, or if it was completely disoriented, it was recorded in the column "bad shape".

The results of this verification procedure are listed in tables 8 and 9. It should not be considered as a judgement of the individual restitution, but primarily in terms of different image scales and methods used.

If the total number of necessary operations —additions, corrections or deletions — is interpreted, it becomes evident that there is absolutely no difference, whether the much larger image scale of 1:18 000 or that of 1:30 000 was used for interpretation. The mean score of correct representations was 85% in both cases.

A number of centres using photo enlargements at the scale 1:10 000 achieved no significant improvement over those operators interpreting directly during stereoplotting. Also the preidentification under a mirror stereoscope applied by several centres did not show an improvement on the results. It seems, however, that operators with practical experience in revision work at this map scale attained results that were on average 6% better than those of others.

If we are to examine the results in detail, we find that 95% of all new buildings and houses were added. The few smaller ones missing are mainly situated in densely built-up areas. The representation of rows of underground garages is a

Table 9: Percentage of buildings correctly represented in the revised maps

Interpretation method: stereo s, orthophoto o, monocular m	1 : 18 000		image scale 1 : 30 000								Mean of	
	s	s	s	s	s	s	o	m,o	s,o	s		
% of buildings	IGN B	NGO N	NSB SF	IGN B	NGO N	NSB SF	LVS D	IfAG D	TD NL	LT CH	all centres	number of buildings
large industrial buildings												
new ones added	100	100	100	88	100	100	100	100	100	100	99 %	+ 17
deleted buildings	100	100	100	0	100	100	100	100	100	-	89 %	- 1
shape corrected	87	67	93	87	87	67	100	80	87	100	86 %	15
correct operations	94	85	97	85	94	85	100	91	94	100	93 %	
large residential buildings												
new ones added	100	100	100	100	100	100	100	100	100	100	100 %	+ 14
deleted buildings	100	100	100	100	100	100	100	100	100	-	100 %	0
shape corrected	100	100	100	100	100	100	100	100	100	100	100 %	2
correct operations	100	100	100	100	100	100	100	100	100	100	100 %	
medium and small size buildings												
new ones added	95	96	93	91	93	97	95	93	93	99	95 %	+ 359
deleted buildings	80	67	66	72	68	78	89	71	77	-	74 %	- 90
shape corrected	53	60	60	53	47	73	67	53	67	100	63 %	15
correct operations	91	89	87	86	87	92	93	88	89	99	90 %	
Total % of correct operations	91	89	88	86	88	92	93	88	89	99	90 %	
bad shapes in % of new buildings	6	2	9	6	3	3	1	10	3	0	4 %	

symbolisation problem in this type of map. They were not specifically requested in the test specifications and are therefore not discussed or included in the results. What was more unexpected was the large percentage (26%) of omitted deletions in the smaller house category. The distribution of these mistakes indicates that more care is needed in general concerning this type of change. From the results the influence of the plotting method is evident. During stereoplotting, it seems to be rather difficult to detect demolished houses. It might be worth remembering here an old wish of all operators engaged in map revision: a device to bring the map to be revised into the field of view. On the other hand the overprinting of the remaining planimetry on the orthophoto causes some problems too, a fact that is however not reflected by the results of the test.

In order to allow for a more thorough analysis of the typical kind of situation in which omissions occur, for houses all clearly identifiable omissions made by one or more of the participants have been recorded on the up-dated planimetry (see figure 62). The large circles indicate the respective house, the dots above the number of errors that occured in stereoplotting and the ones below the errors made when using the orthophoto method. Small circles have been used to indicate small houses or garages omitted in most test samples.

The small circles refer to 43 new small buildings, mainly garages, that were not added by the majority of the participants supposedly because they are below the usual threshold of size that merits a representation.

The interpretation of figure 63 shows that from the 81 houses that were involved in the total of 171 cases of omissions, half of them have been overlooked by only one of the nine operators. 8 houses only were omitted by more than half of all participants. One of these was located in a forest, three of them were still in construction and two of them in the middle of an existing densely built-up area. In 6 cases in one and the same test sample a whole group of houses in a small restricted area were omitted. All other cases concerned obviously single houses here and there, many of them away from larger recently built-up areas.

There were 21 evident cases of necessary deletions of an old house that led to 77 errors. On average in 4 of the 9 test samples a certain house was not deleted. Astonishingly enough in 15 of 21 cases these deletions concern houses next to a number of others that were added.

Another critical element is the changes occurring on existing buildings. Only 75% were detected; in the category of small houses only 65%. Not enough care is normally given to building extensions. The 15 most prominent changes are in-

Fig. 62 : Result of the verification for completeness of houses

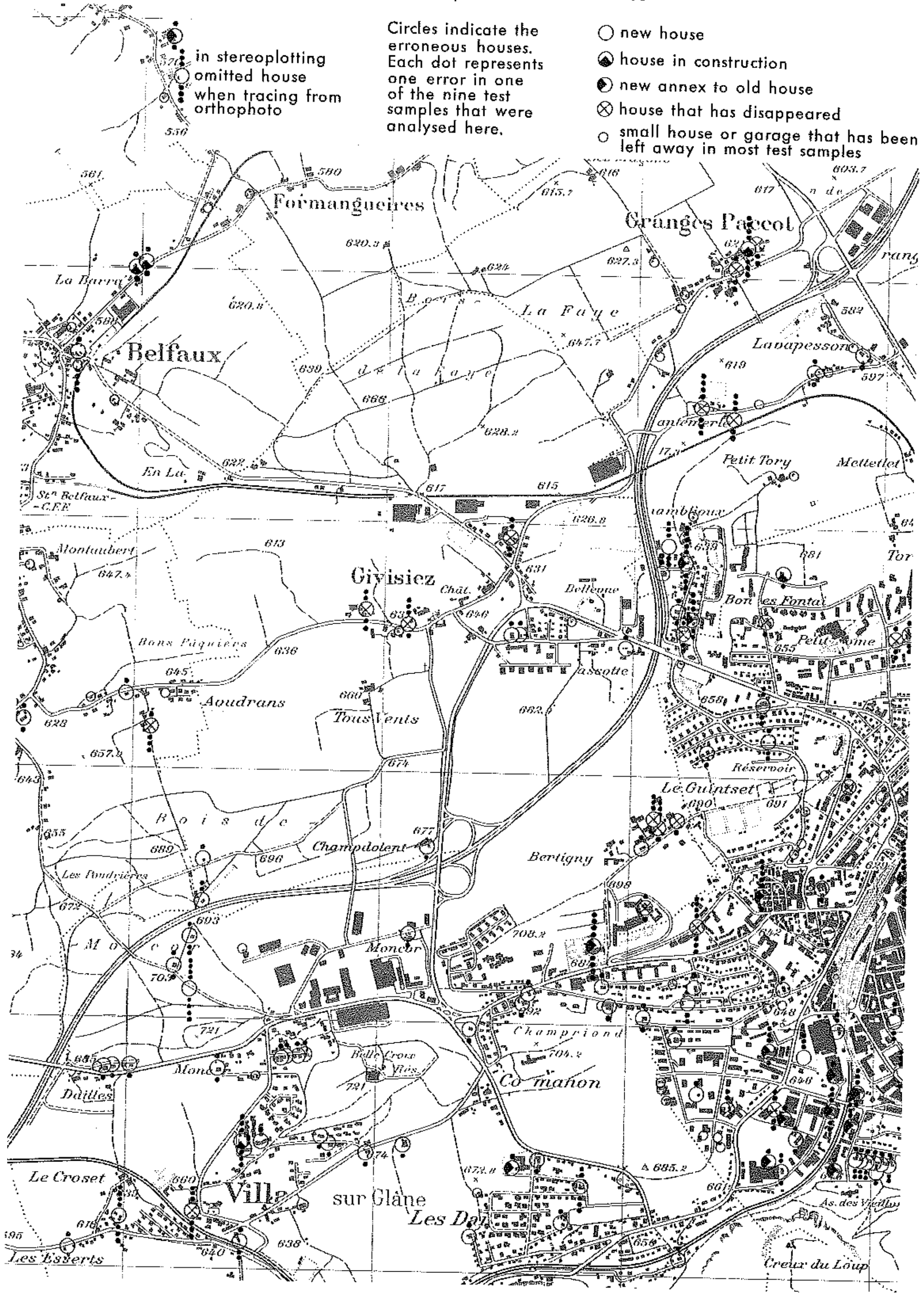
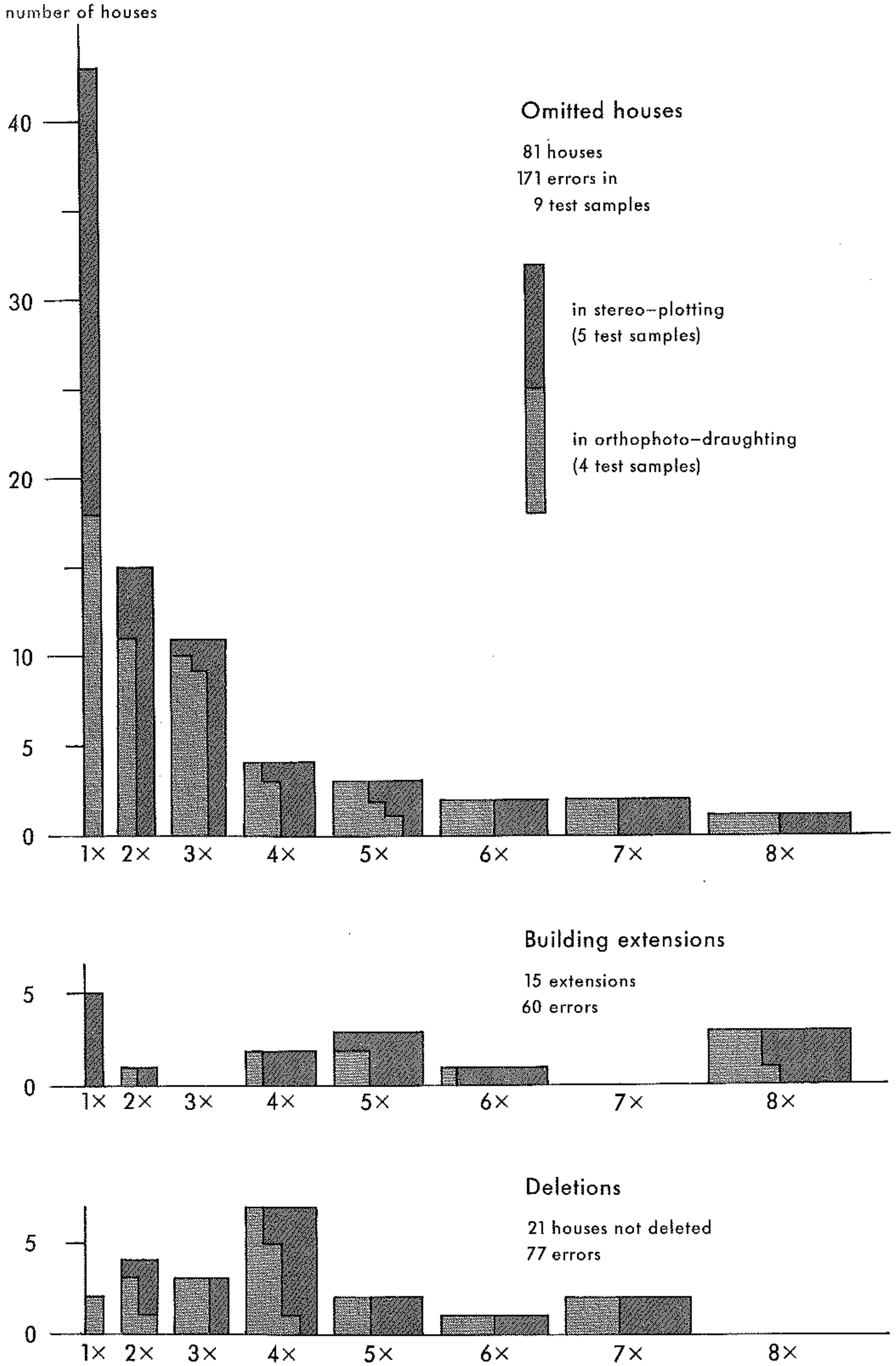


Fig. 63 : Frequency of omissions of houses, building extensions and deletions



dicated in tables 8 and 9. They were the cause for 60 errors, which indicates that approximately half of the participants did not recognize these extensions. The two tables 8 and 9 show that none of the two methods has a significant advantage over the other one with respect to the problems discussed above.

The general evaluation of form of the new houses plotted indicates that 4% of them do not have their characteristic shape or orientation. The poorer results are again found in the medium- and small-sized buildings. This is said with some caution as some of these errors may be due to different generalisation attitudes. This becomes evident if one compares the various treatments of the new settlement north of the church of Villars. The generalisation problems will be discussed in a special chapter.

No obvious conclusion can be drawn from the figures as to the best method for reproducing good shapes. Rather ironically shapes were relatively worse, where plotting was done at 1:10 000, though with a clear exception in one case.

Under the heading of completeness in map revision one has to consider also, if all elements that have disappeared have really been deleted. Figure 65 gives a precise inventory of all detail on the map published 1968 that must no longer be shown in the up-dated map. All elements have been included in this representation. Revision work has to be as careful in this aspect as in adding new items. Detection of change that leads to deletions is therefore quite critical. Every small map detail must be examined and compared with the aerial photograph. The result of the test in this respect is included partly in this chapter and partly in the next one.

In conclusion we can sum up the findings from this part of the verification with the following remarks:

1. Completeness of new buildings is generally very good, but- as was to be expected- decreases with the size of the houses.
2. More care has to be given to deletions of demolished houses and to alterations on existing houses and industrial buildings.
3. From the point of view of completeness and form, none of the methods used seems to offer noticeable advantages.
4. As positive surprises or confirmations we can note the facts that:
   a) the image scale 1:30 000 is absolutely as competent as 1:18 000 and
   b) that direct interpretation during stereoplotting, even at 1:30 000, means no loss of quality when compared to interpretation with the help of 1:10 000 enlargements or orthophotos.

Fig. 64 : Percentage of Medium and Small Size Buildings correctly represented in Revised Maps

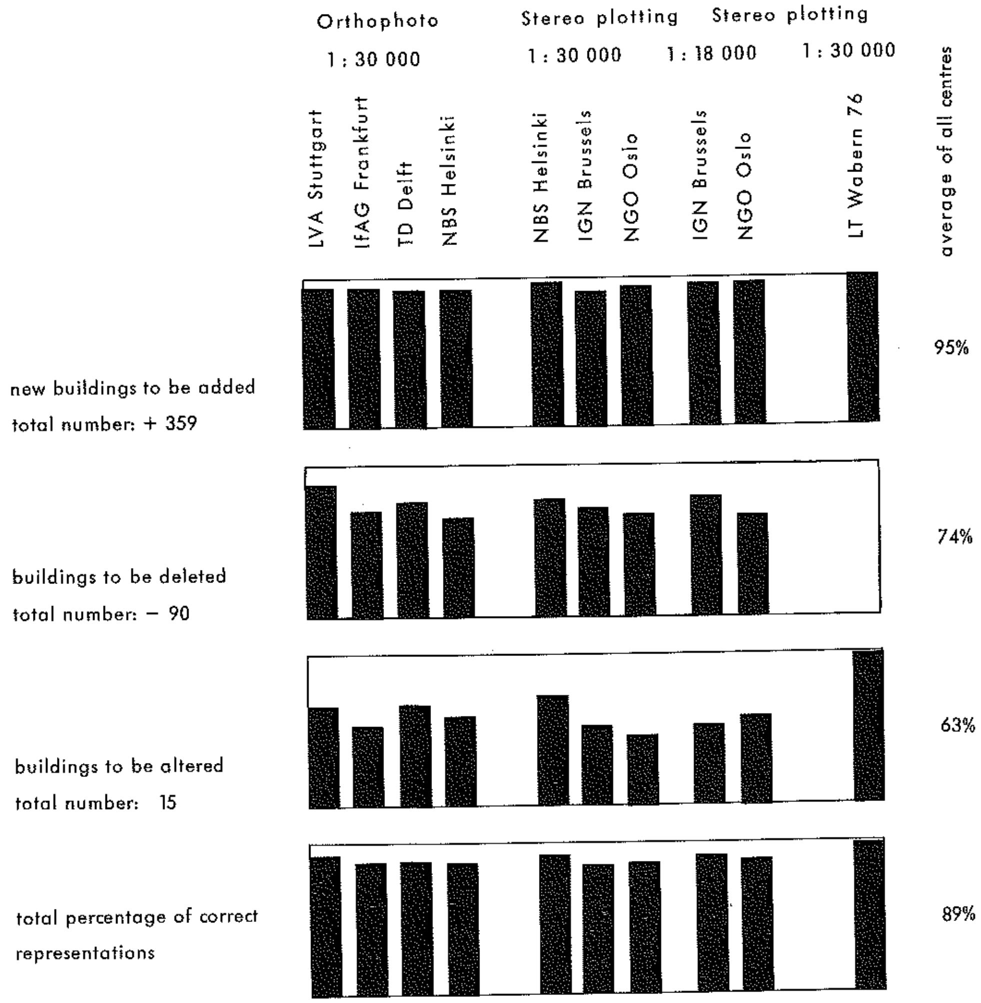


Fig. 65 : Amount of map elements to be deleted in this revision period, including planimetry, hydrography, topography and vegetation

6.6 Completeness and correctness of other elements

There were relatively few elements to be up-dated, other than the planimetry discussed already, with the exception of trees. All these items, for example hydrography, woodland and trees are summarized in this paragraph. In figure 66 all the changes that occurred with respect to these elements are recorded. A number of small streams have been covered in connection with earth movements. A short piece of canal has been constructed, as well as a new pond. The main changes occurred along the new motorway and the river Sarine, which has taken a new course. On its banks some new land has been reclaimed.

The nine completed map samples have been checked on the base of the field identification report on whether these changes were up-dated. These results are listed in table 10. On the whole 65% of all changes along larger streams are correctly represented. The best score is 100%, although one centre made none of these up-dates in the blue plate. The poorer result in the group of small streams should not be overemphasized. All items concern changes of secondary importance, sometimes rather difficult to identify. The result may however be a hint that items of this kind need field identification, if unambiguous revision is to be assured.

There were two new high tension lines to be added. In three of the nine test samples they were included. The only correct representation can be explained by the fact that this centre asked for additional field identification information. Two other operators recognized the new pylons but were in one place not able to discern in what direction the wires extended.

In five places the woodland area had to be corrected. One parcel of land was afforested, in four others the woodland had been removed. The smallest area was a quarter of a hectare, but still easy to detect. Only about 40% of these up-dates had been realized. The individual results ranged between 0% and 80%. None of the methods seems to offer specific advantages in this respect.

On the dark green plate a considerable amount of change concerned trees, mainly fruit trees, but also other individual trees. For verification purposes 13 groups of trees to be deleted, and 24 to be added, were separated. 30% of all these groups together have been more or less corrected in the nine map samples. Five of them showed nearly no change at all. The best result went up as high as 77% for additions and 50% for deletions. Good and poor results again are equally divided between the different techniques used. It seems that the participants considered these up-dates of trees as being of secondary priority, in view of the fact that all changes could have been easily identified.

Fig. 66 : Hydrography and vegetation elements to be changed in the revision period

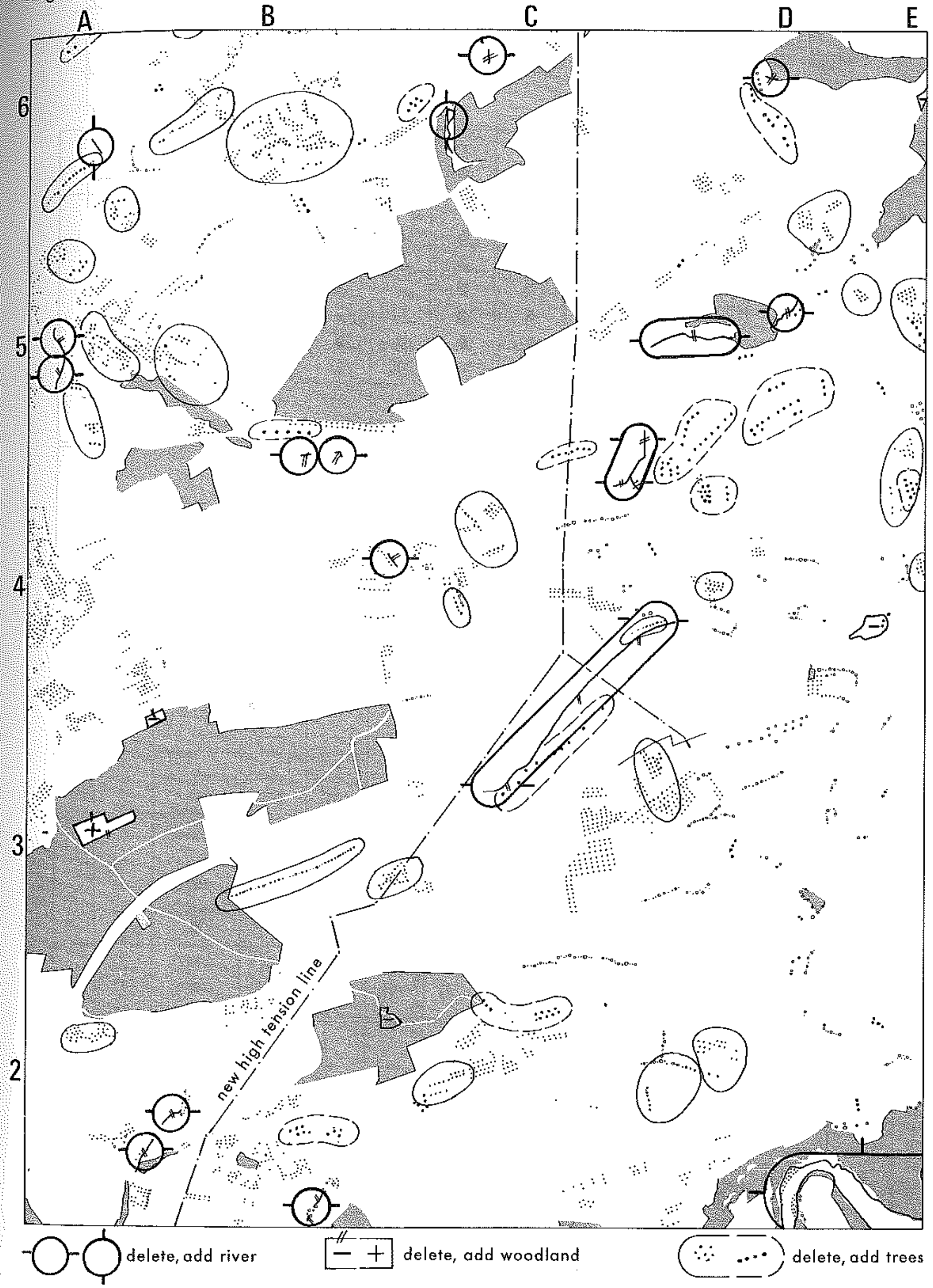


Table 10: Result of the verification for completeness of other map elements as indicated in figure 66 (larger and small streams, high tension line, woodline)

Legend: ● correct up-date

(●) partly correct up-date

— missing up-date

Grid	add delete	Orthophoto				1:30 000 Stereo			1:18 000 Stereo		Total
		LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO	
Larger streams											
C3	delete	●	—	●	●	●	●	●	●	●	
C5	delete	●	—	●	●	●	●	●	●	●	
D2	delete	●	—	—	●	●	—	—	—	—	
D2	add	●	—	—	●	●	—	—	—	—	
D5	delete	(●)	—	●	(●)	●	●	●	●	●	
D5	delete	(●)	—	●	●	●	●	(●)	●	—	
	6 changes 100%	5 83%	0 0%	4 67%	5½ 92%	6 100%	4 67%	3½ 58%	4 67%	3 50%	35 65%
Small streams											
A6	add	●	—	—	—	—	—	—	—	—	
C6	add	●	—	●	—	●	●	●	●	●	
A5	delete	—	—	—	●	—	—	—	—	—	
A5	delete	—	—	—	●	—	—	—	—	—	
B2	delete	—	—	—	—	●	—	—	—	—	
B2	delete	—	—	—	—	(●)	—	—	—	—	
B4	delete	—	—	—	—	—	—	—	—	—	
B5	delete	—	—	—	—	—	—	—	—	—	
C6	delete	—	—	—	—	—	—	—	—	—	
D6	delete	—	—	—	—	—	—	—	—	—	
	10 changes 100%	2 20%	0 0%	1 10%	2 20%	2½ 25%	1 10%	1 10%	1 10%	1 10%	11½ 13%
High tension lines											
B2–C6	add	●	—	—	—	—	—	(●)	—	(●)	
D3	add	●	—	—	—	—	—	●	—	●	
	2 changes 100%	2 100% *)	0 0%	0 0%	0 0%	0 0%	0 0%	1½ 75%	0 0%	1½ 75%	*)
Woodland											
A3	add	●	—	—	—	●	—	—	—	—	
B2	delete	—	—	(●)	—	—	—	—	—	—	
B4	delete	●	—	●	●	●	●	●	●	—	
D4	delete	●	—	—	●	●	—	—	—	—	
E6	delete	●	—	—	●	●	●	—	●	—	
	5 changes 100%	4 80%	0 0%	1½ 30%	3 60%	4 80%	2 40%	1 20%	2 40%	0 0%	17½ 39%

*) were indicated on the field identification manuscript

Table 11: Completeness of changes of trees as indicated in figure 66

Grid	add delete	Orthophoto				1:30 000 Stereo			1:18 000		Total
		LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO	
Trees											
A2	add	—	—	—	—	—	—	—	—	—	
A5	add	(●)	—	●	—	—	●	—	—	—	
A5	add	—	—	●	—	—	(●)	—	—	—	
A5	add	—	—	—	—	—	●	—	(●)	—	
A6	add	—	—	—	—	—	—	—	—	—	
A6	add	(●)	—	—	—	—	—	—	—	—	
A6	add	—	—	●	—	—	(●)	—	●	—	
B3	add	(●)	—	(●)	—	—	(●)	—	—	—	
B5	add	(●)	—	—	—	—	—	—	●	—	
B6	add	(●)	—	●	—	—	●	—	—	—	
B6	add	(●)	—	●	—	—	●	—	(●)	—	
C2	add	●	—	●	—	●	●	—	●	—	
C3	add	(●)	—	—	—	—	●	—	●	—	
C4	add	(●)	●	—	—	—	●	—	●	—	
D2	add	(●)	—	—	—	—	●	—	(●)	—	
D2	add	●	—	●	●	—	●	—	●	—	
D3	add	●	—	●	(●)	(●)	●	—	●	(●)	
D4	add	●	●	●	●	●	●	●	●	●	
D4	add	●	—	●	—	—	●	—	●	—	
D5	add	—	—	—	—	●	●	—	●	—	
D6	add	●	—	●	(●)	●	●	—	●	—	
E4	add	—	—	—	—	—	●	—	●	—	
E4	add	●	—	●	—	—	●	—	●	—	
E5	add	●	—	●	●	●	●	—	●	—	
	24 changes 100%	12½ 52%	2 8%	13½ 56%	4 17%	5½ 23%	18½ 77%	1 4%	15½ 65%	1½ 6%	74 34%
A6	delete	—	—	—	—	—	●	—	—	—	
B2	delete	(●)	—	—	—	●	—	—	●	—	
B5	delete	●	—	●	—	—	●	—	●	—	
B6	delete	—	—	—	—	—	—	—	—	—	
C2	delete	—	—	●	●	●	—	—	—	—	
C3	delete	●	—	—	—	—	●	—	—	—	
C5	delete	—	—	—	—	—	—	—	—	—	
C6	delete	—	—	(●)	—	—	●	—	—	—	
D4	delete	—	—	●	●	—	—	—	—	—	
D4	delete	●	—	●	—	●	●	—	—	—	
D5	delete	●	—	●	—	—	(●)	—	—	—	
D5	delete	—	—	(●)	—	●	—	—	—	—	
D6	delete	●	—	—	—	—	●	—	●	—	
	13 changes 100%	5½ 42%	0 0%	6 46%	2 15%	4 31%	6½ 50%	0 0%	3 23%	0 0%	27 23%

Legend: ● correct up-date

(●) partly correct up-date

— missing up-date

6.7 Generalisation problems

Mapping organisations are well aware of the fact that at the scale 1:25 000 the need for some generalisation can no longer be neglected. All forms that are smaller than the level of perception can no longer be shown by representing their true positions in plan. These map details have to be simplified in form, retaining only the major elements of shape with its primary characteristics. In order to achieve this it may become necessary to exaggerate some items, which decreases the space available for others.

The amount of necessary generalisation depends on the thresholds of visual perceptions. In topographic maps of scale 1:25 000 the following minimal dimensions are usually accepted:

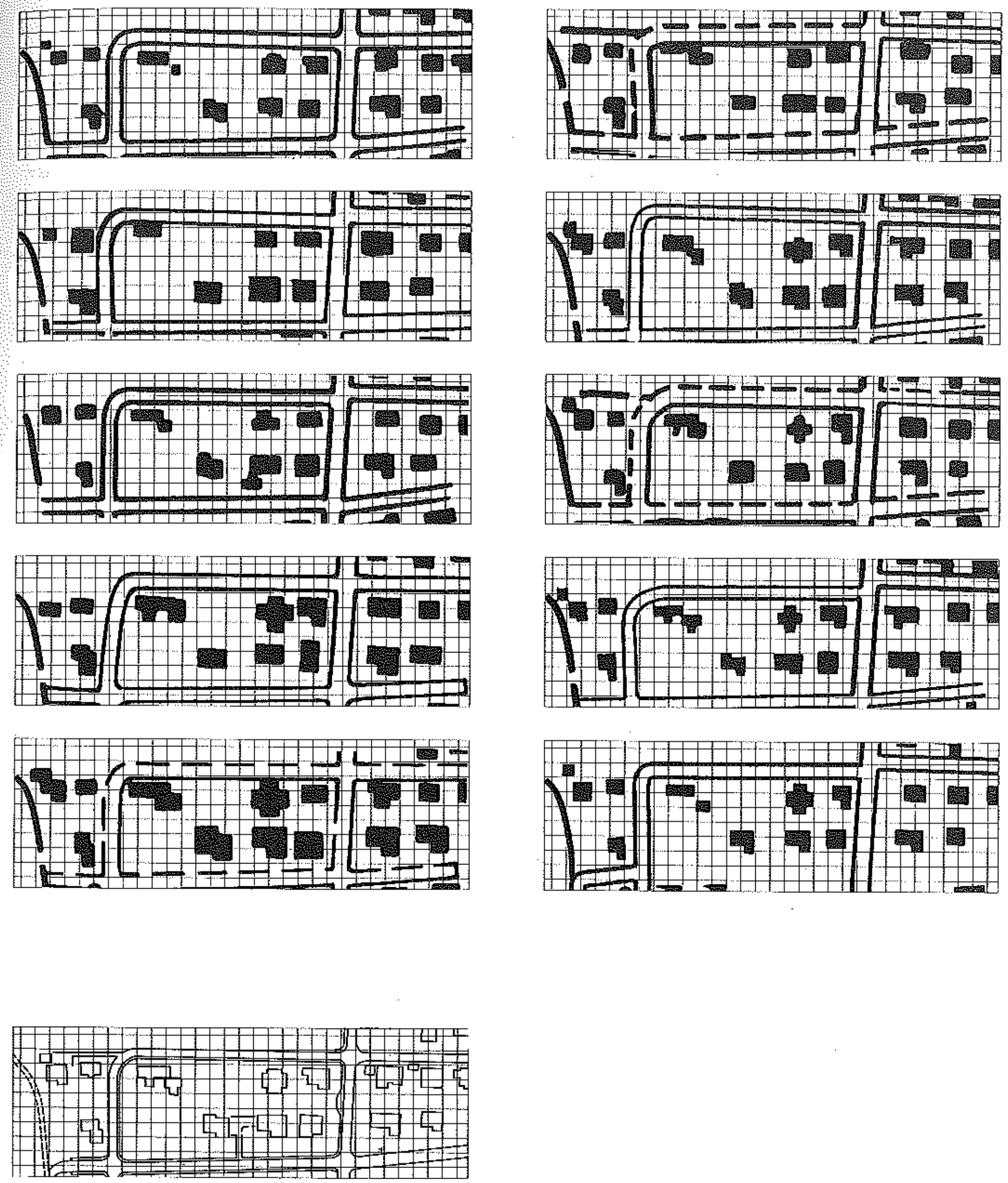
house symbols:		
- minimal width	0.3 mm	≙ 7.5 m
- minimal dimensions of extensions	0.2 mm	≙ 5 m
- minimal intervening space to other map elements	0.15 mm	≙ 3.75 m

Similar values can be determined for other features. A road symbol, for example covers in plan a strip of 15 metres, but effectively only about half or even less. Positional displacement of other symbols along such roads can therefore not be avoided.

The effects of generalisation in these topographic maps are manifold. However, we should concentrate on items of major importance. The approach was to illustrate the differences between the solutions of the individual centres to these problems and to give some quantitative information where possible. The Commission was well aware of the fact that no generally accepted rules exist. But it is interesting to make a comparison of the representations in order to have a look on how generalisation is handled by different compilers, and also from a point of view of photo interpretation.

For this purpose three parts of each test sample were photographically enlarged 5 times to the scale 1:5 000, all with the same standardised procedure, using the final positive of the new planimetry. The small test area "Daillettes" was used for some measurements with a microscope. Figure 67 contains a fine grid of 2 mm interval, corresponding to 10 metres. The same map extract from each test sample was mounted on this base at the scale 1:5 000, using the coordinates of two house corners as determinded previously for a precise adjustment

Fig. 67 : Generalisation ; comparison of identical map sections of different contributions with the original versions of the verification base (below). All sections enlarged to 1 : 5 000 (5 times) and referenced to a 10 metre grid.



of these films on the grid. The planimetry, as restituted from the 1:7 400 imagery for verification purposes, is added for comparison.

The 1968 edition of the map contained only the main road and the trail running north-south, a road junction and two houses, with one of them cut by the border of the extract. All other items are new in the revised samples, namely 14 housee and the local access roads. These houses were already built in 1975, but not all the roads.

A visual comparison between the large scale planimetry in black and the five times enlargement of the map revision samples shows considerable differences. In six of the ten samples the incorrect offset of the upper right road is represented by different curvatures and directions, these deficiencies are however due to lack of accuracy and are not affected by generalisation, as in the case with the varying forms of houses. 11 of the 14 residential single family homes do not have a simple rectangular plan but have some extensions that are smaller than the minimum dimensions. If one wants to be sure that they remain visually distinct, even after some additional reproduction processes, they must be either left out or exaggerated to match the thresholds for sizes and intervening spaces.

The results of the measurements made with a microscope are shown in table 12. Of 100 existing sides of house symbols, between 54 and 94 have be represented, and the others were left out. Of those represented between 0 and 11 sides were smaller than recommended 0.2 mm. There is apparently no correlation between their number and the drawing scale or technique. Much of this seems to be the result of the cartographers individual judgement. Half of the participants avoided all sizes smaller than 0.15 mm. In each test sample there are still 3 to 7 spacings smaller than the limit of 0.15 mm. One third of them is even smaller than 0.1 mm, and thus definitely below the level of perception.

Table 12: Generalisation; threshold of perception for house symbols and spacings, test area Daillettes

This table indicates the number of vertices along house polygones as well as the number of those that were represented smaller than the given thresholds of perception.

Participant:	LVA D	IfAG D	TD NL	NBS SF	NBS SF	IGN B	NGO N	IGN B	NGO N	LT 1975 CH
total number of outlines	75	54	70	74	86	62	92	78	93	78
vertices < 0.22 mm	11	0	2	2	4	0	17	0	10	2
vertices < 0.15 mm	9	0	3	0	1	0	9	0	3	0
spacings < 0.15 mm	7	3	5	7	4	4	3	5	4	3
spacings < 0.15 mm	1	3	1	3	3	2	0	2	0	1

Leaving out sizes that are too small or increasing them to the necessary minimum is one thing, but the question remains of how to do it in each individual case. Two criteria seem to be appropriate at this scale, namely to maintain characteristic forms as well as area. The variety of forms can be derived from figure 68, where we compare in each row the same house as it is represented in the different map samples. The area distortion is shown in table 13. Each house has been measured in hundredths of millimetres, its area on the map is calculated and compared with that of the verification plan. The numerical results show a considerable amount of variation. In most samples more room has been used in the maps for the houses, namely between +7% and 74%, if the area they occupy in reality is taken to be 100%. In two samples slightly less room has been used.

A second map extract has been selected near Moncor. It is a completely new residential area that was partly still under construction at the time of the photography flown in 1976. The sample produced by the LT Wabern for the 1975 edition therefore lacks 4 large blocs compared to the others. The situation with respect to the access roads was to some extent not yet definite, as reflected by the evident differences between the samples in figure 69. But what is most striking are the discrepancies between the house forms and sizes. Some sets of comparable houses are assembled in figure 68. It seemed especially difficult here to decide whether the houses were separated or joined. No measurements have been made on this map extract. But it is obvious that they would result also in a considerable exaggeration of area. It is also significant that two large blocs are missing in one case. In others the underground garages along the western border of the area have either not been detected at all or only partly.

A third example covers the area around the road junction in Cormanon. It is interesting to compare the way this circle junction has been represented. The area needed to represent it varies between 7 and 9 mm^2, the width between 54 and 61 metres, compared to the 45 metres in nature. The Federal Office of Topography does not show the circle and other details and needs therefore only 3 mm^2 and 38 metres across the junction. Antother subject for generalisation is the school buildings in the upper middle of the extract. As we can see from fig.70 there were a number of solutions for this tricky problem.

Table 13: Generalisation; area of house symbols in the residential area "Dailletes"

Participant: Drawing, Scribing, ortho, stereo		LVA D o	IfAG D S o	TD S NL o	NBS D SF o	NBS D SF s	IGN S B s	NGO S N s	IGN S B s	NGO S N s	CH LT 75 S s
house no.	effective area	(areas in mm^2)									
1	.07	.08	.--	.--	.--	.24	.--	.17	.16	.10	.11
2	.27	.18	.14	.30	.26	.40	.30	.32	.33	.29	.28
3	.19	.19	.43	.26	.28	.27	.22	.27	.20	.24	.21
4	.25	.31	.46	.28	.48	.48	.43	.34	.33	.32	.25
5	.34	.34	.28	.31	.57	.53	.28	.40	.38	.30	.26
6	.16	.08	.--	.14	.31	.39	.23	.19	.25	.22	.13
7	.37	.35	.29	.37	.74	.83	.36	.43	.38	.38	.46
8	.32	.35	.33	.32	.55	.39	.32	.37	.40	.42	.29
9	.45	.39	.61	.31	.52	.53	.41	.43	.45	.43	.30
10	.36	.30	.30	.35	.30	.30	.30	.33	.35	.33	.29
11	.25	.29	.32	.34	.44	.60	.34	.33	.24	.32	.25
12	.36	.47	.44	.48	.61	.68	.37	.46	.43	.48	.39
13	.34	.31	.42	.45	.47	.62	.25	.40	.41	.37	.30
14	.41	.34	.62	.66	.45	.73	.47	.46	.31	.40	.36
15	.36	.37	.46	.46	.45	.84	.27	.39	.44	.31	.35
total	4.51	4.35	5.10	5.03	6.43	7.83	4.55	5.29	5.06	4.91	4.23
difference in % of effective total		-3%	+13%	+11%	+43%	+74%	+1%	+18%	+13%	+9%	-6%

Fig. 68 : Series of identical houses extracted from the various contributions, enlarged to the scale 1 : 5 000 (5 times).
The contoured houses show their form in the verification base.

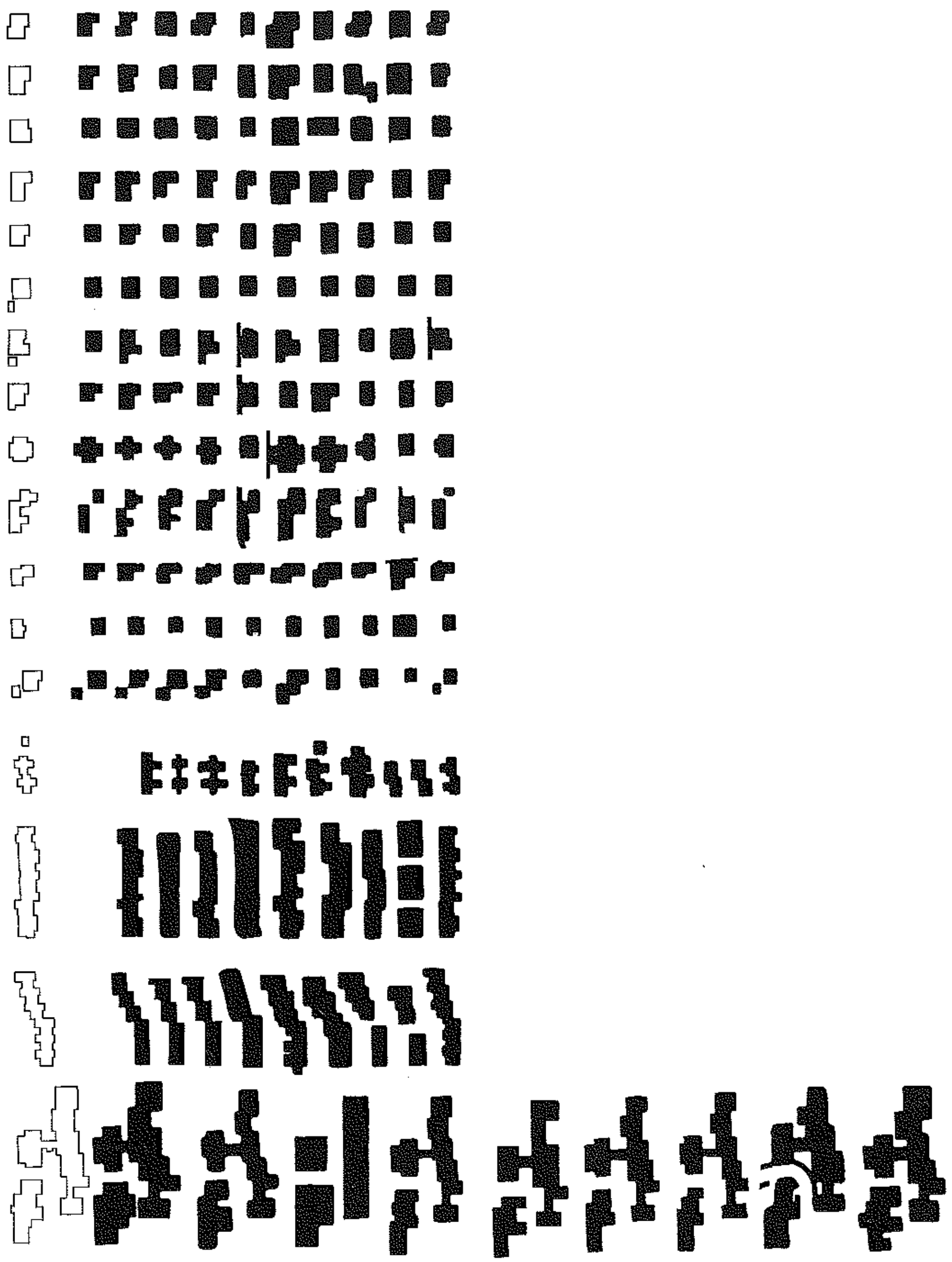


Fig. 69 : Generalisation ; test area Moncor enlarged to 1 : 10 000 (2,5 times).

The first sample is a section of the 1975 revision of the map by the Federal Office of Topography, the others are sections of the various contributions.

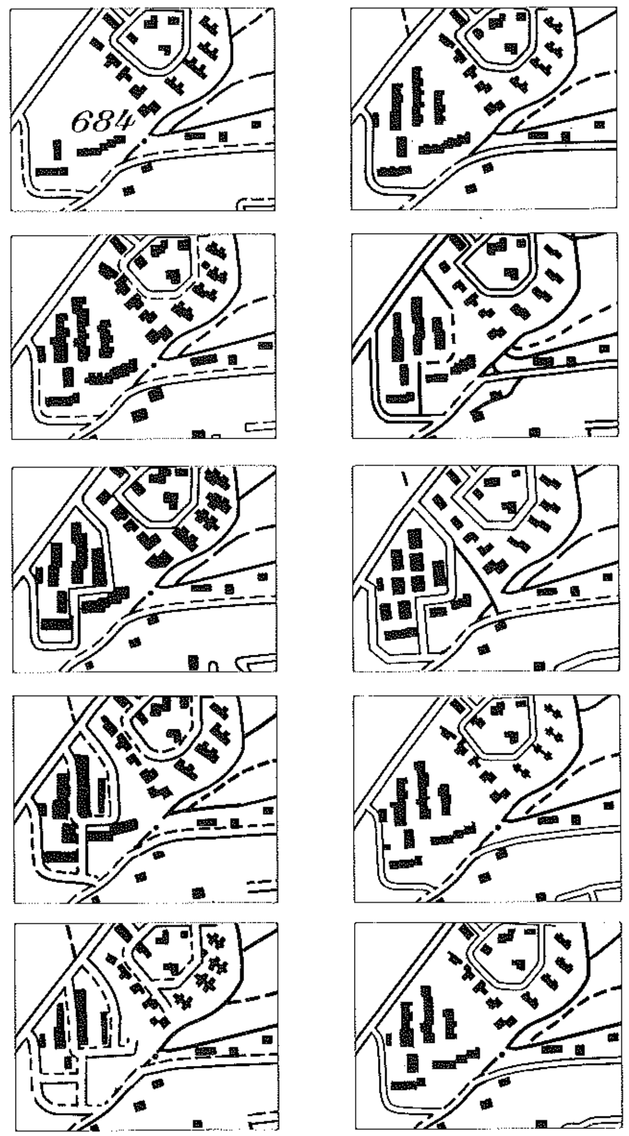


Fig. 70 : Generalisation ; test area Cormanon with a road circle and a large school building, enlarged to 1 : 10 000 (2,5 times)

6.8. Line quality

Of great importance for a continuous revision is minimizing the variation of line weights in the various reproduction processes. If one does not succeed in keeping line weights constant, the original relations between the different map elements will be completely changed. Lines may increase in thickness and corners become rounded. Or in the case of reduced line weight, lines may begin to break. Therefore this aspect has to be carefully considered when one plans long life for a map before it will be entirely renewed.

Within this test we included for these reasons an assessment of the methods used with respect to constancy of line weights. 13 lines have been measured under a microscope for the same points in all 10 test samples. The results are summarized in table 14. We can deduce that the increase or decrease in line weight is fairly constant within each test sample. In 6 out of the 10 contributions the change does not exceed $\pm$ 0.01 mm. Very much more critical are the four other cases, where we notice an increase between 0.02 and 0.04 mm.

In a second series of measurements we were concerned with the form of house corners. It is a well-known effect of continuous reproduction that due to light scattering angles which were originally sharp become more and more rounded. Therefore we made an attempt to measure with the microscope the radii of the rounded house corners in the test area "Daillettes".

The causes for these rounded corner may include some of the following:

- rounded corners of houses already existing in the base map
- repetitive copying and reproduction processes of existing houses
- improper draughting or scribing of new houses, partly dependant also on the thickness of the scribe coat
- subsequent reproduction processes, camera work, photographic or photomechanical copying processes.

The measured values are given only for old and new house corners in the endproduct (see table 15). The first ones compared to the respective data for the base map are indicators for the amount of rounding in all reproduction processes, the second includes the quality of the drawing or scribing. In the case of badly shaped corners, no radius was measured. Thus a total of 47 up to 91 corners was measured in each sample and the mean radius was calculated, including its standard deviation.

Table 14 : Line weight changes after reproduction

Measured line widths in millimetres

S = mean increase or decrease of line width

LT 68 base map	LVA	IfAG	TD	NBS 0	NBS S	IGN 30	NGO 30	IGN 18	NGO 18	LT 75
.059 .059	.056 .048	.054 .055	.093 .094	.050 .049	.049 .051	.025 .025	.074 .078	.075 .078	.070 .079	.049 .055
Δ % Δ S	- 12% -.01	- 8% 0	+ 58% +.03	- 16% -.01	- 15% -.01	- 58% -.03	+ 29% +.02	+ 30% +.02	+ 26% +.01	- 12% -.01
.080 .082 .085 .086	.075 .076 .080 .109	.070 .076 .077 .093	.109 .117 .110 .135	.070 .069 .075 .072	.065 .069 .074 (.073)	.055 .060 .063 .069	.103 .104 .105 .089	.104 .104 .106 (.105)	.097 .101 .109 .090	.074 .075 .077 .080
Δ % Δ S	+ 2% 0	- 5% 0	+ 41% +.03	- 14% -.01	- 16% -.01	- 26% -.02	+ 20% +.02	+ 26% +.02	+ 19% +.02	- 8% -.01
.115 .121	.096 .117	.106 .110	.180 .165	.103 .105	.104 .100	.088 .095	.134 .135	.143 .140	.130 .135	.105 .111
Δ % Δ S	- 10% -.01	- 8% -.01	+ 46% +.05	- 11% -.01	- 14% -.02	- 22% -.03	+ 22% +.02	+ 20% +.02	+ 12% +.01	- 8% -.01
.180 .182	.168 .170	.182 .180	.230 .230	.165 .165	.169 .172	.160 .161	.185 .202	.205 .214	.196 .200	.170 .177
Δ % Δ S	- 7% -.01	0% 0	+ 27% +.05	- 9% -.02	- 6% -.01	- 11% -.02	+ 7% +.01	+ 16% +.03	+ 9% +.02	- 4% -.01
.229 .233 .246	.226 .223 .234	.232 .230 .233	.273 .275 .286	.213 .222 .230	.214 .225 .229	.210 .200 .216	.250 .250 .246	.359 .260 .250	.247 .246 .259	.219 .227 .236
Δ % Δ S	- 4% -.01	- 2% 0	+ 18% +.04	- 6% -.01	- 6% -.01	- 12% -.03	+ 5% +.01	+ 9% +.02	+ 6% +.01	- 4% -.01
Total (includes all line widths): Δ S Δ %	-.01 - 4%	0 - 3%	+.04 + 25%	-.01 - 10%	-.01 - 9%	-.03 - 19%	+.02 + 11%	+.02 + 16%	+.01 + 12%	-.01 - 6%

Table 15 : Sharpness of corners of house symbols

Mean radius of house corners in millimetres

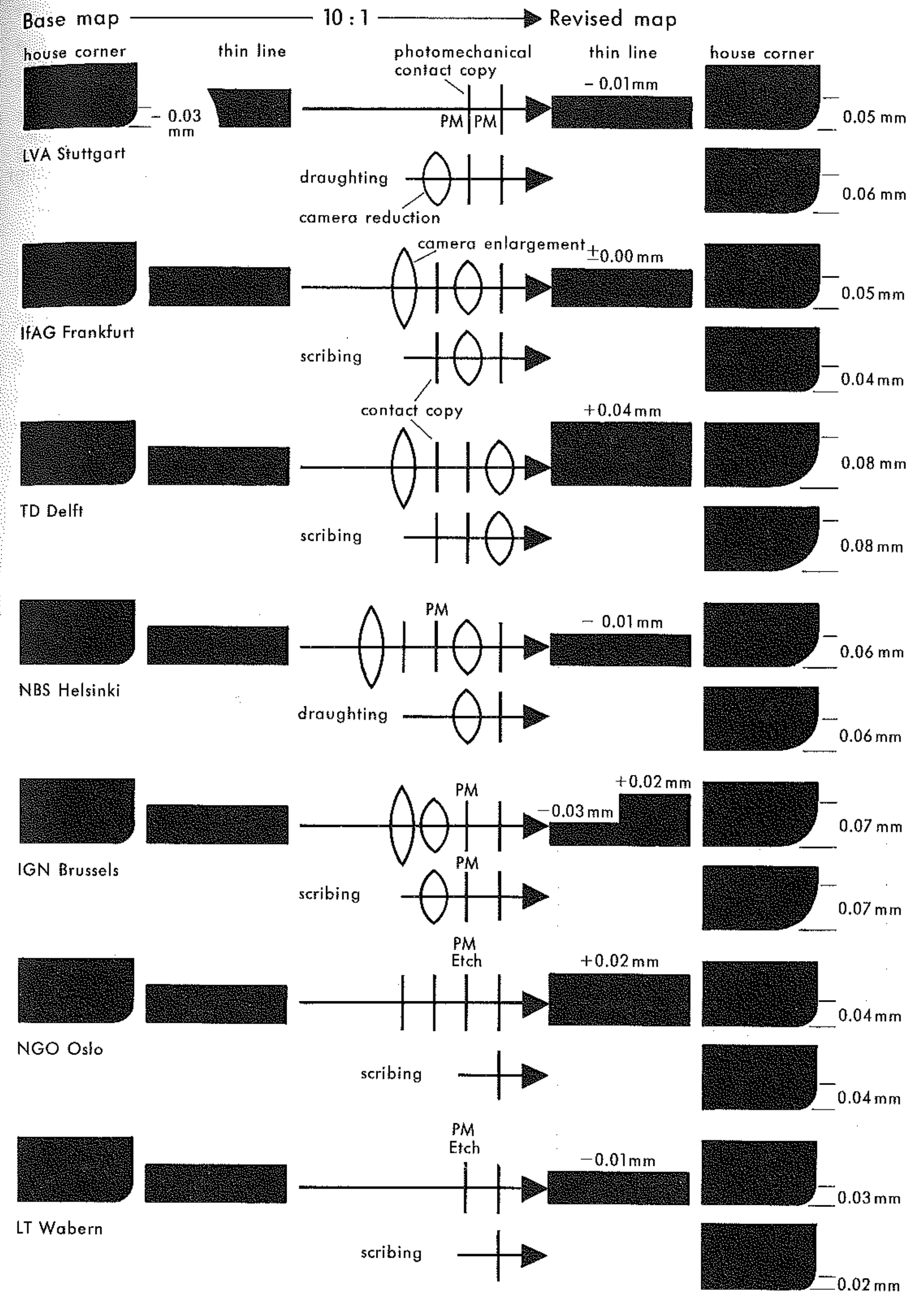
Participant	LT 68	LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO	LT 75
remaining houses, r in mm	0.03	0.05	0.05	0.08	0.05	0.06	0.06	0.04	0.07	0.05	0.03
number of corners	5	5	6	6	6	6	6	6	6	6	6
added new houses, r in mm		0.06	0.04	0.08	0.06	0.06	0.08	0.04	0.07	0.04	0.02
number of corners		74	47	67	72	78	50	91	72	86	73
standard deviation in mm		±0.01	±0.018	±0.022	±0.022	±0.025	±0.022	±0.021	±0.027	±0.017	±0.009
cartography at 1:	25 000	10 000	10 000	15 000	10 000	10 000	16 667	25 000	16 667	25 000	25 000
drawing/scribing d/s	s	d	s	s	d	d	s	s	s	s	s

In the base map that was delivered to the participants a mean radius of 0.03 mm was determined. All 10 revision endproducts show larger curvatures, namely 0.03 up to 0.08 mm for the same remaining houses. The increase of curvature is correlated to the increase of line weight, as was to be expected. But samples with practically no variation in line weight show definitely larger radii of house corners than the original map.

For all those new houses that were draughted or scribed in this revision phase the measured radii varied between 0.02 and 0.08 mm. The smallest values, or the sharpest corners, were achieved by scribing on glass. Scribing on plastic foils at the publication scale of 1:25 000 gave the next best results. The drawings executed at scale 1:10 000 are of slightly worse quality. But here the main problem seems to be the subsequent camera reduction. With one notable exception larger curvature values were als observed when samples which had been scribed were subsequently reduced.

In order to analyse possible correlations between changes of line weight and of house corner radii the whole sequence of reproduction processes for planimetric detail are shown graphically in figure 71. One series refers to the remaining elements form the base map, the other to those that were created only in the process of revision. The number and kind of processes involved becomes quite evident and this illustration can help to improve procedures in terms of line work quality.

Fig. 71: Variation in line weight and on house corner radii in relation to reproduction sequences



6.9 Height accuracies from the spot height test

Main objectives of the spot height test

As an independent and separate test, the programme provided for the restitution of 40 spot heights within the test area. On the one hand this was intended as a substitute for what is necessary in map revision, namely the measuring of a number of additional spot heights replacing those that are for one reason or another to be deleted. In order to have comparable results, the spot heights to be determined were indicated.

At the same time this test should also give some insight into the accuracy of orientation in the respective models, especially where stereoplotting was the main revision process used. It should be possible to establish whether signalised control points are necessary for the measurement of new spot heights.

Layout of the spot height test

40 evenly distributed points for spot height evaluation were selected over the whole test area. The effective heights of these points were established from large scale photographs at scale 1:7 400 or measured in the field on the base of existing trigonometric or traverse points. These heights were taken as correct for the calculation of the root mean square plotting error. Had an estimated root mean square error of $\pm$ 15 centimetres been incorporated, the mean errors of each centre would have been reduced by less than 4 cm, thus not significantly affecting the results.

There is no indication that any one of these 40 points was erroneous and therefore unacceptable for verification purposes. In columns 4 and 13 of table 17 the height differences between the mean calculated from all observations and the true height are given. Sometimes these deviations are considerable, but even then in no case can a systematic error be detected. Positive and negative deviations are equally represented.

The points to be measured were marked and numbered on a paper copy of the aerial photograph (fig.11). On the sheet for the recording of heights, a more detailed sketch of the precise site was given. In some cases it is tempting to suppose that the points to be measured were not precisely identified on the detailed sketch and photo. This is probably true of points 65 and 68. The maximum error of 380 cms, occuring on point 76, has most certainly been measured on the highway below instead of on the bridge. This is the only gross error that was excluded from the total of 359 measurements for the purpose of computing the mean errors. A number of these spot heights were situated on road junctions that are not necessarily level. This concerns particularly points 61, 68, 77, 78, 92, 94 and 97. But a mean error calculated for these seven points is only 20 cm greater than that for all points, a result which is expected to be of this magnitude. Besides these problems, there seem to have been few points that were difficult to measure, and the majority proved to be straightforward.

Results of the spot height test

All centres participated in this part of the test with at least one model. In Brussels and in Oslo these measurements were made at both image scales of 1:18 000 and 1:30 000. All other centres concentrated on the image scale 1:30 000. Table 16 presents a summary of the methods adopted, the accuracy obtained and the time involved.

It should be said that those centres applying the orthophoto method for the planimetry were possibly in a less favorable situation than those using stereoplotting throughout.

When the image scale of 1:18 000 was used, three or four models had to be orientated and measured. As a result in one case a considerable time of 21 1/2 hours was devoted to the orientation of the four models and the restitution of the 40 spot heights. At the image scale of 1:30 000 on the other hand, only Stuttgart made use of two models, which was required in any case for the production of the orthophoto. All but one centre selected images with a 60% overlap. Wabern used 80% in accordance with their current practice in normal map revision.

Delft and Wabern were the only centres that did not make use of signalised control points for the levelling of the model, but instead based themselves on spot heights in the existing base map. These heights are given only to the nearest metre. For this purpose, Delft selected only 6 spot heights, while Wabern chose more than 20 points distributed over the whole model. The diagram (fig. 76) showing the residual errors resulting from Delft indicates that there was most probably an erroneous height used in the south-west corner of the model. Together with a general tendency of a systematically low horizon (only 5 out of 40 error vectors are positive), this resulted in a rather large mean elevation error. The orientation report received yields no clues as to the reasons for this error, which resulted in a mislevelling of the whole model. As a conclusion

Fig. 72 :

Result of the spot height test

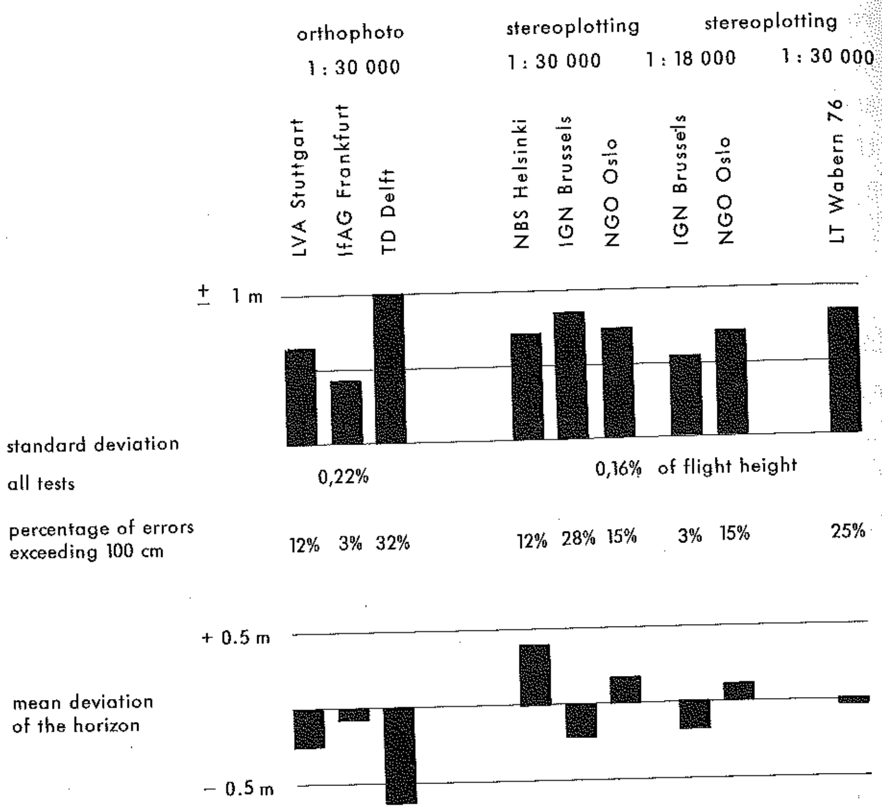
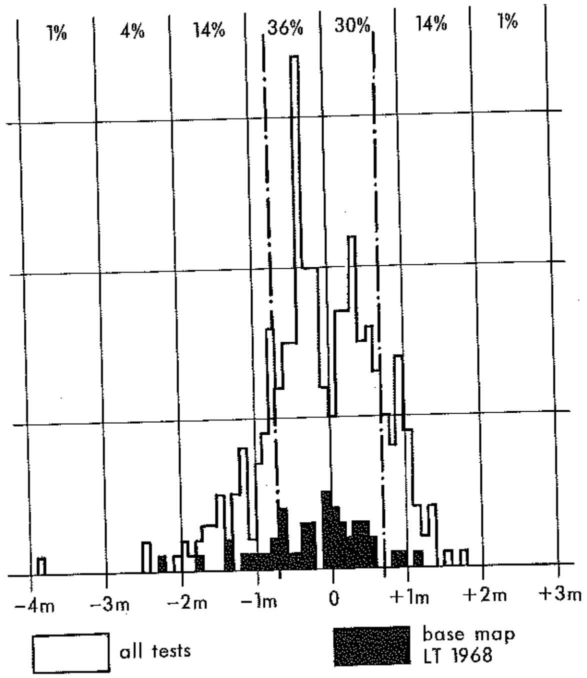


Fig. 73 :

Histogram of the spot height errors



one can postulate that whenever spot heights in the existing map are used exclusively as the levelling base, as many reliable points as possible should be checked in the final stage of model levelling.

If we compare the results of those test samples using the image scale 1:30 000 only, i.e. columns 5 to 9 with 10 and 11 in table 17, a standard deviation of ± 69 cm was obtained when using signalised control points, and ± 92 cm with spot heights only. This difference seems quite significant, although the result is possibly misleading, because of the systematic error in the measurements of Delft. Under the above conditions - base map heights given in metres with an inherent standard deviation of ± 69 cm and rounding-up effect included (see table 3) - additional spot heights were measured in the test with an accuracy of ± 0.19‰ of the flying height. This value was reduced to ± 0.14‰ where signalised control points were used instead of heights taken from the map.

The specified standard deviation of a spot height in the Swiss National Map Series at 1:25 000 is ± 1 metre. The verification of the heights within the test area gave a standard deviation of ± 69 cm. This value is equal to the mean result of the five centres that used image scale 1:25 000 for determining elevation on the basis of signalised control. But even without signalisation the errors are within this tolerance.

All results obtained in this test are shown in table 17. The column for each centre gives for each point i the residual height error

$$\varepsilon = H_i - H_{ie}$$

the difference between the measured elevation H_i and the effective elevation H_{ie}. For each point and at each image scale a mean deviation of all n measurements S_H was calculated

$$S_{H_i} = \pm\sqrt{\frac{(\varepsilon_i \varepsilon_i)}{n}}$$

Furthermore the average deviation from the effective elevation H_e is indicated for each point as

$$\overline{H} - H = \frac{(\varepsilon)}{n}$$

The overall accuracy of the set of 40 spot heights is shown at the bottom of each column as

$$\text{standard deviation } S_H = \sqrt{\frac{(\varepsilon\varepsilon)}{n}}$$

This figure is given also in relation to the flying height h as

$$m_h = \frac{S_H}{h} \cdot 1000 \text{ (in ‰)}$$

The average deviation of the horizon was computed as well in the form

$$\bar{\varepsilon} = \frac{[\varepsilon]}{n}$$

In interpreting the results, it is interesting to compare the two different image scales. The two centres that experimented with the scale 1:18 000 attained a standard deviation of ± 62 cm, and the 7 test samples based on 1:30 000 attained a standard deviation of ± 75 cm. Relative to the flying height these correspond to ± 0.22‰ and ± 0.16‰ respectively. There may be different reasons for the proportionally better results at the smaller scale: one model is probably levelled more carefully than three or four. There is also more homogeneity when the complete set of 40 points can be measured at once. Last but not least it should be mentioned that the photographs for the larger scale were flown on April 6 with some haze, the others under slightly better conditions one month later. Finally, these comparisons should be treated with caution considering the small number of tests carried out at the larger scale.

The calculated standard deviations vary between ± 41 and ± 100 cm, corresponding to 0,09 and 0,21‰ of the flying height. It seems that in this test, no extraordinary exactness was sought for the determination of additional spot heights, bearing in mind that in the map they are only given to the nearest metre.

Looking at the results and reports submitted by centres, it seems that only one centre - the one with the best results - measured heights twice and independently. But one ought also to consider the time and effort involved: three hours were needed to determine these 40 spot heights.

There is no reason to indicate that there was a significant influence due to the instruments used (WILD A7, A8 und ZEISS PLANIMAT).

Besides root mean square errors, gross and maximum errors have also been considered in the evaluation. The histogram fig. 73 shows the distribution of all errors. In the 359 measurements there was one gross error of 380 cm because of misinterpretation as already mentioned above. 66% of all observations lie within the root mean square error of ± 70 cm, instead of 68% expected by definition. 6% of all deviations were greater than twice the mean error. The error distribution in the diagram is therefore quite normal perhaps with a minor assymmetry

Table 16: Restitution procedures and results of the spot height test

Participating centre	Image scale	number of models	overlap	model scale	type of instrument	e=engineer t=technician	number of signalized points used for orientation	number of map points used for orientation	orientation method	accuracy: standard deviation [cm]	accuracy: maximum error [cm]	accuracy: deviation of horizon [cm]	time needed: hours needed for orientation	time needed: hours needed for plotting 40 spot heights
IGN Brussels	1:18 000	4	60%	1: 8 333	Wild A7	t	10	37	graphical	53	-110	-20	16.5	5
NGO Oslo	1:18 000	3	60%	1:12 500	Wild A8	t			graphical	70	-180	+12	5.5	1
IGN Brussels	1:30 000	1	60%	1:16 666	Wild A7	t	7	2	graphical	85	-165	-22	4	3
NGO Oslo	1:30 000	1	60%	1:20 000	Wild A8	t			graphical	71	-195	+18	3	0.5
NBS Helsinki	1:30 000	1	60%	1:30 000	Wild A8	t			graphical	62	+150	+40	3.25	0.5
LVA Stuttgart	1:30 000	2	60%	1:20 000	Zeiss Planimat		8		numerical	64	-175	-25	3	1
IfAG Frankfurt	1:30 000	1	60%	1:20 000	Zeiss Planimat	e	5		numerical	41	+150	- 8	1	3
TD Delft	1:30 000	1	60%	1:20 000	Wild A8	t	-	6	numerical	100	-240	-64	2.75	2.3
LT Wabern	1:30 000	1	80%	1:16 666	Wild A8	t	-	20	graphical	83	-240	- 4	2.5	1

Table 17: Accuracy of spot heights evaluated by stereoplotting

Height errors ε of 40 spot heights, standard deviations and mean deviation of the horizon by centres and by image scale [in cm]

Pt.	Image scale 1:18 000				Image scale 1:30 000								
	IGN	NGO			IGN	NGO	NBS	LVA	IfAG	TD	LT	± S_H	H̄ - H
No.	ε	ε	± S_H	H̄ - H	ε	ε	ε	ε	ε	ε	ε		
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬
60	- 70	- 10	- 50	- 40	- 30	+ 90	+ 70	+ 70	- 10	- 30	-110	68	+ 7
61	- 5	+ 45	32	+ 20	+ 65	- 55	+ 75	+ 85	- 15	- 65	- 55	63	+ 5
62	+ 20	+120	86	+ 70	+ 80	- 40	+110	+ 10	+ 20	- 50	- 40	59	+ 13
63	+ 45	+ 65	56	+ 55	- 25	- 15	+ 5	- 55	- 55	- 65	-115	59	- 46
64	- 75	+ 55	66	- 10	+135	+ 55	+ 35	- 95	- 45	- 75	-145	93	- 58
65	- 85	- 85	85	- 85	- 55	-195	+ 5	- 35	- 95	+ 65	-195	116	- 72
66	- 95	+ 5	67	- 45	-165	- 25	+ 75	-105	- 25	- 95	- 75	92	- 59
67	- 65	+ 55	60	- 5	- 45	- 35	+105	- 35	- 35	+ 45	- 35	53	- 5
68	-110	- 20	79	- 65	- 10	- 40	+ 50	- 90	-120	- 20	-240	110	- 67
69	- 15	+ 45	34	+ 15	+ 55	+ 25	+ 65	- 65	+ 5	- 35	- 75	52	- 4
70	- 60	+ 60	60	- 0	- 10	+ 70	+100	- 30	+ 30	- 50	- 30	54	+ 11
71	- 40	+ 10	29	- 15	- 40	+ 90	+ 90	- 40	- 10	- 80	- 10	61	0
72	- 10	+ 30	22	+ 10	+ 40	+ 30	+ 50	- 50	+ 30	- 40	+ 30	39	+ 13
73	- 60	- 30	47	- 45	+100	+130	+110	- 20	+ 80	- 20	+ 30	102	+ 71
74	- 80	+ 30	60	- 25	0	+ 20	+ 20	- 80	+ 20	- 30	+ 20	36	- 4
75	- 70	+ 30	54	- 20	-140	+130	+ 70	-110	- 10	-110	+ 30	98	- 20
76	- 40	+ 70	57	+ 15	- 50	- 30	- 30	-380[1)]	- 70	+ 10	- 30	41	- 33
77	- 40	- 80	63	- 60	+130	- 30	+ 80	+ 90	- 30	+170	- 30	95	+ 54
78	- 85	+105	96	+ 10	-155	+ 15	+ 35	+ 5	+ 35	- 75	+115	80	- 4
79	+ 20	+ 20	20	+ 20	- 10	- 30	+150	- 20	+ 30	+ 90	+ 70	73	+ 40
80	- 20	+ 40	32	+ 10	-110	+ 20	- 30	- 70	- 80	-70	+ 20	65	- 46
81	+ 10	+ 30	22	+ 20	- 80	+ 90	+ 90	- 20	0	- 60	- 10	62	+ 1
82	- 45	- 15	34	- 30	- 95	+ 5	+ 5	-175	+ 5	- 25	+ 5	76	- 39
83	- 25	-115	83	- 70	+ 55	- 35	- 5	- 65	- 35	- 25	- 35	41	- 21
84	+ 55	- 25	43	+ 15	- 65	+ 65	+ 35	+ 15	+ 5	-135	+115	77	+ 5
85	- 70	-100	86	- 85	-140	+ 50	+ 20	- 50	- 20	-160	+150	102	- 21
86	- 10	- 70	50	- 40	- 30	+100	+ 50	+ 30	- 20	- 70	0	53	+ 9
87	+ 15	+ 85	61	+ 50	+ 15	- 5	- 5	- 25	- 5	- 5	- 55	24	- 12
88	+ 50	-140	105	- 45	+100	- 50	- 50	- 30	+ 60	-240	+ 50	107	- 23
89	- 20	- 10	16	- 15	-120	+ 90	+ 70	- 10	- 10	- 160	+ 90	94	- 7
90	- 15	+ 85	61	+ 35	- 65	+ 85	+ 15	- 35	+ 15	-125	+ 35	65	- 11
91	- 40	+ 90	70	+ 25	- 90	+ 40	+ 20	+ 20	- 20	-120	+ 40	62	- 16
92	+ 35	- 45	40	- 5	- 35	+ 65	+ 35	+ 85	+ 15	-175	+ 65	84	+ 8
93	+ 50	+ 20	38	+ 35	- 10	+ 30	+ 20	0	+ 30	-140		57	- 6
94	+ 50	+ 10	36	+ 30	-120	+ 90	+ 10	- 30	+ 30	-130	+ 90	84	- 9
95	+ 60	+ 90	76	+ 75	+ 40	+ 10	+ 10	- 40	0	- 30	+ 10	25	0
96	+ 35	+ 65	52	+ 50	+ 45	- 45	- 65	- 65	- 35	- 45	- 45	50	- 36
97	- 70	-180	137	-125	+ 50	0	- 20	+120	+ 10	-200	+100	98	+ 9
98	+ 50	+ 60	55	+ 55	+ 60	+100	+ 90	- 30	+ 40	-110	+100	81	+ 36
99	+ 45	+ 75	62	+ 60	+ 25	-155	+ 35	- 75	- 55	- 75	- 55	79	- 51
S_H	± 53	± 71	± 62		± 85	± 71	± 62	± 64	± 41	±100	± 83	± 75	
ε/n	- 20	+ 12		- 4	- 22	+ 18	+ 40	- 25	- 8	- 64	- 4		- 10
ε>100	3%	15%	9%		28%	15%	12%	12%	3%	32%	25%	18%	
S_H/ho.	19%	0.25%	0.22% of fl.ht		0.18%	0.15%	0.13%	0.13%	0.09%	0.21%	0.17%	0.16% of fl.ht.	

on the negative axis. 301 errors or 83% are smaller than ± 1 m, only 4 (or 1%) are greater than ± 2 m. The results of the individual centres differ considerably in this respect; the percentage of points deviating 1 m and more lies between 2,5% and 32%.

Some of these bigger discrepancies can be explained by the fact that the errors indicate a shifted horizontal origin. In the case of the greatest root mean square error (± 100 cm) much of these discrepancies are due to the 64 cm horizontal displacement. The corresponding error vectors in fig. 76 show systematically distributed residual errors. They are the result of poor absolute orientation. A repetition of the procedure at a later stage gave a better result. As can be seen from other vector diagrams, levelling could have been improved in some cases too.

Some investigation was made as to which types of points were more difficult to measure, but no obvious conclusions could be drawn. As an example, the best results (± 24 and 25 cm), as well as the worst (± 116 and ± 110 cm), were achieved on crossroads.

The number of hours needed for this part of the test is given in table 16. They are separated in time required for model orientation and time for measuring spot heights. The average time indicated was 3 hours for the orientation and 2 hours for plotting the 40 spot heights. This time effort varies enormously however between 1/2 and 5 hours. The participating centres reported that the time involved in this spot height test was between 31/2 hours and 211/2 hours. Further conclusions cannot been drawn from these results. Spending more time on plotting evidently does not necessarily mean producing better results.

Table 17: Accuracy of spot heights evaluated by stereoplotting

Height errors ε of 40 spot heights, standard deviations and mean deviation of the horizon by centres and by image scale [in cm]

Pt. No.	Image scale 1:18 000				Image scale 1:30 000								
	IGN ε	NGO ε	± S_H	$\bar{H}$ - H	IGN ε	NGO ε	NBS ε	LVA ε	IfAG ε	TD ε	LT ε	± S_H	$\bar{H}$ - H
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬
60	- 70	- 10	- 50	- 40	- 30	+ 90	+ 70	+ 70	- 10	- 30	-110	68	+ 7
61	- 5	+ 45	32	+ 20	+ 65	- 55	+ 75	+ 85	- 15	- 65	- 55	63	+ 5
62	+ 20	+120	86	+ 70	+ 80	- 40	+110	+ 10	+ 20	- 50	- 40	59	+ 13
63	+ 45	+ 65	56	+ 55	- 25	- 15	+ 5	- 55	- 55	- 65	-115	59	- 46
64	- 75	+ 55	66	- 10	+135	+ 55	+ 35	- 95	- 45	- 75	-145	93	- 58
65	- 85	- 85	85	- 85	- 55	-195	+ 5	- 35	- 95	+ 65	-195	116	- 72
66	- 95	+ 5	67	- 45	-165	- 25	+ 75	-105	- 25	- 95	- 75	92	- 59
67	- 65	+ 55	60	- 5	- 45	- 35	+105	- 35	- 35	+ 45	- 35	53	- 5
68	-110	- 20	79	- 65	- 10	- 40	+ 50	- 90	-120	- 20	-240	110	- 67
69	- 15	+ 45	34	+ 15	+ 55	+ 25	+ 65	- 65	+ 5	- 35	- 75	52	- 4
70	- 60	+ 60	60	- 0	- 10	+ 70	+100	- 30	+ 30	- 50	- 30	54	+ 11
71	- 40	+ 10	29	- 15	- 40	+ 90	+ 90	- 40	- 10	- 80	- 10	61	0
72	- 10	+ 30	22	+ 10	+ 40	+ 30	+ 50	- 50	+ 30	- 40	+ 30	39	+ 13
73	- 60	- 30	47	- 45	+100	+130	+110	- 20	+ 80	- 20	+ 30	102	+ 71
74	- 80	+ 30	60	- 25	0	+ 20	+ 20	- 80	+ 20	- 30	+ 20	36	- 4
75	- 70	+ 30	54	- 20	-140	+130	+ 70	-110	- 10	-110	+ 30	98	- 20
76	- 40	+ 70	57	+ 15	- 50	- 30	- 30	-380 1)	- 70	+ 10	- 30	41	- 33
77	- 40	- 80	63	- 60	+130	- 30	+ 80	+ 90	- 30	+170	- 30	95	+ 54
78	- 85	+105	96	+ 10	-155	+ 15	+ 35	+ 5	+ 35	- 75	+115	80	- 4
79	+ 20	+ 20	20	+ 20	- 10	- 30	+150	- 20	+ 30	+ 90	+ 70	73	+ 40
80	- 20	+ 40	32	+ 10	-110	+ 20	- 30	- 70	- 80	-70	+ 20	65	- 46
81	+ 10	+ 30	22	+ 20	- 80	+ 90	+ 90	- 20	0	- 60	- 10	62	+ 1
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86	- 10	- 70	50	- 40	- 30	+100	+ 50	+ 30	- 20	- 70	0	53	+ 9
87	+ 15	+ 85	61	+ 50	+ 15	- 5	- 5	- 25	- 5	- 5	- 55	24	- 12
88	+ 50	-140	105	- 45	+100	- 50	- 50	- 30	+ 60	-240	+ 50	107	- 23
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94	+ 50	+ 10	36	+ 30	-120	+ 90	+ 10	- 30	+ 30	-130	+ 90	84	- 9
95	+ 60	+ 90	76	+ 75	+ 40	+ 10	+ 10	- 40	0	- 30	+ 10	25	0
96	+ 35	+ 65	52	+ 50	+ 45	- 45	- 65	- 65	- 35	- 45	- 45	50	- 36
97	- 70	-180	137	-125	+ 50	0	- 20	+120	+ 10	-200	+100	98	+ 9
98	+ 50	+ 60	55	+ 55	+ 60	+100	+ 90	- 30	+ 40	-110	+100	81	+ 36
99	+ 45	+ 75	62	+ 60	+ 25	-155	+ 35	- 75	- 55	- 75	- 55	79	- 51
S_H	± 53	± 71	± 62		± 85	± 71	± 62	± 64	± 41	±100	± 83	± 75	
ε/n	- 20	+ 12		- 4	- 22	+ 18	+ 40	- 25	- 8	- 64	- 4		- 10
ε>100	3%	15%	9%		28%	15%	12%	12%	3%	32%	25%	18%	
S_H/ho.	19%	0.25%	0.22% of fl.ht		0.18%	0.15%	0.13%	0.13%	0.09%	0.21%	0.17%	0.16% of fl.ht.	

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Summary of the spot height test

This part of the whole test programme proved to be a good approach for answering some of the basic questions in map revision.

1. The standard deviation of an individual spot height measured in images at the scale 1:30 000 was ± 75 cm; only one in a hundred was greater than ± 2 m.
2. The respective value received from images at the scale 1:18 000 was ± 62 cm, an improvement that is not justified in view of the considerably greater time spent on this work.
3. The loss of accuracy, when using only spot heights of the existing map for the model orientation is not significant.
4. In this case model levelling should be based on as many map points as possible.
5. With wide-angle photography 80% overlap in a model gives equally good results as 60% overlap.

Fig. 74 : Residual errors in the spot height test, image scale 1 : 18 000

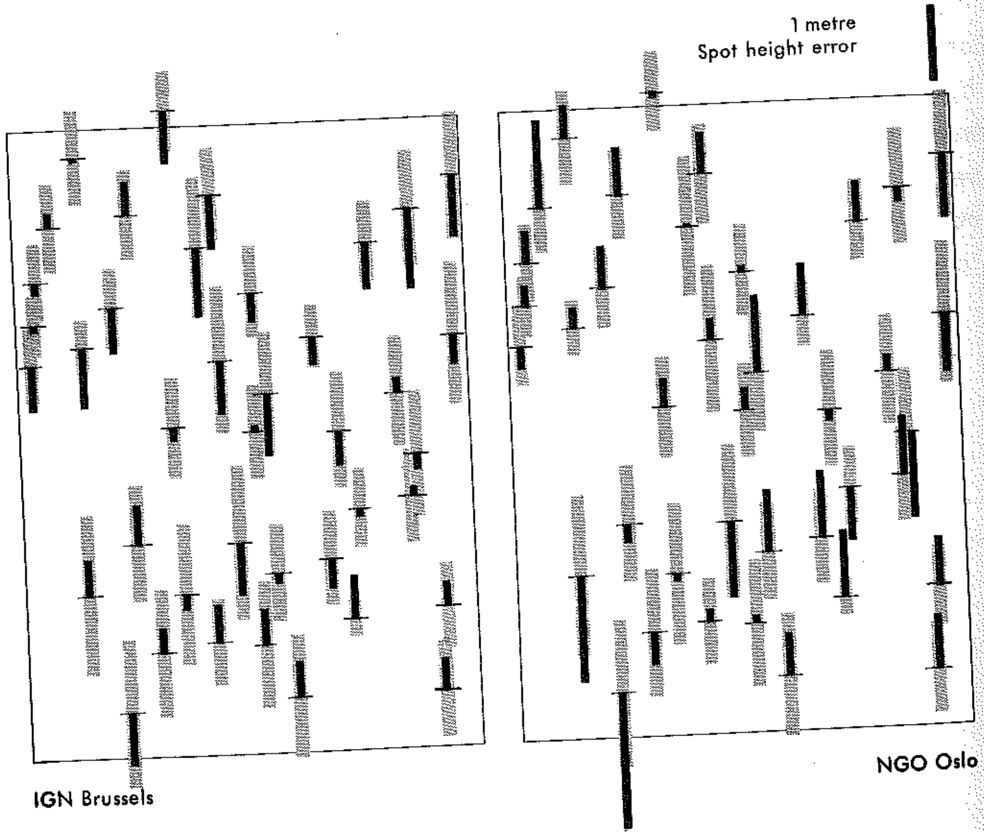


Fig. 75 : Residual errors in the spot height test, image scale 1 : 30 000

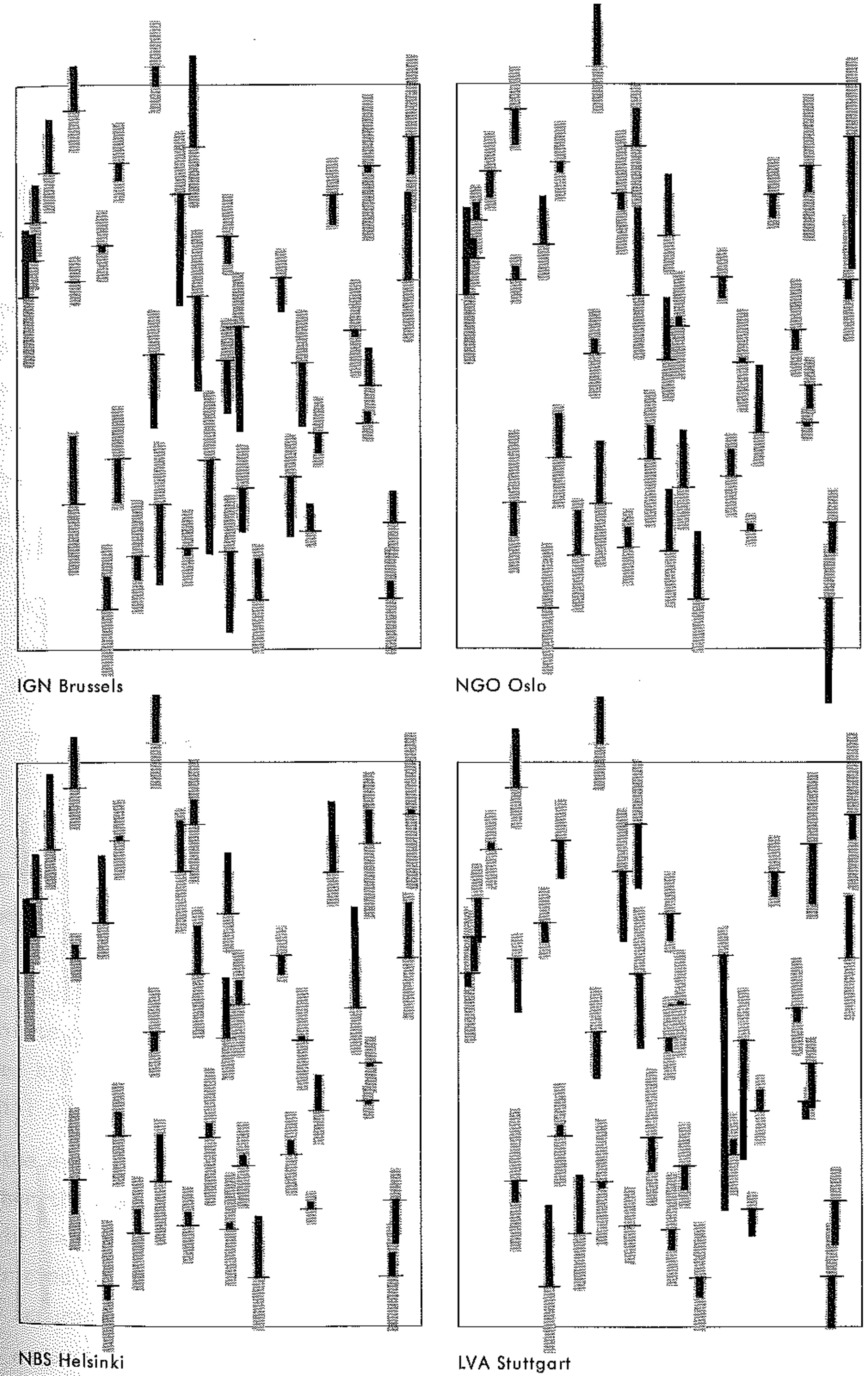
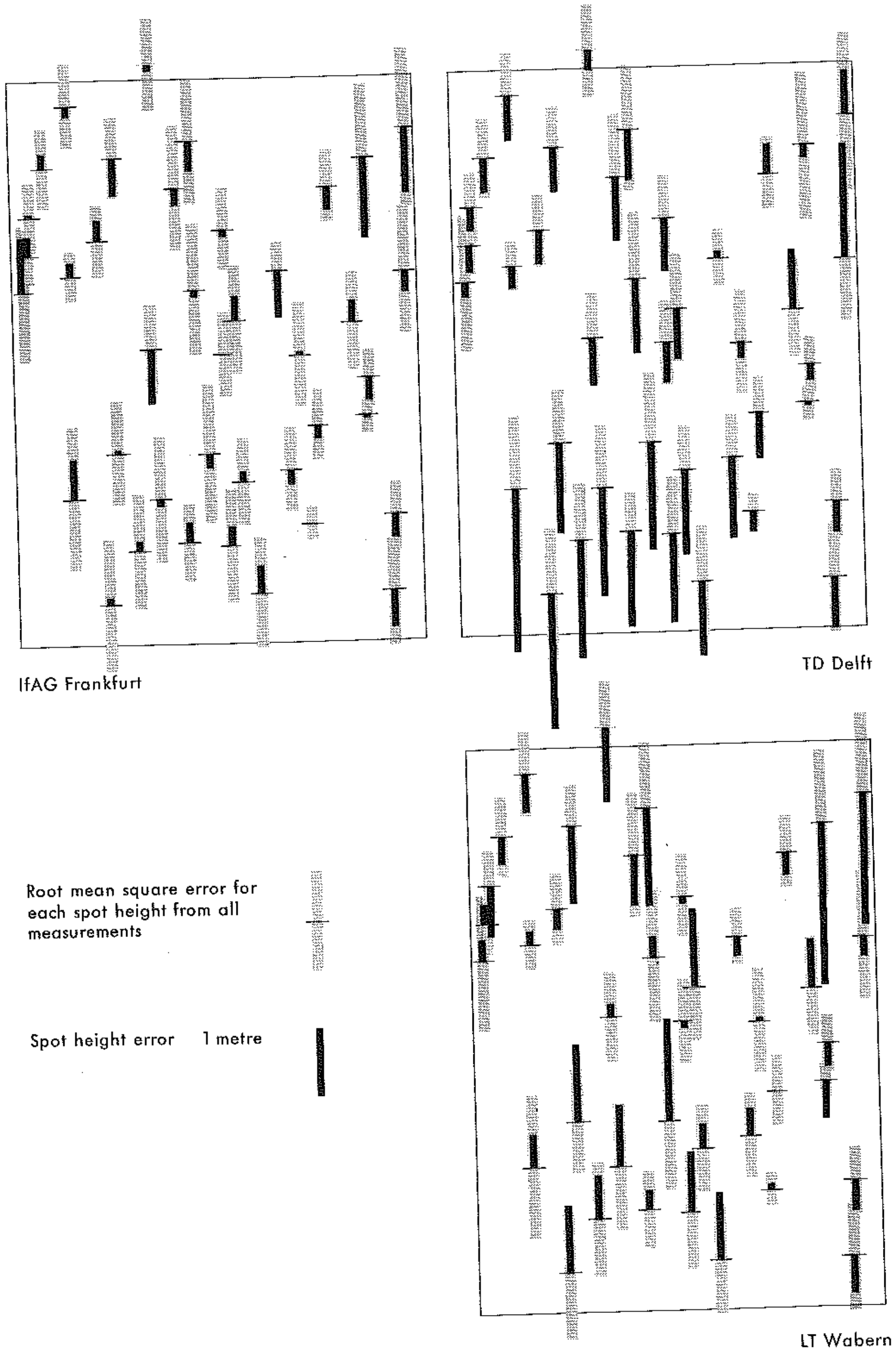


Fig. 76 : Residual errors in the spot height test, image scale 1: 30 000



6.10 Evaluation of the revised contour lines

The participants were also asked to amend the contour plate of the map to be revised. It contains contours with a contour interval of 10 m, selected intermediate contours of 5 m with dotted lines, hundred metre contours with heavy lines and slope hachures for dams and cuts.

All the contour plates revised by the participants have been made visually comparable to a standard derived from the verification reference map at a scale of 1:2 500 (fig.39). Details of this standard are described in paragraph 5.3. In the figures its contour lines are shown with a fine line, while the superimposed contours produced by the participants are thicker. The areas that were subjected to terrain movements in the revision period are left white. The grey tint shows where the terrain did not change.

Evidently there are deviations also for the contours of the base map. They can be observed in the grey zone. The tolerance adopted for the 1:25 000 map by the Swiss Federal Office of Topography is

$m_{hk} = \pm (1.5 + 7.5 \text{ tg } \alpha)_{(m)}$ standard deviation of the height of a contour in metres (α is the slope angle)

or

$m_{lk} = \pm (0.06 \text{ ctg } \alpha + 0.3)_{(mm)}$ standard deviation of the position of a contour in millimetres on the map

Therefore 3 mm are allowed in flat areas, but only 0,5 mm in steep terrain, or 0,3 mm in the two areas with extremely steep slopes. The base map certainly meets this requirement. In only a very few spots is the deviation larger than the allowed standard. The task of the operators was therefore restricted to restitute new contours, only where changes had occured. These changes were caused by the construction of the motorway and of larger industrial and residential sites.

For the evaluation of the test results two approaches are followed, namely whether the change has been detected or not and whether it has been plotted within the given tolerance. Therefore the assessment on qualitative aspects is restricted, especially in view of the fact that no generally agreed quantitative accuracy test data is available.

Table 18: Changes of contours and slopes detected by the participants

Participants: / Object:	LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO
Motorway	●	●	●	●	●	●	●	●	●
Industrial site Chamblioux	●	●	●	●	●	●	○	●	●
Fill at Chantemerle	●	●	●	●	●	●	●	●	●
Fill at Lavapesson	●	○	●	●	●	●	●	●	○
Fill at Hopital	●	●	●	●	●	○	○	●	○
Fill N of Granges Paccot	●	●	●	●	●	●	○	●	○
Fill S of Petit Rome	●	●	●	●	●	○	○	○	○
Fill at Le Guintset	●	●	●	●	○	●	○	○	○
Fill at Le Croset	○	○	○	○	○	○	○	○	○
Fill at Prê Neuf	○	○	○	○	○	○	○	○	○
● detected	80%	70%	80%	80%	70%	60%	30%	70%	30%
○ not detected	20%	30%	20%	20%	30%	40%	70%	30%	70%

The above results confirm the well-known fact that it is often rather difficult to detect terrain changes, if they are not directly related to new large constructions. So the in-filled area near the hospital, that has already been covered with grass again, was not recognized by 33% of the participants. In 3 out of the 9 tests only the contour lines are also connected across the new roads.

In terms of accuracy the amended contours are with few exceptions situated within the band of tolerance mentioned above. It seems that somewhat less care was given to the intermediate contours. In two places (south of La Chassotte) a large majority of participants did not realize that the terrain beside the new road has also been in-filled. As long as the map to be revised meets the specifications, accuracy does not seem to be a real problem, because the new contours are inserted in close relation to the old ones.

Much care has been given by all participants to complete and up-date the contour plate with slope hachures, expecially for cut and fill associated with new dams. There are no options left open in this respect, although the decision where slope hachures ought to be used is arbitrary to some extent.

Fig. 77 : Comparison of the contour lines of the base map LK 1968 with the verification contour lines of 1976

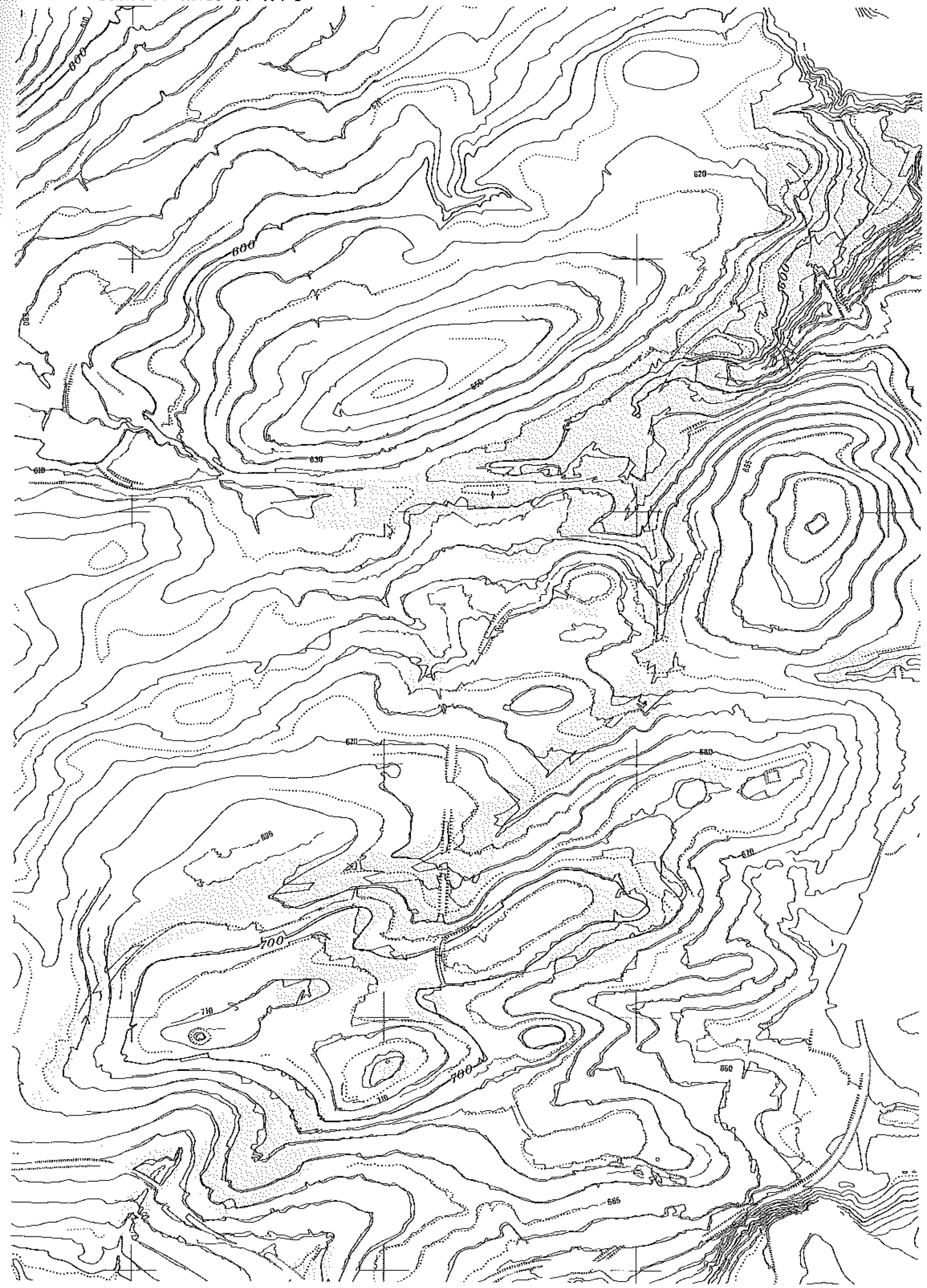


Fig. 78 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (LVA Stuttgart)

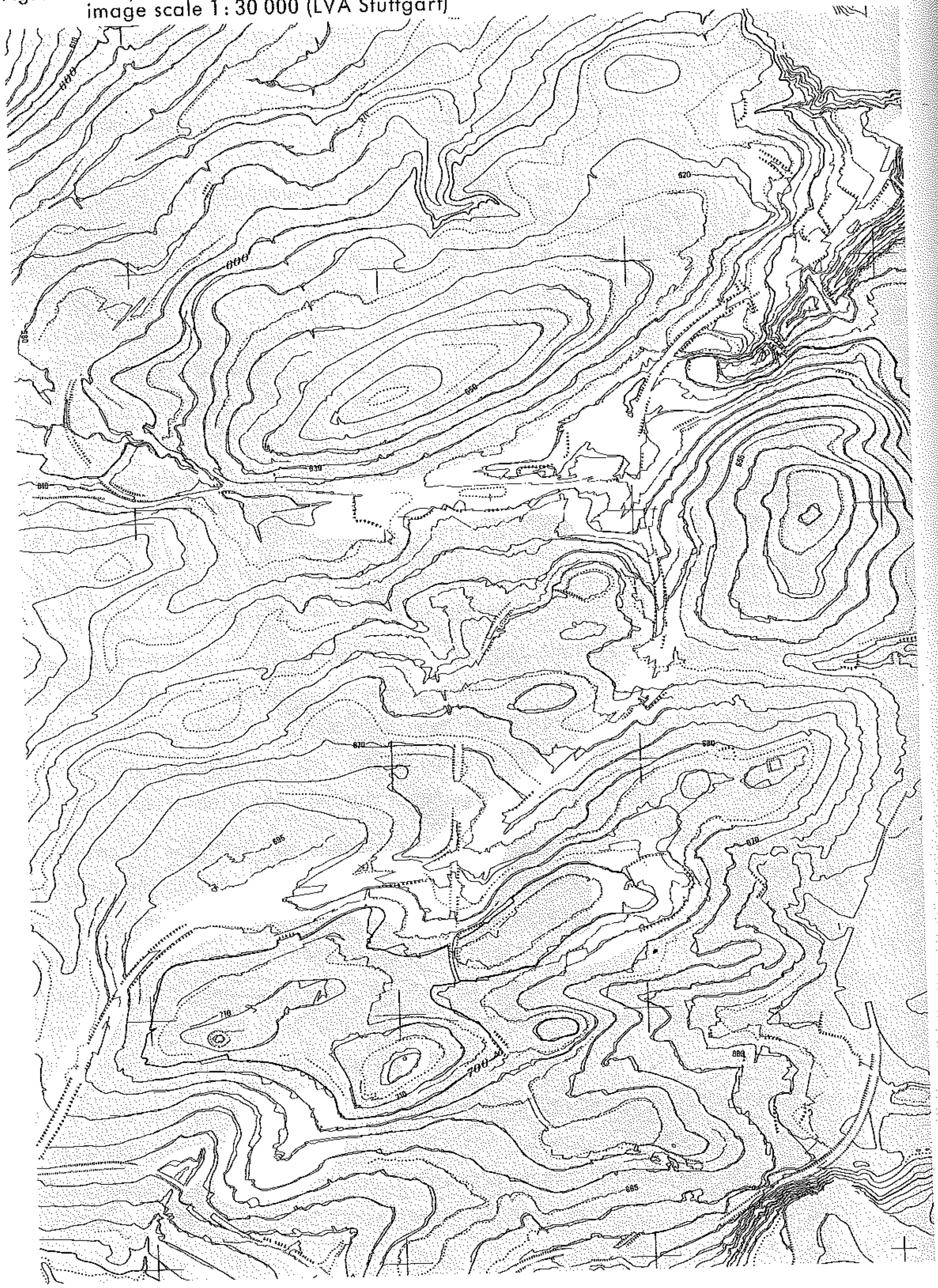


Fig. 79 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (IfAG Frankfurt)

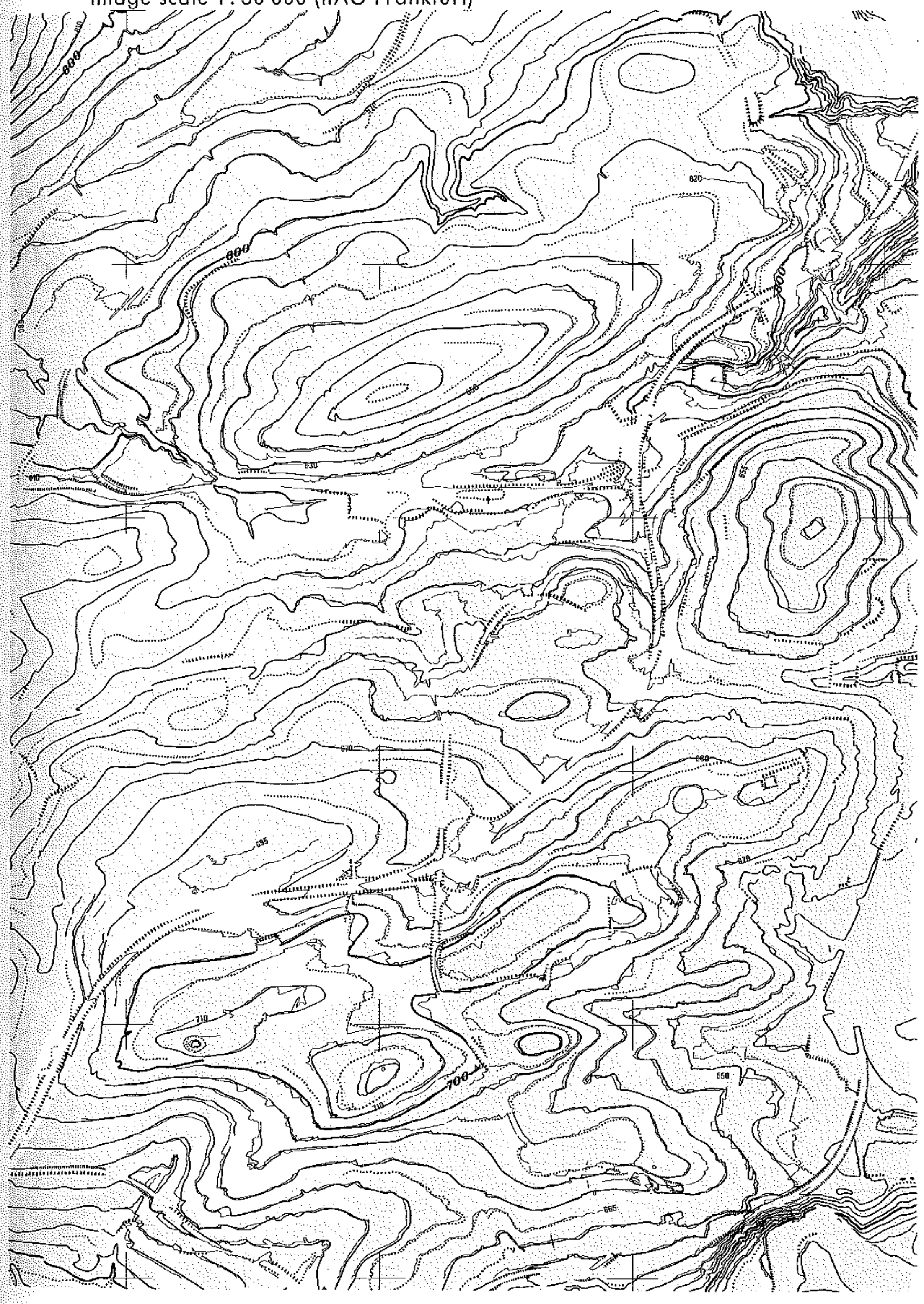


Fig. 80 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (TD Delft)

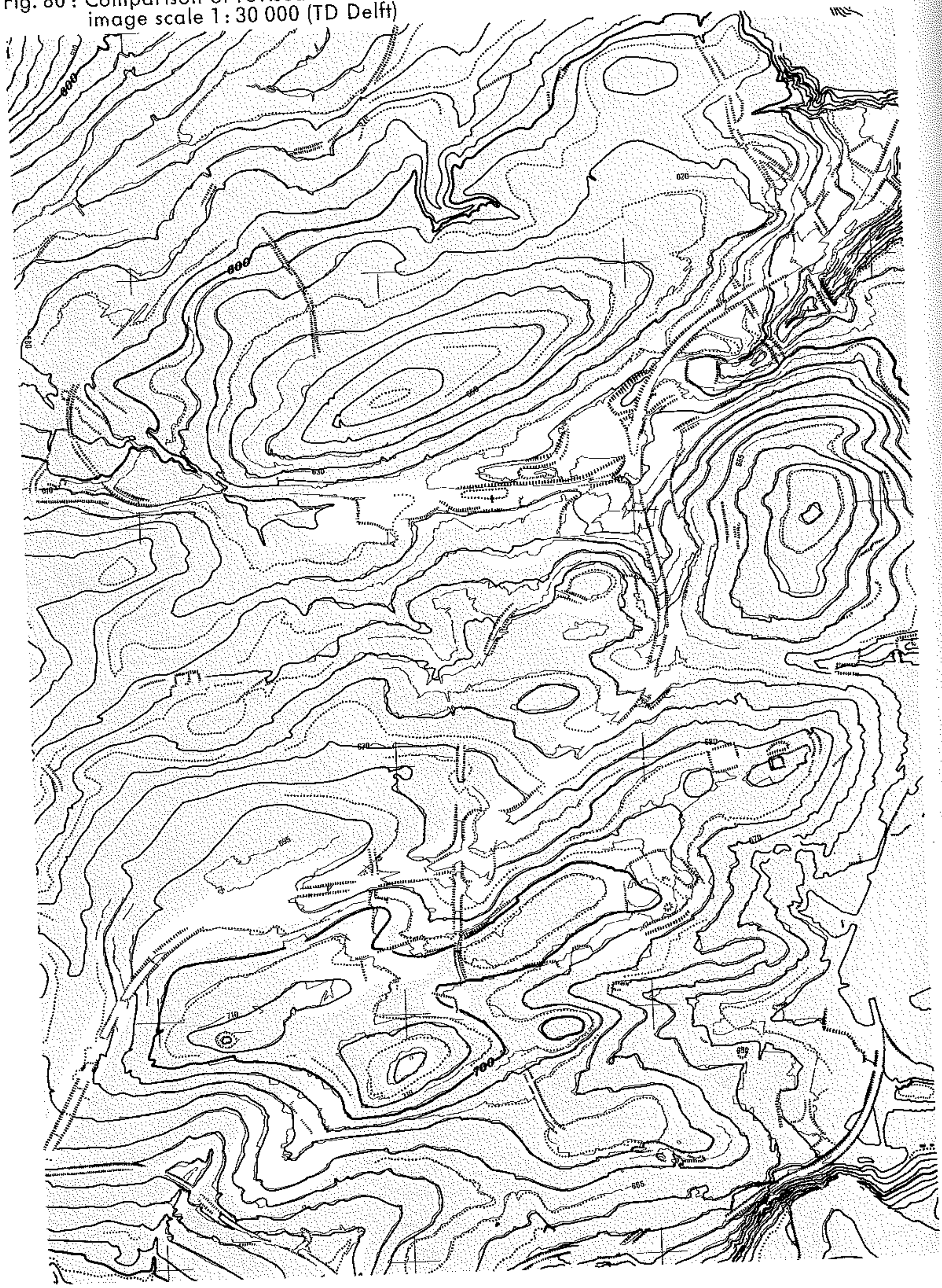


Fig. 81 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (NBS Helsinki (o))

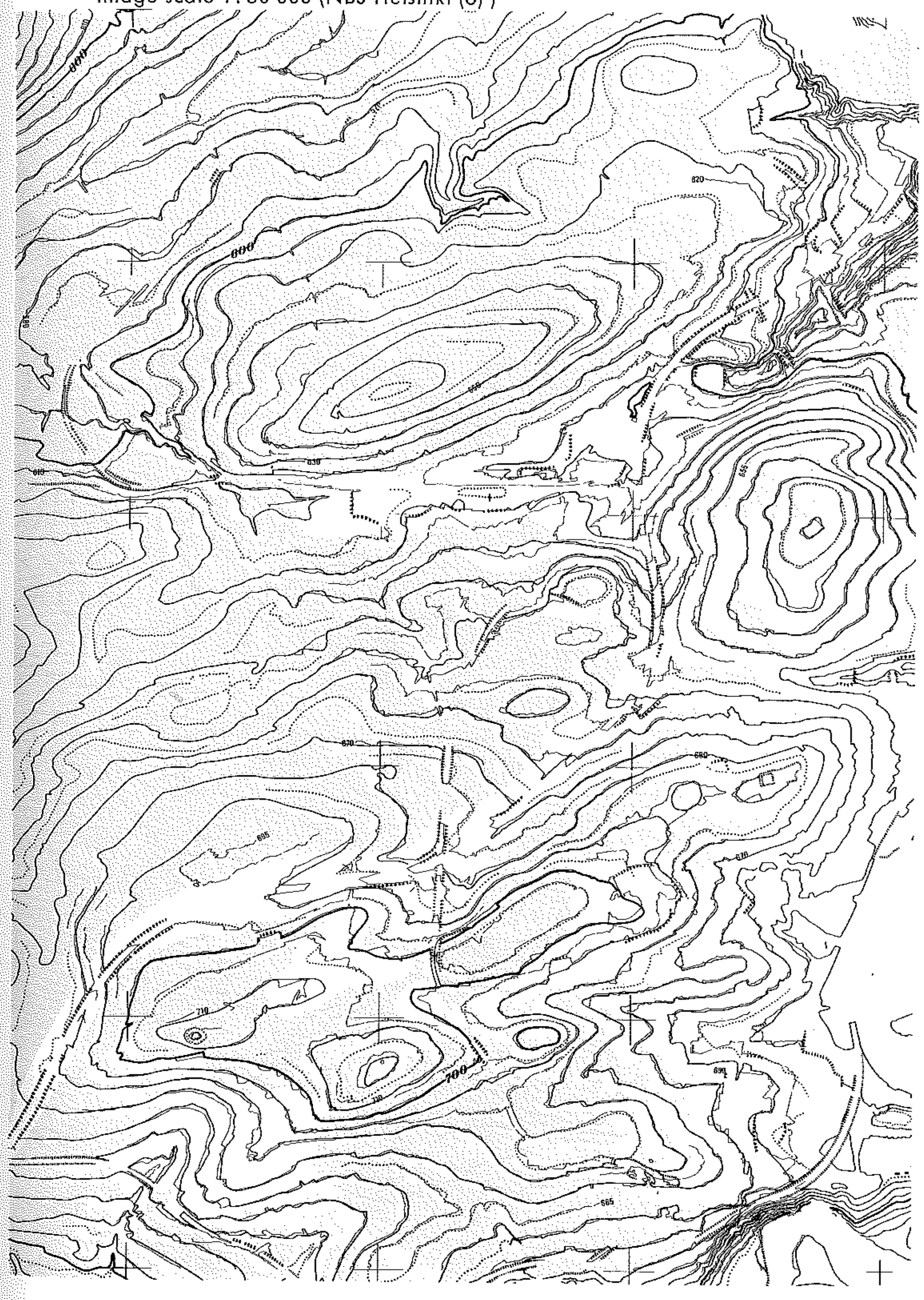


Fig. 82 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (NBS Helsinki (s))

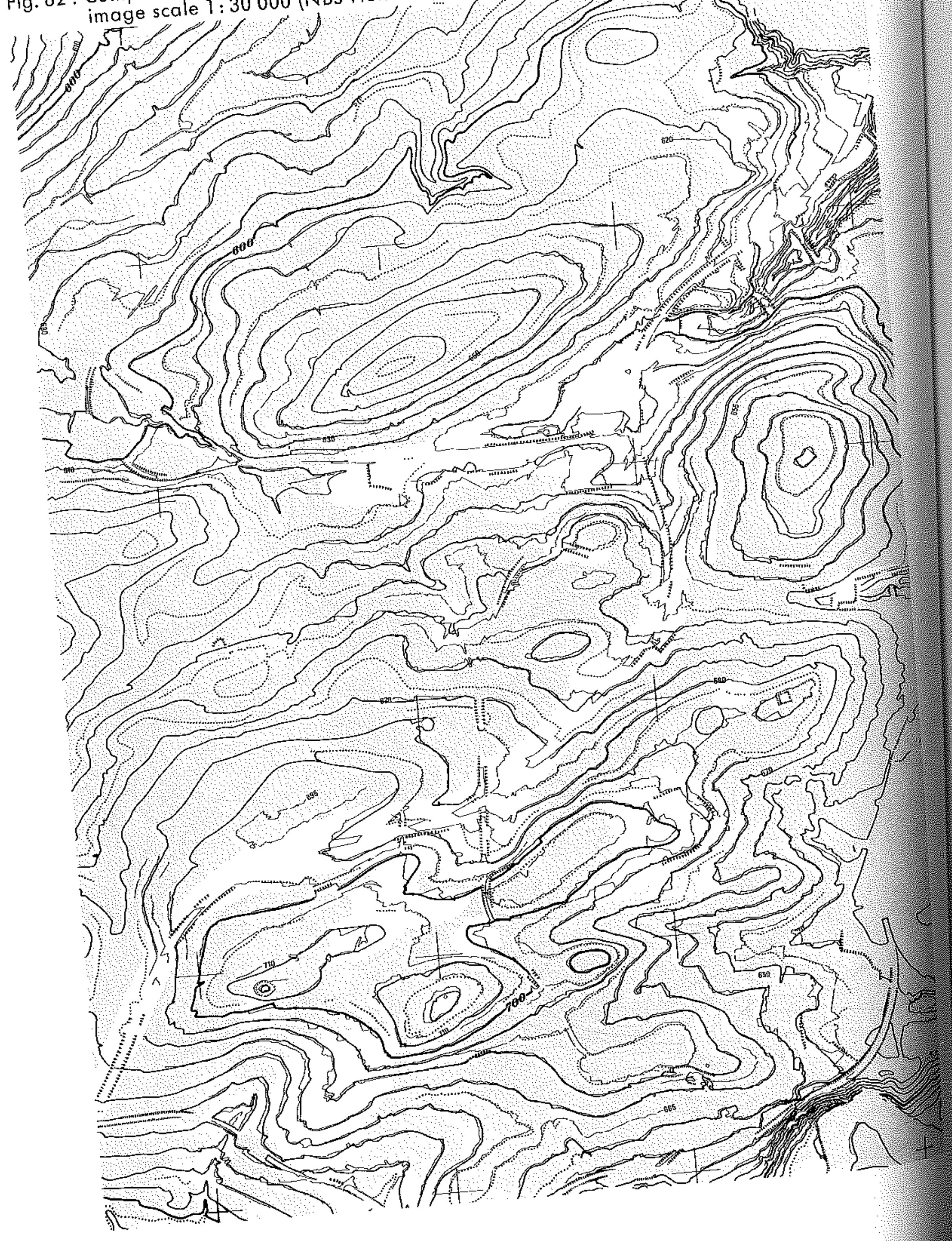


Fig. 83 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (IGN Brussels)

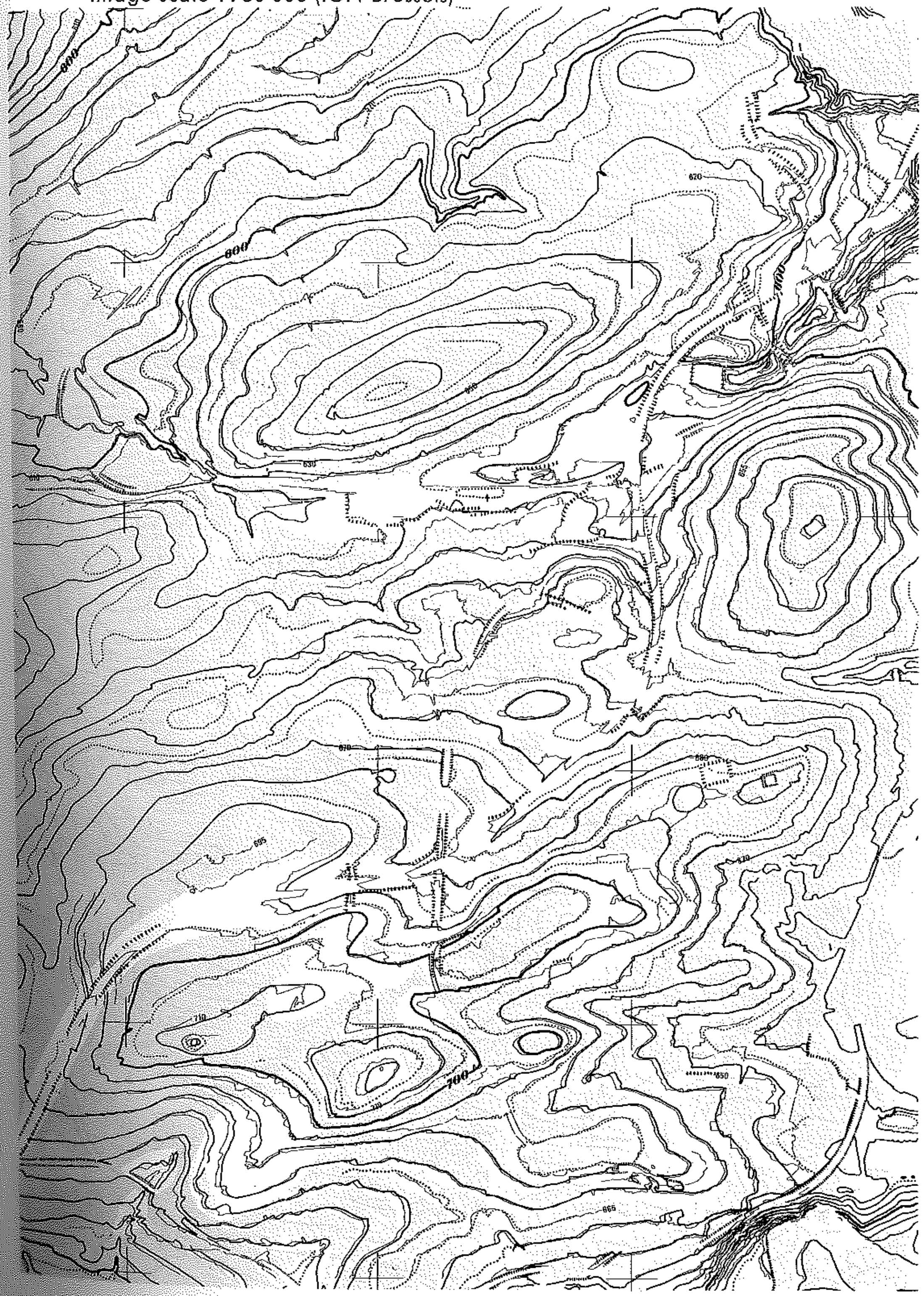


Fig. 84 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (NGO Oslo)

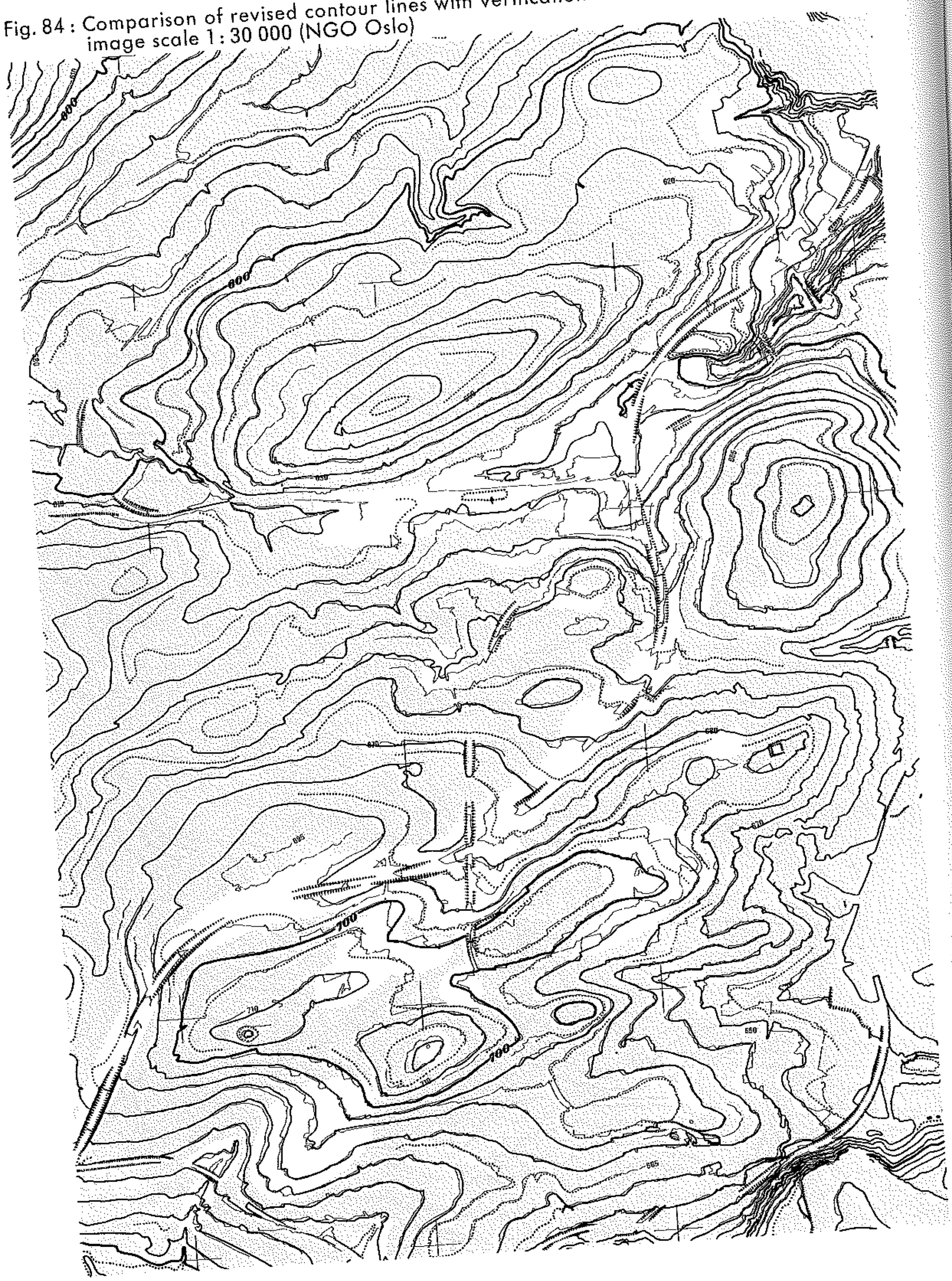


Fig. 85 : Comparison of revised contour lines with verification contour lines, image scale 1 : 18 000 (IGN Brussels)

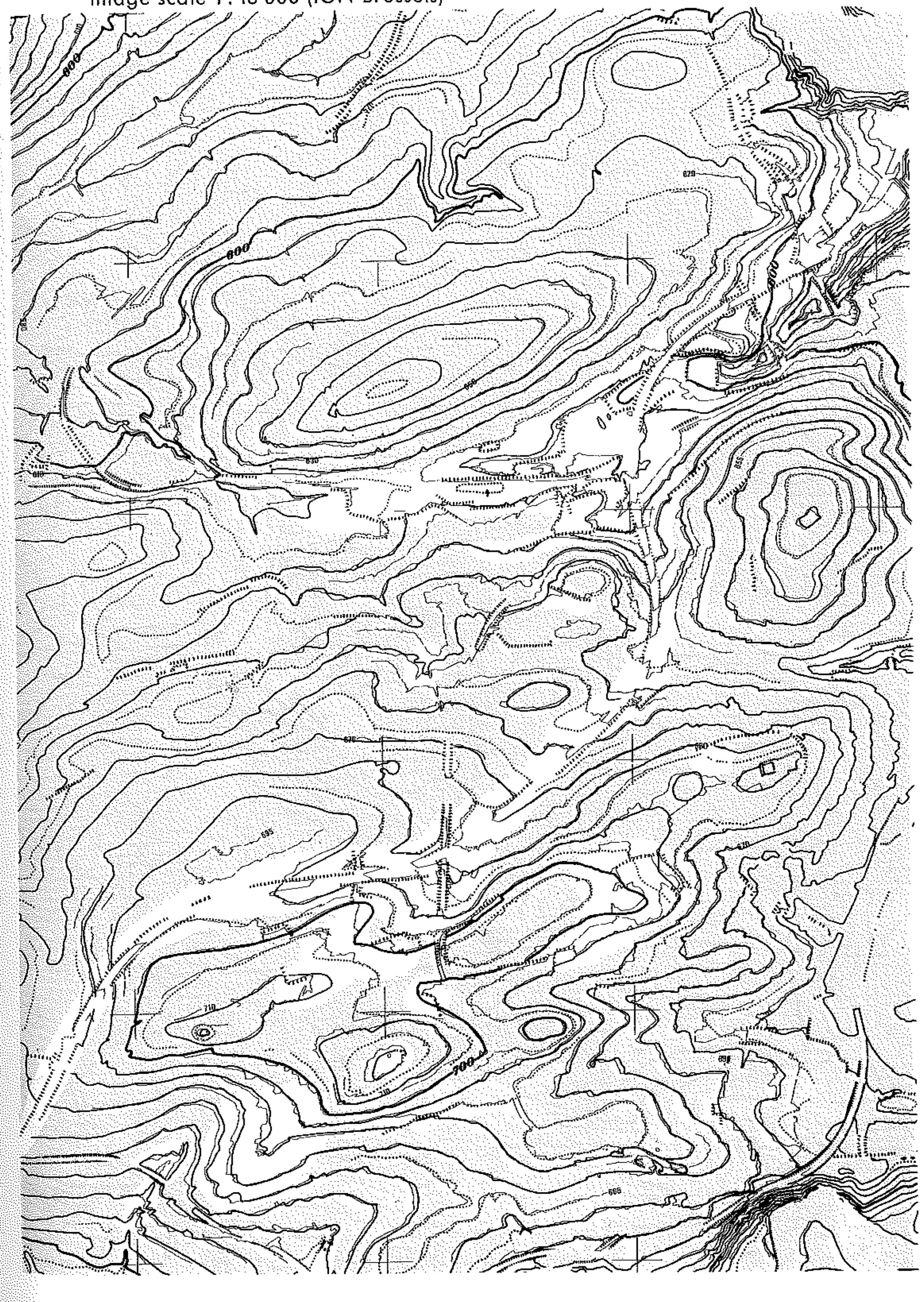


Fig. 84 : Comparison of revised contour lines with verification contour lines, image scale 1 : 30 000 (NGO Oslo)

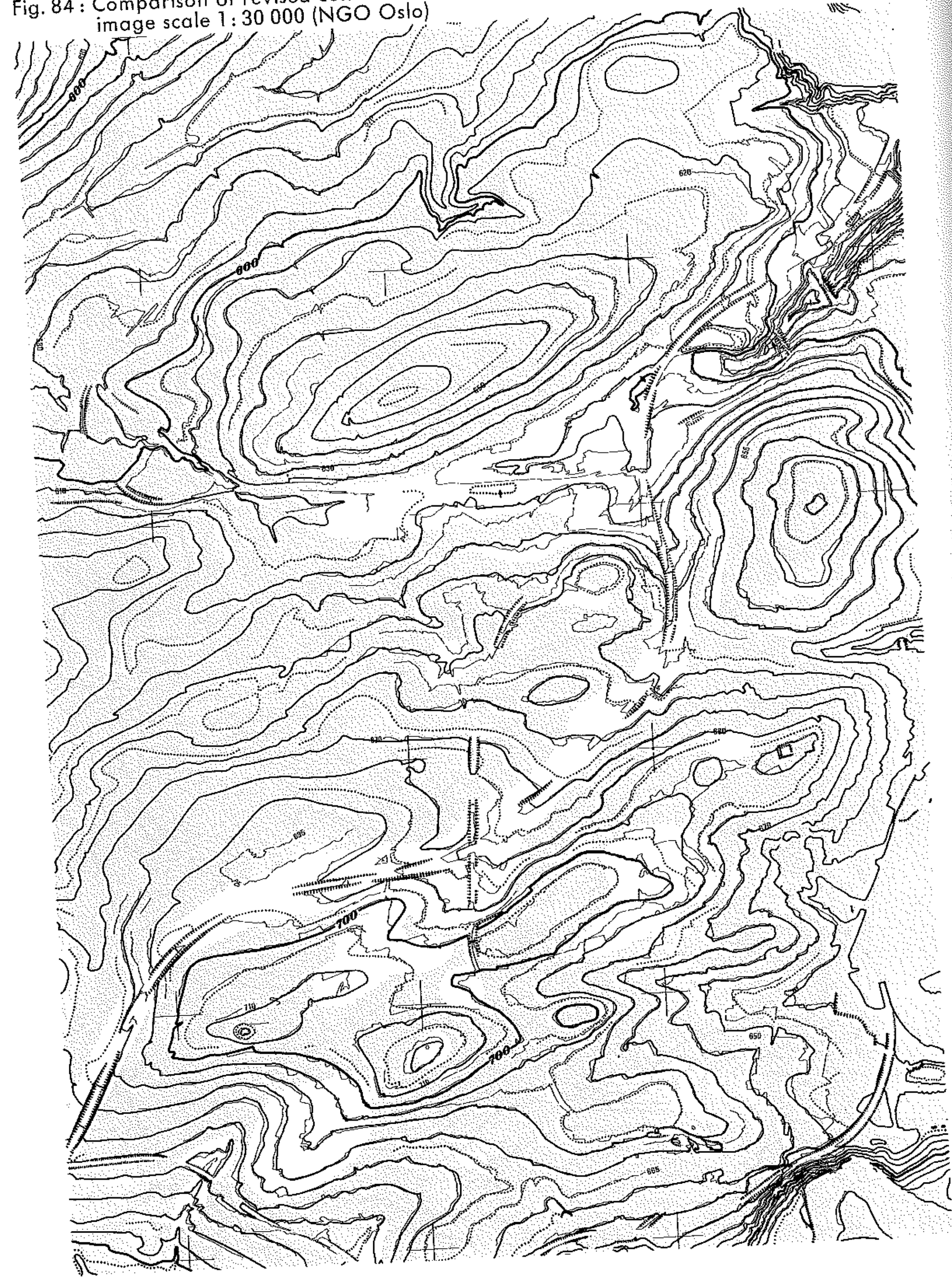


Fig. 85 : Comparison of revised contour lines with verification contour lines, image scale 1 : 18 000 (IGN Brussels)

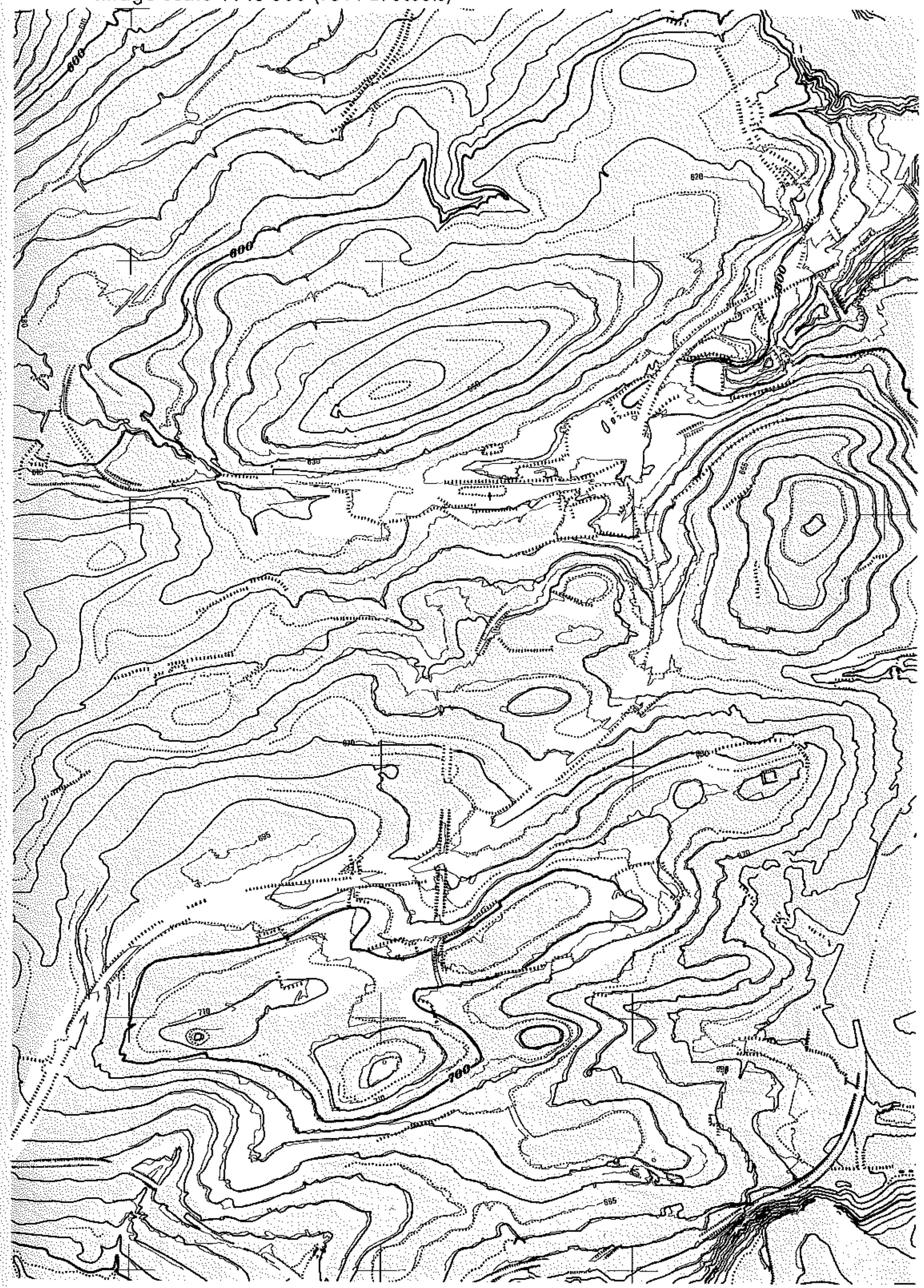


Fig.86 : Comparison of revised contour lines with verification contour lines, image scale 1 : 18 000 (NGO Oslo)

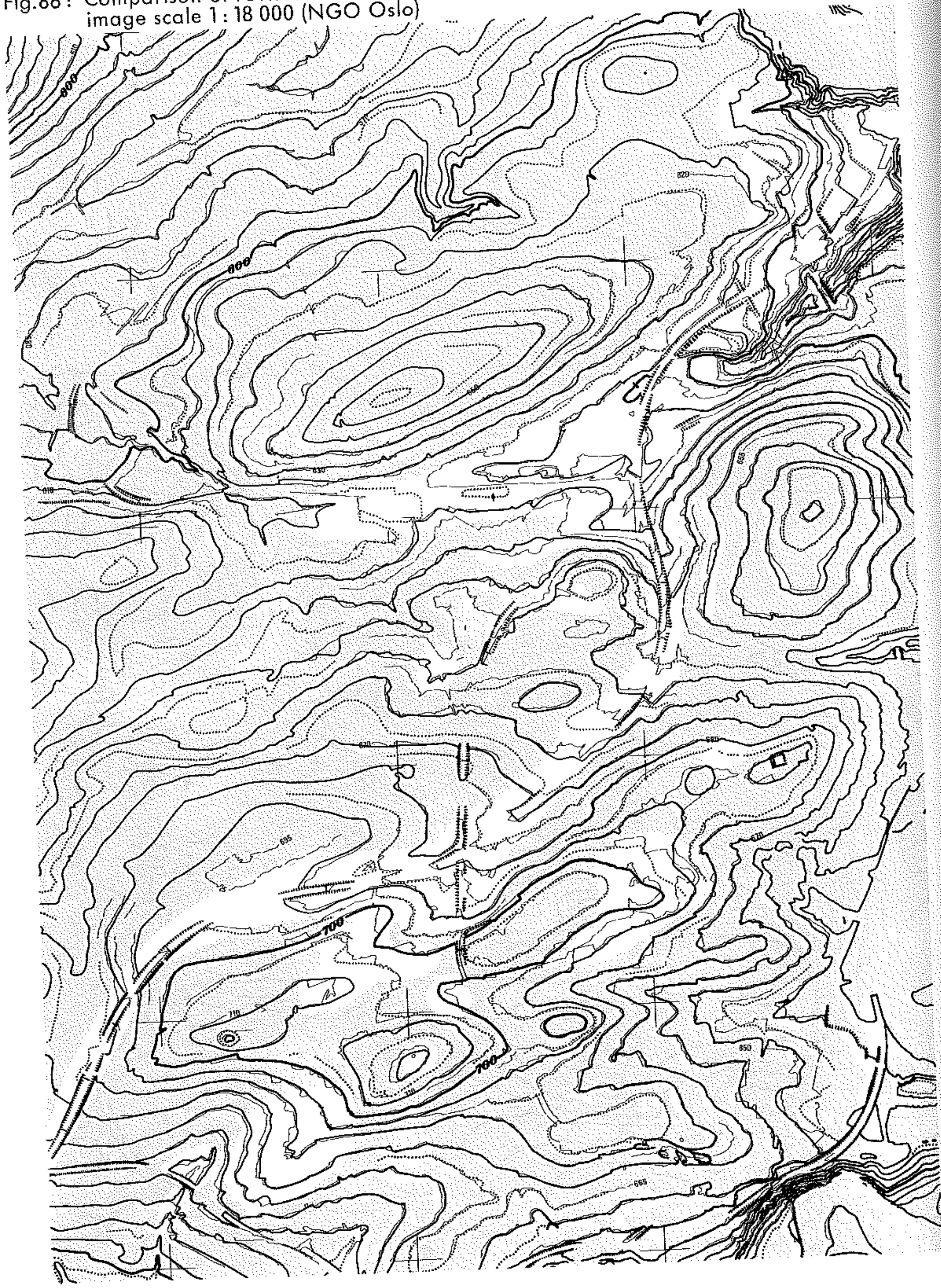
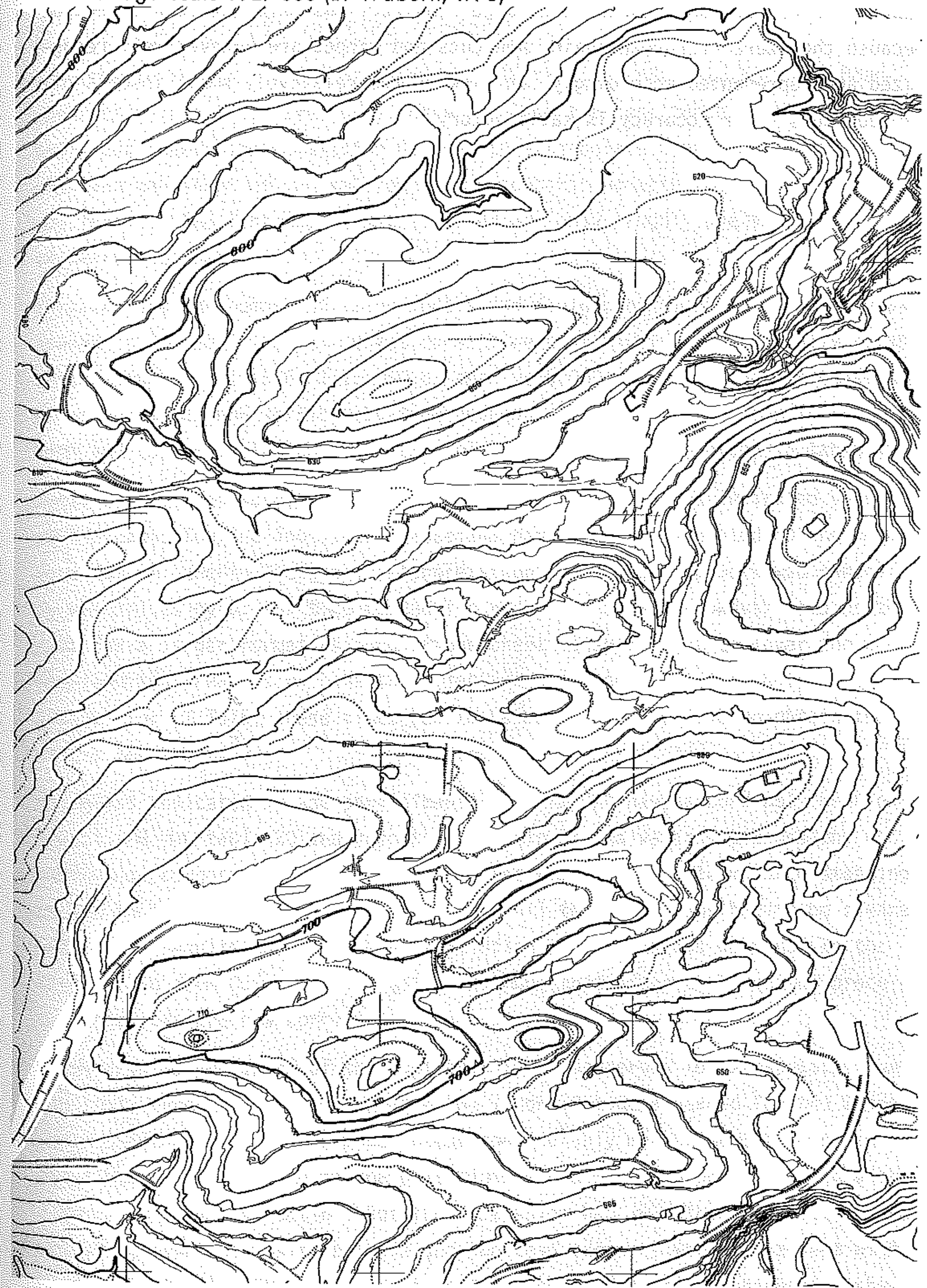


Fig. 87 : Comparison of revised contour lines with verification contour lines, image scale 1 : 27 000 (LT Wabern, 1975)



In summarizing this part of the test we can state that 40% of the terrain changes in connection with new and large constructions have not been detected, because they were overgrown again. New cuts and slopes are however well recognized and represented accordingly. In view of the relatively small inserts of new contours their accuracy is satisfactory.

7. Time needed for individual procedures

7.1 General remarks on time needed

In order to reduce the effort needed by all participants this test has been restricted to a small area only, covering less than one tenth of a normal Swiss map sheet. The commission decided to extrapolate time and cost to a standard map sheet of 100 km^2 for easier comparisons with the various national map formats. The test map format is 18.43 km^2 only, rughly one fifth of such a standard map sheet.

In each case the number of image models and field control points had to be extended to 100 km^2. The full sheet formats were not suitable, especially as an enlargement to 1:16 666, 1:15 000 or even 1:10 000 was envisaged. In these cases more than one working sheet of reduced size was provided for in the time and cost calculations. All the relevant data are summarized in table 19.

Table 20 gives an account of all factors by which the times indicated by the participants for the individual processes have been extrapolated to the standard 100 km^2 sheet. Plotting, interpretation and draughting work was generally multiplied by 5. The time needed for reproduction work however remains the same for a larger format as long as one sheet is sufficient to cover the whole standard map area. As we have the effective hours needed for a whole sheet of 210 km^2 for LT 1975, these times had to be multiplied by 0.48 to obtain the effort for 100 km^2.

All hours indicated by the participants in form C/D have accordingly been extrapolated in table 20 and reported in table 21. As various discussions and additional correspondance have shown, there was considerable misunderstanding on how to fill in the form C/D correctly. All these problems had to be cleared before the results could be finalized. Often these problems were due to the translation from German into English. We hope that after this tedious procedure the data are now correct.

In general we are aware of the fact that it is dangerous to extrapolate from one, two, three or four models to 4, 6, 12 or 20 models needed for the whole sheet. Certainly the first model needs considerably more time than a subsequent one, expecially so as the participants had first to be acquainted with a foreign map and situation. But the Commission had no other choice, if a realistic comparison was to be made and the test expenses were to be kept within reasonable limits. The reader must be aware of this fact when assessing the following results.

Table 19:

Suppositions for the standardization to a standard map sheet of 100 km^2

Area of the FRIBOURG Test:		18.43 km^2
		5.05 x 3.65 km
	Format:	20.2 x 14.6 cm
Area of standard map:		100 km^2
		12 x 8.33 km
	Format:	48 x 33.33 cm

Working scale	Reproduction format needed for above standard map size	
1:25 000	(33 x 48)	50 x 60 cm
1:16 666	(50 x 72)	60 x 90 cm
1:15 000	(56 x 80)	70 x 100 cm
1:10 000	(84 x 120)	100 x 130 cm
	(or 2 x 60 x 84)	or 2 x 70 x 100 cm

Number of photos needed (80% coverage)	
image scale 1:30 000 :	14
image scale 1:18 000 :	52
Number of orthophoto models needed	
image scale 1:30 000 :	6

Number of stereo models and control points needed (extrapolated from the test area):

image scale:	coverage:	models:	controls:	centres:
1:30 000	60%	6	26	LVA,IfAG,TD, NBS,IGN,NGO
1:30 000	80%	4	(20)	LT (no controls used)
1:18 000	60%	20	64	IGN,NGO

Fig.88: Time needed for individual procedures (hours needed for 100km²)

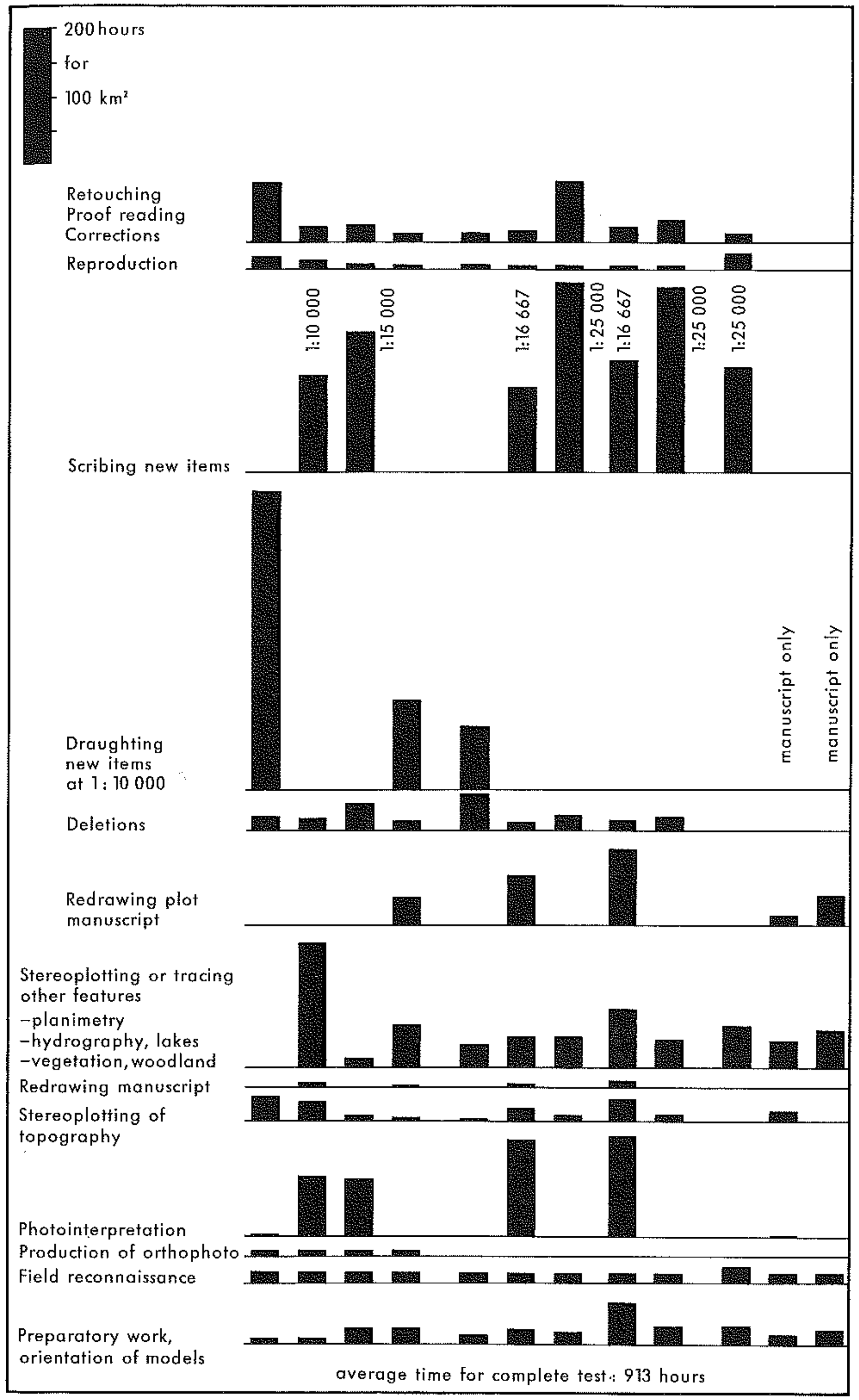


Table 20: Factors by which times have been multiplied in tables 7.1.2 / 7.1.3

	Orthophoto				Stereoplotting							SFP	Price unit
Test area 18.43 km²	LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO	LT 75	LT 76	NBS	
Image scale 1:	30 000	30 000	30 000	30 000	30 000	30 000	30 000	18 000	18 000	27 000	30 000	30 000	sFr. or DM
Number of Models used	2	1	1	1	1	1	1	4	3	2	1	1	1980
Number of signalized control points used	9	5	-	5	5	5	5	8	8	-	-	-	
Coverage	60%	60%	60%	60%	60%	60%	60%	60%	60%	80%	80%	60%	
Factors for 100 km²													
Control points signalized	26	26	-	26	26	26	26	64	64	-	-	-	15.-
Personnel factors	x2.15	x2.15	-	x2.13	x2.13	x2	x2	x2	x2	-	-	-	42.-
Model orientation and preparation													
Model factors for 100 km²	x6	x6	x6	x6	x6	x6	x6	x5	x7	0.48 xeff.	x4	x6	42.-
Personnel factors	x1.15	{x1.3 x1.5	{x1.07 x0.85	{x086 x1	{x1 x086	x1	{x1 x1.2	x1	{x1 x1.2	x1	x1	{x1 x0.86	
Orthophoto production													
Orthophoto for 100 km²	x6	x6	x6	x6									42.-
Personnel factors	x1.15	x1	x1	x1									
Field reconnaissance													
Time for 100 km²	35	30	30	30	30	30	30	30	30	50	30	30	57.-
Tracing from Orthophoto/Photo interpretation/ Stereoplotting													
for 100 km²	x5	x5	x5	x5	x5	x5	x5	x5	x5	0.48 xeff.	x5	x5	42.-
Personnel factors	x1.15	{x1.15 x1.3	x1.07 x1.14	x1	x1	x1	x1	x1	x1	0.48 xeff.	x1	x1	
Redrawing plot manuscript													
for 100 km²	-	x 5	-	x5	x5	x5	-	x5	-	-	x5	x5	42.-
Personnel factors	-	x1.3	-	x1	x1	x1	-	x1	-	-	x1	x1	
Deletions													
for 100 km²	x5	x5	x5	x5	x5	x5	x5	x5	x5	-			42.-
Personnel factors	x1.15	x1.15	x1	x1	x1	x1	x1	x1	x1	-			
Draughting/Scribing													
for 100 km²	x5	x5	x5	x5	x5	x5	x5	x5	x5	0.48 xeff.	not executed		42.-
Personnel factors	x1.15	x1.15	x1	x1	x1	x1	x1	x1	x1	x1			
Reproduction 1:	10 000	10 000		10 000	10 000								
for 100 km² (approx.factors)	x2 x1	x2 x1	x1	x2 x1	x2 x1	x1	x1	x1	x1	0.45 xeff.			42.-
Personnel factors	x1	{x1.15 x1	x0.86	x0.86	x0.85	x0.67	x1	x0.67	x1	x1			
Final checking													
for 100 km²	x5	x5	x5	x5	x5	x5	x5	x5	x5	0.48 xeff.			42.-
Personnel factors	{x1.15 x1.3	{x1.15 x1.3	{x1.14 x1	{x1.13 x1	{x1.13 x1	x1	{x1.2 x1	x1	{x1.2 x1	x1			

Fig. 89 : Total time needed for the whole revision process and for each subprocess

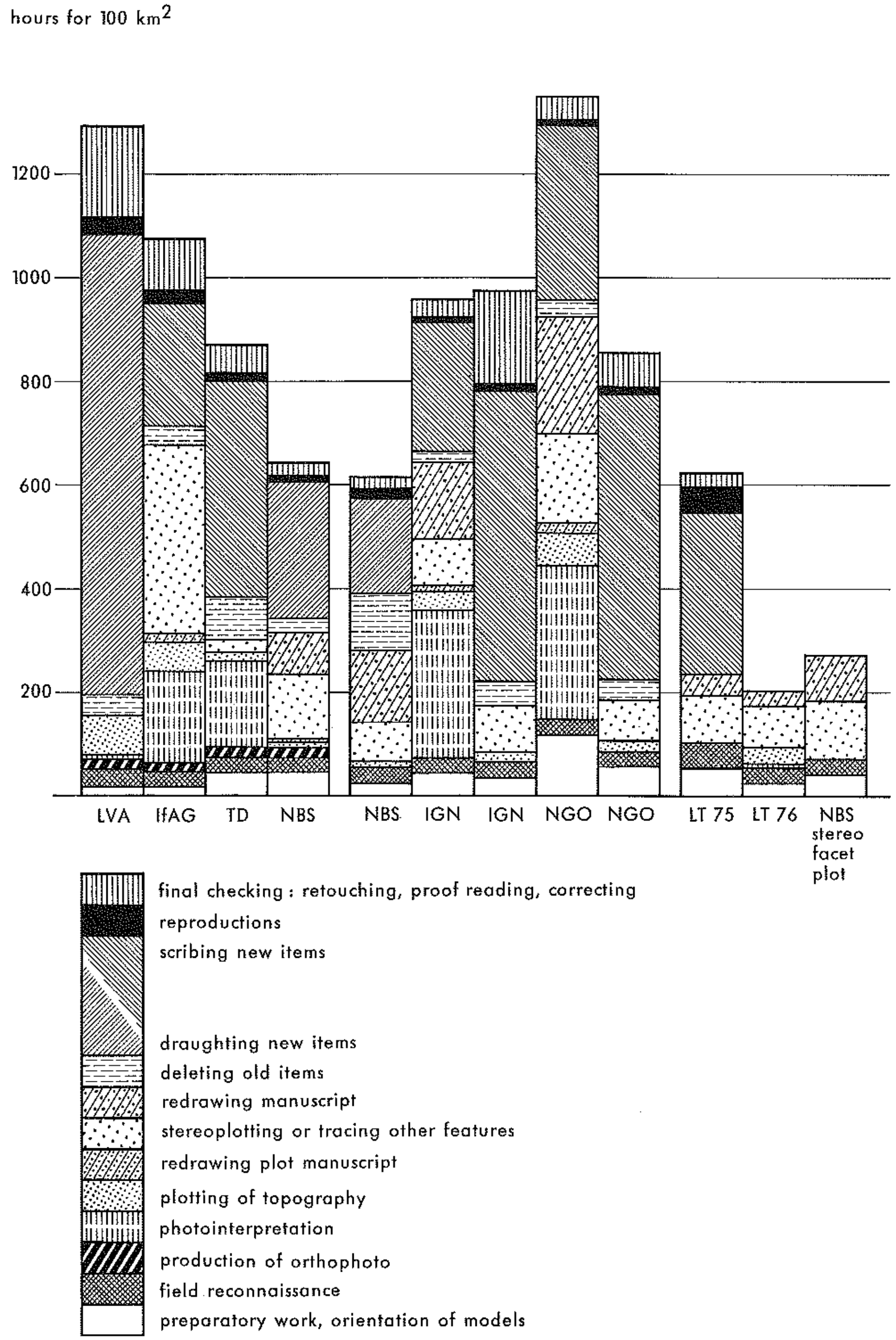


Table 21: Time needed for individual procedures

Hours needed in the revision test, converted to a sheet of 100 km²

D = drawing
S = scribing mainly

Executed by: e = engineer
t = technician
d = draughtsman
p = photographer
T = topographer

	LVA D	IfAG D	TD NL	NBS SF	NBS SF	IGN B	NGO N	IGN B	NGO N	LT 1975 CH	LT 1976 CH	NBS Stereo Facet Plot
Image scale 1:	30 000	30 000	30 000	30 000	30 000	30 000	30 000	18 000	18 000	27 000	30 000	30 000
Photogrammetry												
Preparatory work		9 e	8 t				18 e		18 e		11 t	
Preparatory reproduction work		(3)t	21 p	25 p	4.5p	20 t	1 t	37 t	1 t			4.5p
Orientation of models	18 t	6 e	16 t	(19.5)d	19.5d	24 t	18 t	82.5t	38.5t		15	36 d
Time until models ready:	18	18	45	44.5	24	44	37	119.5	57.5	55	26	40.5
Field reconnaissance	35	30	30	30	30	30	30	30	30	50	30	30
Production of orthophoto	19	19.5	19.5	19.5								
Photointerpretation												
Preparatory work			1 d								4.5	
Preparatory reproduction work	7.5t	6 e										
Comparison of map with orthophoto or aerial photograph		170t	165t			285t		295t				
Photointerpretation:	7.5	176	166			285t		295 t			4.5	
Plotting of topography												
contour lines	50 t	30 e	15.5t	5 d	5 d	35 t	17.5t	60 t	20 t		17.5t	
spot heights		5 e										
new slopes	25 t	20 4		5 d	2.5d						16 t	
	75	55	15.5	10	7.5	35	17.5	60	20		33.5	
Spot height test (40)	1 t	3 e	2 t	0.5	0.5	3 t	0.5t	5 t	1 t		1 t	
Redrawing plot manuscript		15 e		5 d		10 d		20 d				
Plotting other features	Tracing from orthophoto				Stereorestitution			Stereorestitution				
traffic network		145 t		60 d	32.5d						22.5	40 d
buildings		207.5t	25 t	45 d	24 d	90 t	90 t	170	80		45	45 d
land use		5 t		10 d	7.5d						9	12.5d
hydrography		7.5t		10 d	11.5d						2.5	15 d
Plotting or tracing:		365	25	125	75.5	90	90	170	80	131	79.0	112.5
Redrawing manuscript				80 d		145 d		225			30	87.5d
Total time needed for manuscript	155.5	681.5	303	314.5	137.5	642	175	924.5	188.5	236	204	270.5

Table 21: Time needed for individual procedures (continued)

Hours needed in the revision test, converted to a sheet of 100 km²

D = drawing
S = scribing mainly

Executed by: e = engineer
t = technician
d = draughtsman
p = photographer
T = topographer

	LVA D	IfAG D	TD NL	NBS SF	NBS SF	IGN B	NGO N	IGN B	NGO N	LT 1975 CH	LT 1975 CH	NBS Stereo Facet Plot
Image scale 1:	30 000	30 000	30 000	30 000	30 000	30 000	30 000	18 000	18 000	27 000	30 000	30 000
Drawing/Scribing	D	S	S	D	D	S	S	S	S	S		
Cartography; deletions												
traffic network	5 t	15 t		12.5d	70 d		} 25 t		} 25 t			
buildings	2.5t		81 d	10 d	17.5d			} 35 t				
blue plate, hydrography	2.5t	2.5t			7.5d	} 22.5	2.5t		2.5t			
light blue plate, lakes												
woodland edges, land-use	5 t	10 t		1			2.5t		2.5t			
woodland areas	2.5t	5 t		1	10 d							
brown plate, contour lines	2.5t	2.5t		2.5d	6 d		15		15 t			
by masking and retouching	20 p											
Deleting old items:	40	35	81	27	111	22.5	45	35	45			
Drawing/Scribing	D	S	S	D	D	S	S	S	S	S		
Cartography												
traffic network	250 t	} 150 t	} 305 d	135 d	61.5d	} 150 t	} 400 t	} 165 t	} 380 t	} 123 d		
buildings	450 t			45 d	82.5d							
hydrography	35 t	5 t	2.5d	10 d	5 d	5 t	50 t	5 t	42.5t	29 d		
solids of lakes			4.5d	7.5d		2.5t	5 t	2.5t	5 t	1 d		
woodland edges, land-use	70 t	5 t	25 d	17.5d	10 d	20 t	10 t	40 t	12.5t	54 d		
woodland areas		7.5t	4.5d	10 d	6.5d	10 t	5 t	10 t	2.5t	18.5d		
contour lines, slopes	80 t	120 t	74 d	40 d	20 d	60 t	90 t	110 t	105	86 d		
Draughting new items:	885	287.5	415.5	265	185.5	247.5	560	332.5	547.5	311.5		
Reproduction												
photogr.enlargements			3 p		4 p							
photogr.reductions	2 p	3 t	1 p	4 p	4 p	(3) t		(3) t				
photogr.contact copies	1 p	16 t	7 p	3 p	3 p	(4) t	1 t	(4) t	1 t			
photomech.guide copies		2 t	4.5p			(3) t	2 t	(3) t	2 t			
dye up copies	28 p	2 t		6 p	6 p		1 t		1 t			
etch scribe copies							6 t		6 t			
multicolour copies	7 p	3 p	2.5p			2 t	4 t	2 t	4 t			
Reproductions:	38	26	18	13	17	(12)	14	(12)	14	50 p		
Retouching	165 t					5 t	55 t	5 t		11.5d		
Proof copy reading	5 e	40 e	22.5T	20 t	20 t	20 t	50 e	20 t	30 e	15.5t		
Correcting colour plates	5 t	5 t	30 d	5 d	5 d	10 t	75 t	20 t	35 t			
Final checking:	175	45	52.5	25	25	35	180	45	65	27		
Total time needed for 100 km²	1293.5	1075	870	644.5	476	959	974	1349	860	624.5		

( ) estimation

Comparison of the total time needed for the test sample.

The total time needed is simply the sum of all subprocesses listed in table 21, including the spot height test. The average time for all participants for all 10 tests for the 100 km^2 is 913 hours. The individual results however vary widely, the lowest sum being 476, the highest 1349 hours. On average the 4 orthophoto tests needed 971 hours, stereoplotting from 1:30 000 images 803 hours, and 1104 hours from 1:18 000 images. Such an interpretation is however not applicable in this case, because the great differences are mainly due to the cartographic processes used. Therefore we will concentrate on interpreting the hours needed for the individual subprocesses. Numbers in parenthesis are estimated hours in those cases where data were missing but needed for fair comparisons.

7.2 Preparatory time

This work phase includes the planning of the revision, the preparation of the base map, applying register marks and reproduction processes such as paper prints, guide copies etc. These figures vary considerably, because each sequence of processes has different requirements for preparatory work.

In the time needed until the models were ready we included also the orientation of the models. The average time for this phase is 2,8 hours. One hour has been needed only, if a numerical procedure was applied. The highest rate was 4,1 hours. In these figures the number of models needed for the standard area of 100 km^2 is quite decisive. Whereas only 4 models are needed when 80% overlap is arranged for at the 1:30 000 image scale, up to 20 models are necessary at the scale 1:18 000 and with 60% overlap. So this second disposition results in 5 times more time for the model orientation.

For field reconnaissance the time needed effectively in the field by the pilot centre to prepare the road classification manuscript has been extrapolated to 100 km^2. Stuttgart was asking for some additional information regarding slopes and high tension lines. We ought to mention here that the figures indicated by the Federal Office of Topography in Wabern for their 1975 revision are considerably higher.

Another position that may be subsumed under preparatory work is photointerpretation, mainly a comparison of the map with the orthophoto or the aerial photographs before plotting. Here again considerable differencies in the procedures may be noted. We may refer to chapter 4 for details. Some centres prepare a drawing or plotting model in form of a sketch with the intention to reduce cartography or plotting times. In the case of the orthophoto method this seems to pay off, whereas in stereoplotting photointerpretation directly while plotting is by far the quickiest way to do it, and sufficiently reliable as we have seen in chapter 6. The many hours spent for preinterpretation in Brussels neither really speed up plotting nor result in better results than the average for completeness.

We did not account for any time involved in studying the test specifications before the work was started.

7.3 Restitution time

Under this heading we listed all the hours indicated, that have close relation to plotting, including the spot height test and redrawing the plot manuscript.

We can compare the times needed for the plotting of the topography by all participants, because the methods were much the same, namely stereoplotting. Again the figures indicated vary considerably from a minimum of 8 hours (6 models) to a maximum of 85 hours, in which case 20 models were involved. The average time is around 40 hours for up-dating the contours of an area of 100 km^2.

Tracing from the orthophoto has been combined in two cases with the cartographic work. Therefore comparisons are difficult.

On the other hand the stereorestitution processes for the plotting of other features can be directly compared. If we include the redrawing of the manuscript we computed an average time of 159 hours for plotting the traffic network, buildings, vegetation and hydrography for an area of 100 km^2, but these figures vary between 75.5 and 395 hours. These figures include, of course, only plotting of new items for the above features. For the 12 stereomodels that were restituted for the test area the average time per model, orientation included, has been computed to be 23 hours. Evidently the plotting time per model is less (17 hours) for images at 1:18 000 but higher with 1:30 000 models (31 hours), which contain 4 to 5 times more area.

A question which is often discussed in pratice is whether redrawing the compilation manuscript pays off in subsequent processes. At the IGN more time was spent on refining the manuscript than on the restitution itself. In fact cartography thereafter consumed comparatively less time than average. But on the whole there remains some excess of hours.

There is little evidence from the test results received on what feature is most time-consuming in this revision. As was to be expected, the traffic network and the buildings rank highest. Few items had to be plotted for the woodland and the hydrography plate.

It is quite interesting to compare the total time needed up to the preparation of the manuscript. In all those tests that applied stereoplotting 358 hours were spent in the average. But in some cases only 40%, in another more than 250% of this time has been invested in a good base for fair draughting. Table 22 gives this time for the manuscript in percentages of the total hours consumed for the revision of this map. These values vary between 12% and 69%, both of them result in the highest absolute number of hours. We might deduce from this finding that either no manuscript at all, or one that is not too elaborate must be recommended.

Table 22: Fractions of time used for the preparation of the plotting manuscript and for the cartographic work

	orthophoto				stereoplotting					
	LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO	LT 75
Preparation of plotting manuscript	12%	63%	35%	49%	29%	67%	18%	69%	22%	38%
cartography, retouching corrections	88%	37%	65%	51%	71%	33%	82%	71%	78%	62%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total time needed for 100 km^2	1293.5	1075	870	644.5	476	959	974	1349	860	624.5

One third of the total revision time should ideally be devoted to the manuscript and two thirds for fair draughting or scribing. This conclusion can be drawn from the above table, when the total time needed is the criterion.

7.4 Cartography time

In table 22 the time needed for the cartographic work is split up in several items. For some comparisons we sum up the following ones in table 23:

- deleting old items
- draughting new items
- retouching
- correcting colour plates

Table 23: Time needed for all the cartographic work

	LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO	LT 75	Mean
manuscript or orthophoto	o	m	o	m	m	m	m	m	m	m	
drawing at 1:	10000			10000	10000						
scribing at 1:		10000	15000			16660	25000	16666	25000	25000	hours:
deletions	40	35	81	27	111	22.5	45	35	45	-	49
cartography											
- drawing	885			265	185.5						445
- scribing		287.5	415.5			247.5	560	332.5	547.5	311.5	386
retouching	165					5	55	5		11.5	48
corrections	5	5	30	5	5	10	75	20	35	-	21
total time needed for cartography	1095	327.5	526.5	297	301.5	285	735	392.5	627.5	323	491
cartography in % of total time	85%	30%	61%	46%	63%	30%	75%	29%	73%	52%	54%

In table 23 we have listed the averages for some work phases. In sumarizing two other figures ca be given:

- drawing, retouching and correcting (3 tests): 505 hours
- scribing, retouching and correcting (7 tests) : 422 hours

Again these averages do not give a true picture, because the individual results vary within quite wide limits. The time needed for scribing, corrections included, varies between 285 and 725 hours, drawing even between 297 and 1095. This last value however is partly due to the absence of a manuscript. Because of such unequal random conditions, it is impossible to compare the average times for drawing with those needed for scribing. If we exclude this test (LVA), scribing needed 71% more time than drawing at 1:10 000. This result is in contradiction with the usual statement that scribing is less time-consuming than drawing. But revision work is of course not so straightforward as when a new map is scribed. The great number of small inserts, of tedious corrections and the variety of features involved may slow down the production.

An interesting fact, that can be deduced from the analysis, is that scribing time is considerably less (321 hours) when done at a larger scale than at the publication scale (411 hours). But here again, the results are remarkably different within each group. In drawing it becomes evident that drawing times are higher, when no manuscript has been prepared (LVA).

Precisely two thirds of the whole time involved in cartographic work is related to the traffic network and to the buildings, another 20% concerns contour lines and slope hachuring. All the other features need only a limited effort in this area. May we mention once more that lettering, a usually time-consuming revision procedure, has been excluded from this test.

7.5 Reproduction time

The various reproduction processes take on average slightly more than 2% of the total time for the map revision, a percentage that could be neglected. What is more of an imposition on the work progress are the frequent interruptions caused by all the intermediate reproduction phases.

For two out of the ten test samples strikingly higher figures are listed. It concerns the reproduction procedures applied by the LVA and the LT. What mainly account for the additional hours are in both cases the dyed up copies which are the main processes used in both organizations. In Stuttgart they are prepared on astralon, in Wabern on glass.

Compared to this process, all the common photographic processes are on one hand much quicker, but on the other hand the silver coatings are more expensive.

7.6 Proof reading time

On average 2,7% of the total time or 5% of the cartography time has been invested in proof reading. The amount of time devoted to an improvement of the overall result is different from organisation to organisation and shown in table 24.

Table 24: Time invested in proof reading in percent of the total time for the cartographic work

Average	LVA	IfAG	LT	NBS	NBS	IGN	NGO	IGN	NGO	LT 75
5%	0.5%	12%	4%	7%	7%	7%	7%	5%	5%	5%

The percentage used for proof reading is obviously higher where less time has been spent for the cartographic work.

Regarding time for corrections we should emphasize that the drawings needed very little (5 hours) in comparison to the 29 hours on average for scribing. The basis on which the corrections have been applied has been indicated only in two cases.

7.7 Total time versus completeness and accuracy

As everyone involved in cartographic production knows, there is some apparent relation between the time a photogrammetrist or a cartographer spends on a certain job and the quality of his work. We expect better quality where more time has been devoted to the job. Completeness and accuracy results are integral parts of this report. Attempts to quantify such qualitative aspects will necessarily be somewhat arbitrary, and the results of our studies are summarised as follows.

The above hypothesis has been confirmed to some extent. The samples that have been qualified slightly better in terms of completeness and accuracy, have also needed most time for their preparation. There are two exceptions to this rule. In one case nearly the same good result has been obtained with only two thirds of the time. In the other case the contrary is true, due to too little experience in this field, as has been stated by the respective participant.

The gain in quality being to some extent the result of a sacrifice of time, it becomes an optimisation problem, which may have an entirely different solution from organisation to organisation. The question to be answered is, whether it is worthwhile to spend 30% additional time or even more in order to gain 5% in completeness or to improve positional quality from $\pm$ 0.24 mm to $\pm$ 0.18 mm. The effect of entirely different working procedures has been neglected in these considerations, an assumption that will be discussed further in the next paragraph.

7.8 The influence of different working procedures on the time needed

In optimizing any working procedure, one of the main concerns is always to eliminate unnecessary intermediate steps. A comparison of the test reports gives quite a number of indications along these lines. Wherever one centre omits such a subprocess we have a hint for possible savings.

One of these critical items is comparing the map with the aerial photographs before stereoplotting (see table 21). It has been done only in two out of eight tests. Up to 28% of the total time has been devoted to this preliminary photointerpretation. When one looks at the plotting phase, it seems not to pay off in time, although it does to a certain extent in quality. Plotting time is of the same order as the average of all others without preinterpretation. One comes to the conclusion that a quarter of the total time could be saved by simply leaving out the preinterpretation with practically no loss of quality.

The same question studied in the group that plotted from orthophotos leads to a rather different answer. Each of these four participants has chosen a completely different approach. Two of them invest in a manuscript, the first one with 63% preinterpretation which is apparently too much, the other one with 30% which is probably an optimum. No pretreatment at all makes draughting rather slow. Direct scribing on an orthophoto base requires some stereo-preinterpretation. A stereo-interpretation manuscript and subsequent draughting at 1:10 000 was the shortest procedure.

Why the scribing times for the traffic network and the buildings differ by a factor of 2.6 is hard to explain. There is no obvious reason for this difference. All scribe coatings were ideally prepared with guide copies of the plotting manuscript. This is just one of a number of insignificant results within the whole test. The personnel involved in this type of work can hardly be standardized. It is unlikely that they will work at their usual pace in view of many unusual problems and some uncertainties.

8. Cost comparisons

8.1. Cost of man-hours

There were different kinds of personnel involved in this test work, for various reasons, intentionally or accidentally. For cost calculations a common basis had to be found. It was decided to fix as a standard for comparisons a cartographer, 40 years old, having a wife and one child, and to relate all other personnel to this standard. Table 25 gives the respective percentages.

Table 25 : Relation between salaries of different groups of personnel involved in the test

Participant	cartographer d	engineer e	technician topographer t	photographer p
LVA Stuttgart	1,oo	1,3o	1,15	1,oo
IfAG Frankfurt	1,oo	1,3o	1,15	1,oo
TD Delft	1,oo	1.98 1,13	1,07 1,14	0.86
NBS Helsinki	1,oo o,87	1,53	1,13	o,86
IGN Brussels	1,oo	1,78	1,oo	o,67
NGO Oslo	1,oo	1,2o	1,oo	1,oo
LT Wabern	1,oo	----	1,oo	1,oo

For all cost calculations the hours needed for each part of the job were multiplied with the above personnel factor.

For such a standarized cartographer-hour the following rate has been chosen:

SFr. or DM 42.- per man-hour (basis 1980)

8.2 Cost of field work

For those centres that used signalized control points for the absolute orientation of the orthophotos or models, the cost for these field operations was included. Two man-hours were charged for each signalized control point (two men for one hour each) and these hours again were extended to the whole 100 km^2. Field transportation was calculated from LT's experience in the 1975 field campaign. The rates chosen are as follows:

Field transportation by car	SFr. or DM 5.- per hour
Field equipment	SFr. or DM 10.- per hour of field work

Apart from the signalized control points a number of church towers could be used for the absolute orientation and scaling. There was no charge made for these permanent points.

Field identification work was extrapolated also to 100 km^2 from the experience gained during the verification campaign. All centres have been charged equally for the road classification. Only one centre (LVA) had asked for additional information and was charged accordingly for it.

8.3 Cost per instrument-hour

In addition to the cost of working-hours the cost of instrument-hours has to be taken into account. The cost of a map revision process depends in part also on the cost of the equipment used. To fix rates of instrument-hours is still more arbitrary than standardizing man-hours for different categories of personnel. Much depends on how many hours a year an instrument is effectively in production and on how many years the amortisation of an instrument is extended. The structure of the work and the instrumentation of a specific organization therefore largely influences these rates.

For the purpose of comparisons it appeared that it would be not correct to apply the rates that each participating centre could have submitted. The same instrument-hour rates were applied instead to all tests. They are supposed to include an amortisation rate and servicing but no other overhead cost. The following rates are based on cost accounts of the Swiss Federal Office of Topography (LT), which enables comparisons to be made with the cost data gathered for the 1975 revision.

Table 26 : Instrument-hour rates

Stereoplotting instrument (Planimat D2, Wild A7 und A8)	SFr. 80.- per hour of plotting
Orthophoto equipment (GZ 1/SG 1/LG 1, PPO 8, Avioplan)	60.-) per hour of operation
(OR 1 - Avioplan)	120.-)
Stereo Facet Plotter (OMI)	20.- per hour of plotting
Photographic equipment (Camera, copy frame, darkroom equipment, all included)	20.- per hour of work by the photographer

8.4 Cost of material

The participants have reported in all details the amount and kind of material they have used in the revision process. The amount of material needed for a standardized sheet with 100 km^2 has been extrapolated from the indications given in the reports and from the items listed in the flow diagrams. Each step was carefully analysed to take care of the consequences of the larger format in reproduction. Where one and the same sheet was able to cover the whole area of 100 km^2, only the format was adapted to a sheet size of 48 by 33 cm. In those cases where the published map was enlarged to 1:10 000 (120 by 84 cm), it was decided to divide it up in two sheets. For each of the 12 tests listed in table 28 the total amount of films, plates, paper copies, scribing sheets etc. was determined.

The same price was applied for all participants, independently from the specific trade mark used, so that the material costs remain comparable. These prices are listed in table 27. The price basis was again the year 1980.

The cost for material does not exceed on average 2% of the total cost for this revision process (Table 30). This percentage varies from o,3 to 5%. The latter is mainly due to the many large formats of photographic silver film that are used when working at the scale 1:10 000.

Table 27 : List of prices for reproduction materials needed in revision procedures

Prices in SFr. or DM (basis 1980)

Formats / Filmtype	24 x 24 cm	50 x 60 cm	60 x 90 cm	70 x 100 cm	100 x 130 cm
Photographic litho films		10.--	19.--	22.--	40.--
Photographic duplicating films		12.--	22.--	26.--	48.--
Photographic line films		8.--	16.--	19.--	35.--
Photographic continuous tone films		15.--			
Photographic paper copies	-.50				
Photographic enlargements		3.--	5.--		
Astralon/Pokalon films		6.--	8.--	10.--	20.--
Polyester draughting films		3.--	5.--	8.--	11.--
Polyester diazo films		5.--	10.--	12.--	20.--
Scribing sheets		14.--	28.--	33.--	60.--
Glass plates		5.--	(re-usable)		

Table 28 : Material needed for 100 km^2 Prices in SFr. or DM (basis 1980)

	Orthophoto				Stereoplotting							SFP
	LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO		LT 76	NBS
Image scale	30 000	30 000	30 000	30 000	30 000	30 000	30 000	18 000	18 000	27 000	30 000	30 000
Draughting/Scribing	D	S	S	D	D	S	S	S	S	S	S	D
Working scale	10 000	10 000	15 000	10 000	10 000	16 667	25 000	16 667	25 000	25 000	25 000	10 000
Materials format: price per unit	x number of sheets = cost of these sheets											
Photogr. lith films 50 x 60 10.-	14 x 140.-	32 x 320.-	4 x 40.-	12 x 120.-	12 x 120.-	15 x 150.-	7 x 70.-	15 x 150.-	7 x 70.-	2 x 20.-	2 x 20.-	12 x 120.-
60 x 90 19.-						10 x 190.-		10 x 190.-				
70 x 100 22.-			16 x 352.-									
100 x 130 40.-	2 x 80.-	14 x 560.-		30 x 1200.-	30 x 1200.-	2 x 80.-		2 x 80.-				29 x 1160.-
Duplicating films 50 x 60 12.-	2 x 24.-					2 x 24.-		2 x 24.-				
Photogr. lith plates 50 x 60 70.-										2 x 140.-	2 x 140.-	
Continuous tone films 50 x 60 15.-	6 x 90.-	6 x 90.-	6 x 90.-	6 x 90.-								
Photo paper copies 24 x 24 -.50	14 x 7.-	14 x 7.-	14 x 7.-	14 x 7.-	14 x 7.-	14 x 7.-	14 x 7.-	52 x 26.-	52 x 26.-	20 x 10.-	14 x 7.-	14 x 7.-
Enlargements paper 30 x 40 2.-								12 x 24.-				
50 x 60 3.-				6 x 18.-								
60 x 90 5.-			8 x 40.-	8 x 40.-	8 x 40.-	8 x 40.-						
Astralon/Pokalon 50 x 60 6.-	15 x 90.-	1 x 6.-				7 x 42.-	2 x 12.-	7 x 42.-	2 x 12.-			
70 x 100 10.-			2 x 20.-									
100 x 130 20.-	8 x 160.-	4 x 80.-		14 x 280.-	14 x 280.-							13 x 260.-
PE draughting films 50 x 60 3.-							1 x 3.-		1 x 3.-			
60 x 90 5.-		2 x 10.-										
70 x 100 8.-			1 x 8.-									
100 x 130 11.-	12 x 132.-											
PE diazo films 50 x 60 5.-												2 x 10.-
60 x 90 10.-						2 x 20.-		2 x 20.-				
Scribing sheets 50 x 60 14.-							5 x 70.-		5 x 70.-			
60 x 90 28.-						4 x 112.-		4 x 112.-				
70 x 100 33.-			5 x 165.-									
100 x 130 60.-		4 x 240.-										
Glass plates, re-usable 50 x 60 5.-										14 x 70.-	14 x 70.-	
Color Key 50 x 60 30.-										4 x 120.-	4 x 120.-	
Total cost of material	723.-	1313.-	722.-	1755.-	1647.-	665.-	162.-	668.-	181.-	360.-	357.-	1557.-

Table 29 : Cost analysis of the map revision test

Total cost and cost of individual processes for 100 km² in SFr. or DM (price basis 1980)

	Orthophoto				Stereoplotting							Stereo Facet plotting
Centre	LVA D	IfAG D	TD NL	NBS SF	NBS SF	IGN B	NGO N	IGN B	NGO N	LT75 CH	LT76 CH	NBS SF
Image scale 1:	30 000	30 000	30 000	30 000	30 000	30 000	30 000	18 000	18 000	27 000	30 000	30 000
Drawing/Scribing	D	S	S	D	D	S	S	S	S	S	S	D
Subprocesses												
Control point signalization	2 738	2 738	-	2 716	2 716	2 574	2 574	6 336	6 336	-	-	-
Preparation and model orientation												
man-hours	869	964	1 837	1 722	981	1 848	1 705	1 554	2 566	2 301	1 092	1 674
instrument-hours	1 440	480	1 280	1 560	1 560	1 920	1 440	6 600	3 080		1 200	720
photoequipment-hours	-	60	420	500	90	400	20	740	20		-	80
Orthophoto production												
man-hours	531	819	819	819								
Instrument-hours	1 140	2 340	1 170	2 340								
Field reconnaissance												
man-hours incl. equipment	1 995	1 710	1 710	1 710	1 710	1 710	1 710	1 710	1 710	2 840	1 710	1 710
Photointerpretation												
man-hours	362	8 539	7 942			11 970		12 390			189	
photoequipment-hours	150	120									90	
Tracing from/Stereo Orthophoto plotting												
man-hours	3 671	20 795	1 910	5 691	3 507	5 376	4 536	9 870	4 242	5 502	4 767	5 838
instrument-hours	6 080	4 640	3 400	840	6 680	10 240	8 640	18 800	8 080	10 480	9 080	2 700
Redrawing plot manuscript												
man-hours	-	819	-	3 570	-	6 510	-	10 290	-	-	1 260	3 675
	18 976	44 024	20 488	21 468	17 244	42 548	20 625	68 290	26 034	21 123	19 388	16 397
Cartography; deletions												
man-hours	1 806	1 690	3 402	1 134	4 662	945	1 890	1 470	1 890			
Cartography; drawing or scribing new items												
man-hours	42 745	13 886	17 451	11 130	7 791	10 395	23 520	13 965	22 995	13 083		
Reproduction												
man-hours	1 596	1 237	650	470	614	504	588	504	588	2 100		
photoequipment-hours	760	520	360	260	340	240	280	240	280	1 000		
Final checking, corrections												
man-hours	8 484	2 425	2 337	1 159	1 159	1 470	7 980	1 890	2 982	1 134	357	1 557
Material (see table ...)	723	1 313	722	1 755	1 647	665	162	668	181	360		
Total cost for 100 km2 (lettering not included)	75 090	65 095	45 410	37 376	33 457	56 767	55 045	87 027	54 950	38 800		

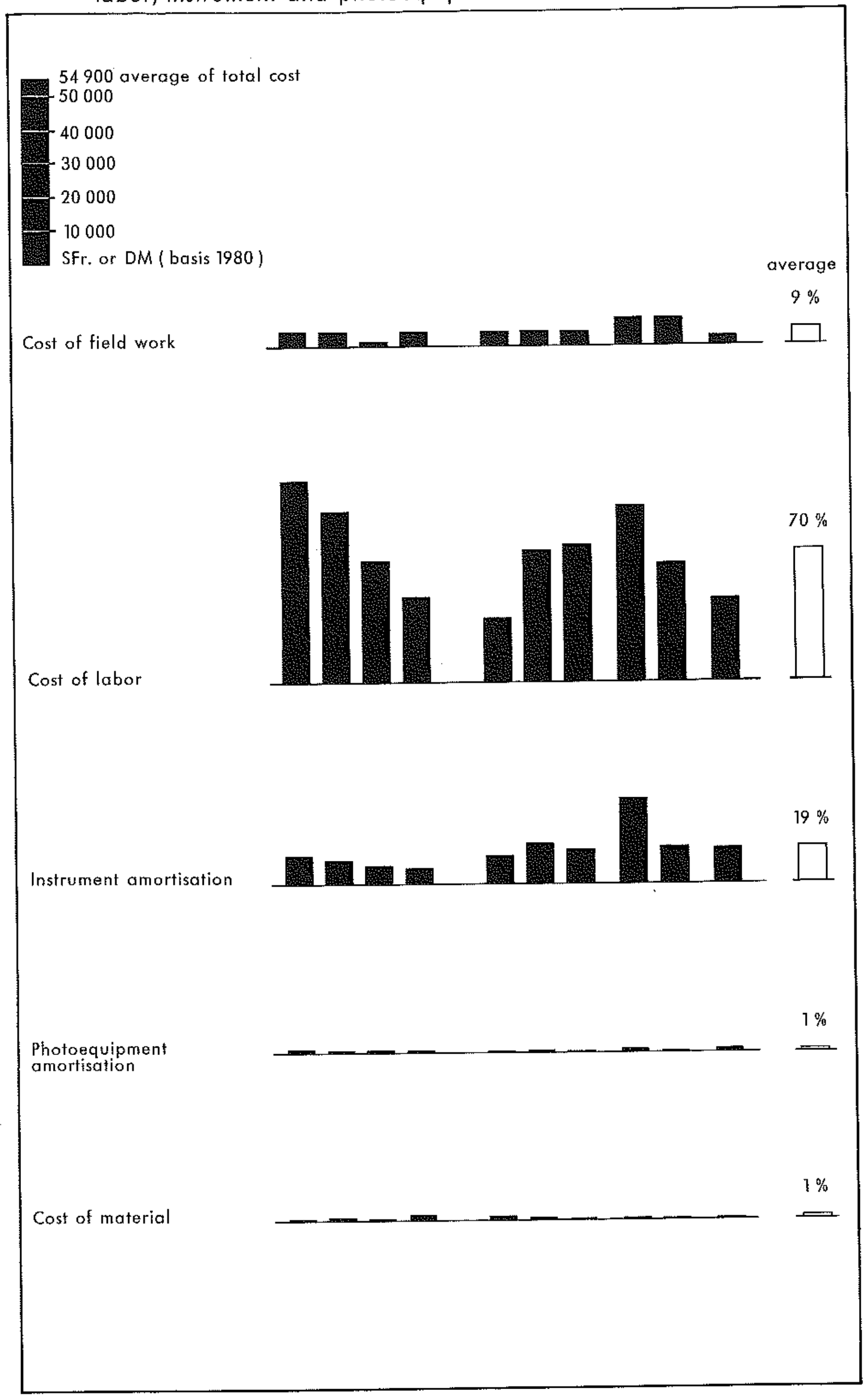
Table 30 : Partition of cost

Cost for the revision of a sheet of 100 km² in money and in % of the total

Cost in SFr. or DM, basis 1980

Method	Orthophoto method				Stereoplotting method					
Cost factor / Centre	LVA	IfAG	TD	NBS	NBS	IGN	NGO	IGN	NGO	LT75
Image scale	30 000	30 000	30 000	30 000	30 000	30 000	30 000	18 000	18 000	27 000
Signalized control points used	5	5	-	5	5	5	5	8	8	-
Draughting/Scribing	D	S	S	D	D	S	S	S	S	S
Working Scale	10 000	10 000	15 000	10 000	10 000	16 667	25 000	16 667	25 000	25 000
Cost in SFr. or DM										
Field work (man hours and transportation)	4 733	4 448	1 710	4 426	4 426	4 284	4 284	8 046	8 046	2 840
Man hours	60 064	51 174	36 348	25 695	18 714	39 018	40 219	51 933	35 263	24 120
Instrument hours	8 660	7 460	5 850	4 740	8 240	12 160	10 080	25 400	11 160	10 480
Photo equipment hours	910	700	780	760	430	640	300	980	300	1 000
Material	723	1 313	722	1 755	1 647	665	162	668	181	360
Total cost 100 km²	75 090	65 095	45 410	37 376	33 457	56 767	55 045	87 027	54 950	38 800
Cost in %										
Field work	6%	7%	4%	12%	13%	8%	8%	9%	15%	7%
Man hours	80%	79%	80%	69%	56%	69%	73%	60%	64%	62%
Instrument hours	12%	11%	13%	13%	25%	21%	18%	29%	20%	27%
Photo equipment hours	1%	1%	2%	2%	1%	1%	1%	1%	1%	3%
Material	1%	2%	1%	4%	5%	1%	0%	1%	0%	1%
Total in %	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Average cost by method	4 orthophoto tests: SFr. 55'743.--				5 stereoplotting tests: SFr. 54'341.--					SFr.38'800.--
Average cost all tests included	SFr. 54'902.--									

Fig. 90 : Cost for the revision of a sheet of 100 km², divided up in field work, labor, instrument and photoequipment amortisation and material



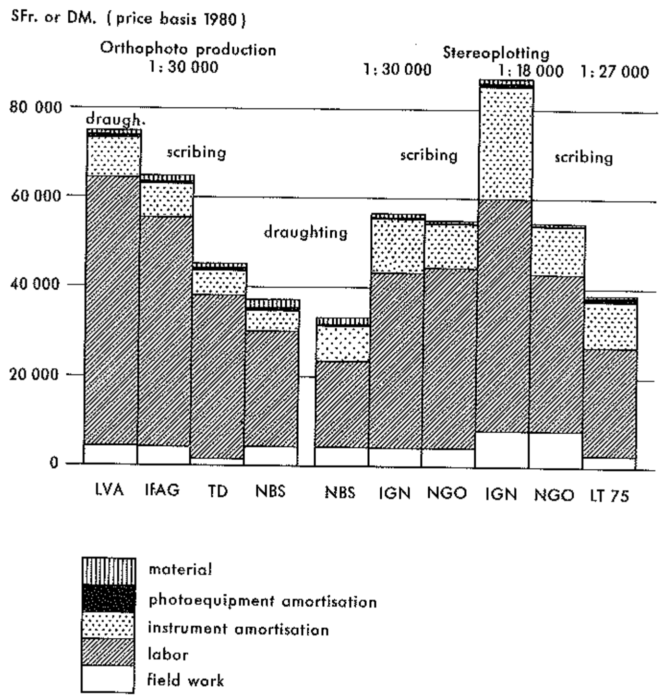
8.5 Cost analysis of the various map revision processes

A summary of major costs is given in table 30. The largest cost factor in map revision is definitely the cost of personnel. Its share varies between 59 and 79% of the total cost. The factor of second importance is the instrument-hours. Their share is relatively low for the orthophoto-equipment (around 13%), because it is used only for a short time, but it increases to 30% for the instrument intensive stereoplotting method with large scale images. The shares for photoequipment and material (o,5% up to 3%) can practically be neglected.

In terms of money it is surprising that the total cost for 100 km^2 of map revision varies considerably, namely between DM or SFr. 33 000.- and 87 000.-. The total sum of man-hours show as well a 2 to 1 ratio. The instrument-hours can be kept relatively low in the orthophoto-method, due to the fact that scanning and exposing processes are fairly quick.

On average the stereoplotting revision process is slightly cheaper than the orthophoto compilation, at least with images at 1:30 000. However, stereoplotting is more expensive when working with an image scale of 1:18 000. Individual differences within each group are extremely large as well and there are equally cheap orthophoto processes as there are stereoplotting processes.

Fig. 91: Total cost for the revision of a sheet of 100 km^2



If we sum up all the items that are contained in the stereoplotting manuscript, we have an average cost of SFr. or DM 29'000. Again there is an extraordinary wide distribution of the individual results. The minimum of 16'000 SFr. for the Stereo Facet Plotter test sample is due to its very low instrument cost. Working hours, however, are slightly above average. The maximum cost of SFr. 68'000 is caused at least partly by the considerably larger number of models at the larger image scale. The average cost for plots from the image scale 1:30 000 is only SFr. or DM 23'000.

As already mentioned above the same comparison is not relevant for the orthophoto method. Two manuscripts have been prepared only, one for SFr. or DM 20'000, the other for 44'000. They can be produced therefore approximately at the same price as stereoplotting manuscripts. The two other methods do not make use of such intermediate plots.

For the cartographic work it seems appropriate also to include deletions, final checking, retouching and correcting. As a special case we must consider the method of the LVA, in which the great majority of labour is accomplished in this phase. Therefore it is not comparable as a subprocess. There remain two other tests that made use of pen and ink drawing. This work costs approx. SFr. or DM 14'500,fairly cheap in comparison to scribing. The average cost for scribing in 7 tests is SFr. or DM 22'300, the extremes being 13'500 and 34'300. Scribing is more time-consuming and therefore more expensive than drawing. This seems to hold true for revision work only, which does not allow for continuous scribing, using for quite some time the same instrument. Careful adaptions and frequent changes of the scribing tools are typical in up-dating and not ideal for fast progress of the work.

8.6 Comparative cost analysis of sub-processes

The cost of control point signalization depends primarily on the image scale applied. On the basis of 5 control points per stereo model, whereby some of them can serve for more than just one model, and on the permanent points available in addition (mainly church towers) 26 control points were estimated for 100 km^2 and for 1:30 000 image scale, against 64 for 1:18 000. The following approximation may be useful:

$$N = \frac{21 \cdot 10^9}{M^2}$$

N = number of control points needed per 100 km^2

1 : M = image scale

We should, however, emphasize that no signalized control points are needed, provided that the map to be up-dated meets good accuracy standards. The Fribourg test proves that this thesis is realistic. The two samples were absolutely positive in terms of accuracy. We also should not forget that a minimum of control is guaranteed by the permanent control points.

The model-orientation procedures are obviously very much the same. Similar types of instruments were used with the exception of the stereo facet plotter. The use of this cheaper instrument reduced cost somewhat; but they are increased again by more time needed to complete the task. The only predominant exception is the low cost of model orientation in the case of the IfAG. Their cost is only half that of most others, apparently due to an efficient numerical solution. The importance of the figures must not be overestimated in view of the fact that most centres oriented only one model, causing eventually accidental results. Orienting three or four models multiplied of course this cost factor for those that used the 1:18 000 image scale.

The cost of an orthophoto was about SFr. or DM 500 per model, reproduction not included.

Photointerpretation, tracing, stereoplotting, redrawing of the plot manuscript and cartography are certainly the most expensive operations and their cost consists largely of man-hours. Any comparison is rendered difficult, because several of these activities are combined in some procedures. So, for example photointerpretation is integrated in stereoplotting except in the method used by the IGN in Brussels. Or, to give another example, orthophoto compilation is combined with cartographic draughting in the case of the LVA Stuttgart. Therefore not all cartographic work can be compared directly. The same is true for stereoplotting or orthophoto compilation.

The average cost for stereoplotting 100 km^2 was SFr. or DM 15 000, labor and instrument rate included.

9. Synthesis of accuracy, time and cost

9.1 Recommendations for integrated map revision procedures

From the results of the test we can develop on a modular basis optimized revision procedures with the following elements:

A first recommendation that can be made concerns the image scale. Steropairs of aerial photographs at the approximate scale of 1:30 000 are entirely sufficient for revision work of maps at 1:25 000. Larger scales are more costly and time-consuming and bring only an insignificant improvement in quality. This statement is equally applicable for the orthophotomethod as well as for stereoplotting.

On the assumption - which cannot be made in all cases - that the map to be up-dated has a reasonable accuracy, control point signalization is not a necessity.

Because fewer stereo models mean less plotting time, an image overlap of 80% per model with wide angle photography can be applied without loosing accuracy, according to the test results. In orthophotography the preparation of double models from 60% overlap will be the most economic solution. The orthophoto production is comparatively cheap with 2 to 5% only of the total revision cost. The orthophoto revision method with images enlarged to 1:15 000 or 1:10 000 is of the same order of accuracy as stereoplotting, provided that certain precautions are taken. A manuscript of a preceding stereo-interpretation is recommended for easier and faster draughting on the base of an orthophoto. On the other hand, no preinterpretation seems to be needed before stereoplotting, and results in considerable savings in cost.

There remains free choice between different draughting techniques. Drawing at 1:10 000 is quite economic, in spite of many more reproduction processes with rather large formats. Too many reproduction steps are anyway critical, because the line weight gets difficult to control.

There is no significant advantage in scribing at a larger or at publication scale. In the second case etched scribings of the remaining items have been up-dated on the base of the plotting manuscript. This technique allows for a precise match between old and new items. In repeated revisions it may become critical to control line weights.

Short reproduction sequences are recommended for these reasons and in order to reduce cost and time. Repeated camera work tends to round the corners of houses. Avoiding camera enlargements and reductions may mean using more time when scribing and retouching at publication scale.

In conclusion advantages and disadvantages are present in every possible procedure. When one sets up a new revision sequence, one has to decide on priorities one wants to give to certain aspects. Such aspects are economy in time, in cost of material and line quality, especially in view of repeated revisions.

9.2 Assessment of the test procedure

When this revision test was initiated, there was some reservation concerning the feasibility of such a study, in which 10 groups had to up-date a section of a foreign map of a foreign landscape with unaccustomed map symbols and map specifications. Looking at the results of the study, it seems that these difficulties have been mastered by all participants with much effort and skill. The problems that have to some extent prevented unambiguous conclusions have been either minor misunderstandings caused by language problems, or due to the fact that only a rather limited test area could be treated. Even so the effort made by all participating centres is very high. Up to 450 working hours have been sacrificed by some of them, an involvement that is certainly unusual in a purely photogrammetric test, but unavoidable when cartography is included. Table 30 which gives the percentages of time used for photogrammetric versus cartographic work, shows that the first cannot be separated from the second, the processes being divided up among the two phases quite differently.

This interdependancy makes it somewhat difficult to analyse fracions of the procedure. But splitting it up into small pieces would also be difficult, because it would hardly be possible to assess the merits of each method when combined with further steps. Too much depends on what has preceded and on how the procedure continues.

The other evaluation problem is that of the interrelations between accuracy, completeness, graphic quality, time and cost. Depending on what priorities are set, completely different conclusions may be drawn. Only after tolerances for the first three criteria have been determined, can an optimal fast and economic solution be fixed for the whole revision process. We ought to emphasize once again that this revision test work was based on a good, reliable base map. Conclusions might be quite different when the map to be revised is of a much lower standard.

A problem that was not included in this test is the use of stereoorthophotos for map revision. When the test was started, there was no stereocompiler available within the organisations represented in Commission D. It would be relatively easy to follow up with such a test. The image material is still available. The orthophoto production, however, would have to be repeated, because digital scanning data have not been stored from the FRIBOURG test. We might speculate about the probable procedure and result of such an additional test: On the stereocompiler a manuscript could be plotted which makes use of the main advantages of a stereo-interpretation. Such a partial manuscript for the finer detail, together with the orthophoto for roads etc., would then be passed on to cartography. It seems that there would be no substantial gain from this procedure. This might change when on the instrument side it becomes possible to switch into the stereoorthophoto of the previous revision, getting in this way a convenient means for change detection.

Change detection and cartographic techniques are the keywords for the critical path in the whole map revision. The most recent technical developments in image processing may offer in the near future new solutions to these problems that may be worth-while investigating. But there remains a strong feeling from this test work that any reliable topographic map revision at 1:25 000 scale is a rather complex operation that calls for an intellectual human operator with a broad experience in this field.

Fig. 92 : Section of the multicoloured edition of the Swiss National Map Series at 1 : 25 000, published 1968 by the Swiss Federal Office of Topography in Wabern-Berne

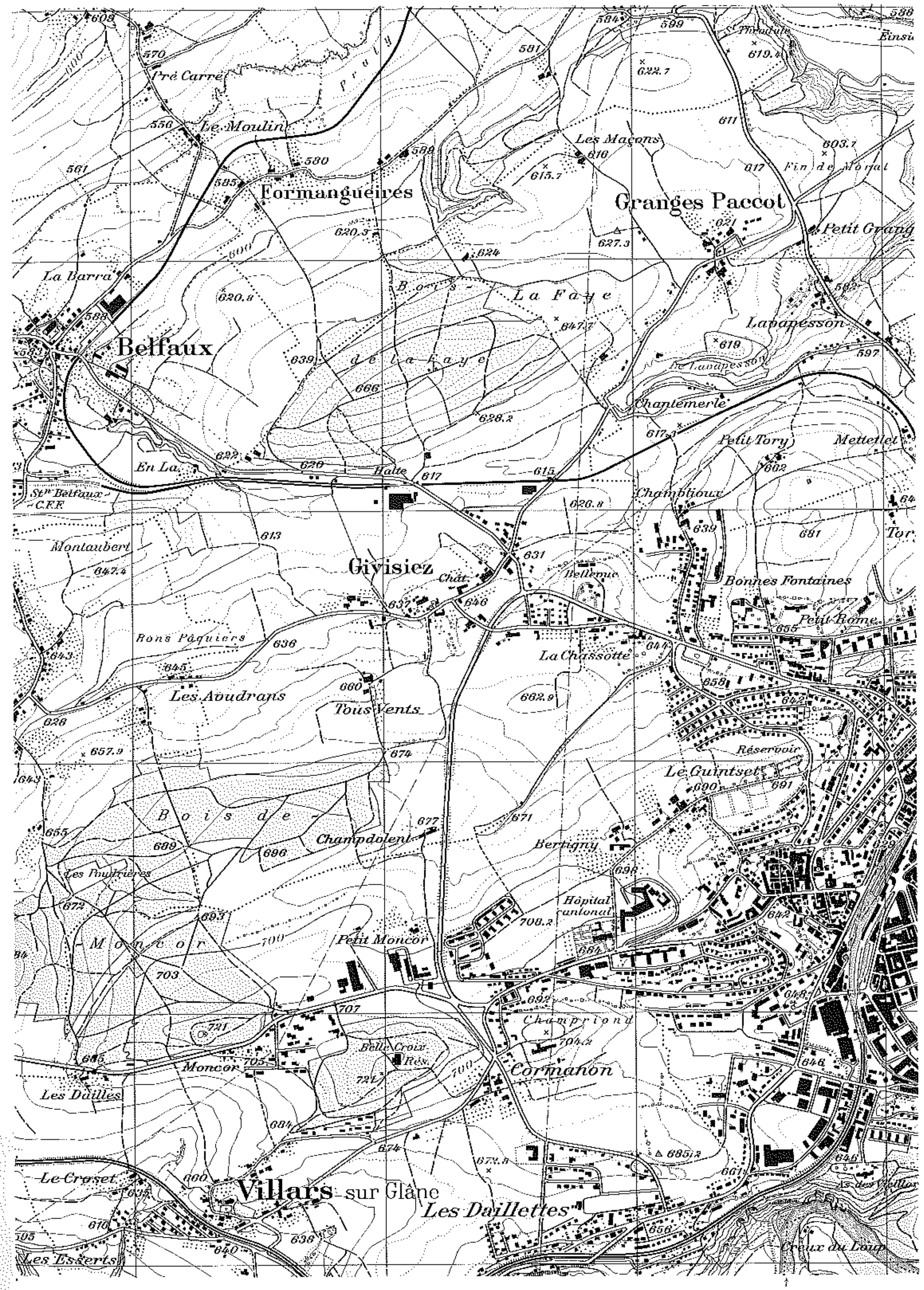


Fig. 93 : Multicoloured map revision test sample, produced on the basis of an orthophoto by the Land Survey Office Baden–Württemberg in Stuttgart

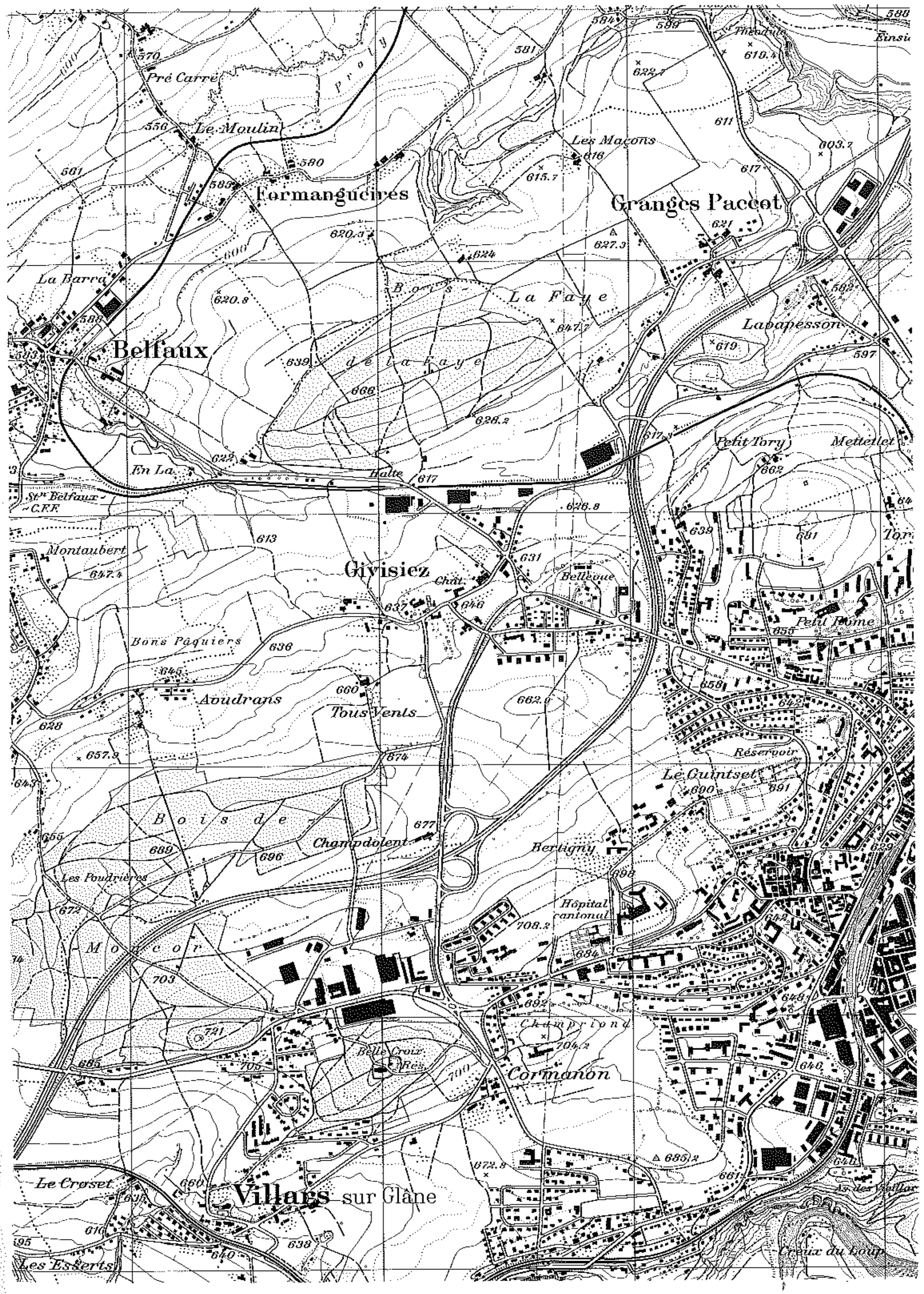


Fig. 94 : Multicoloured map revision test sample, produced on the basis of an orthophoto by the Institute for Applied Geodesy in Frankfurt a. M.

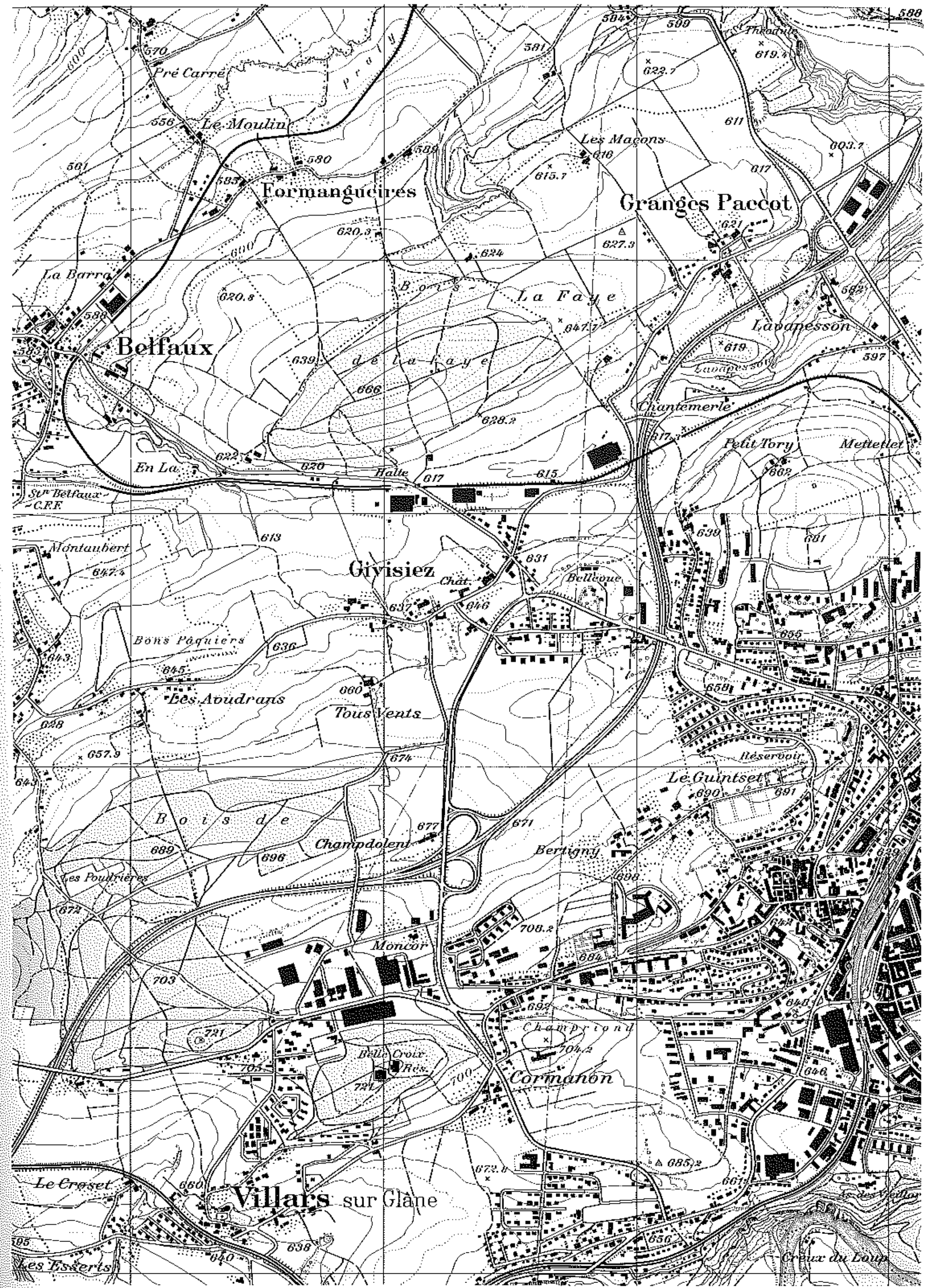


Fig. 95 : Multicoloured map revision test sample, produced on the basis of an orthophoto by the Topographic Service in Delft

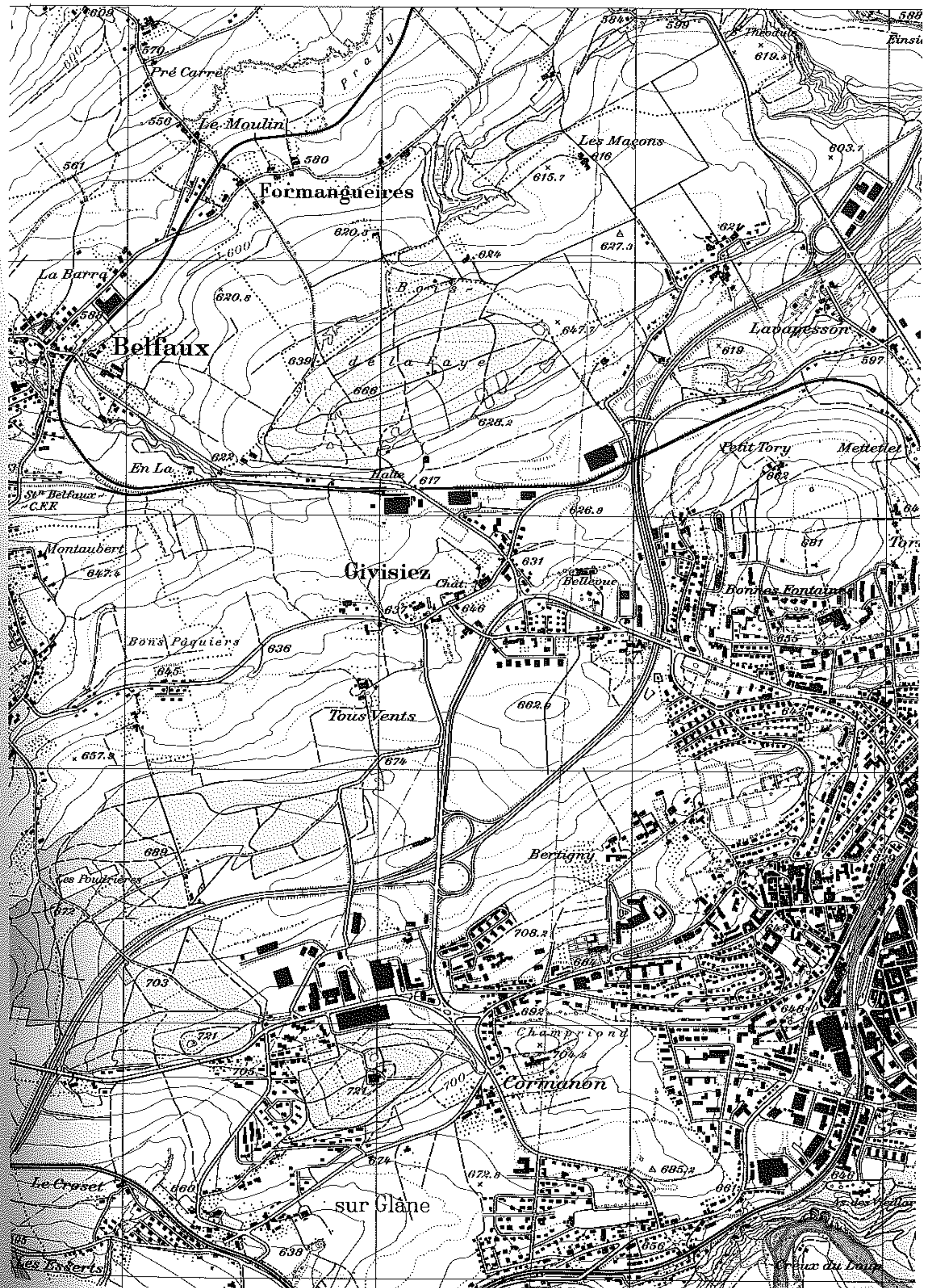


Fig. 96 : Multicoloured map revision test sample, produced on the basis of an orthophoto by the National Board of Survey in Helsinki

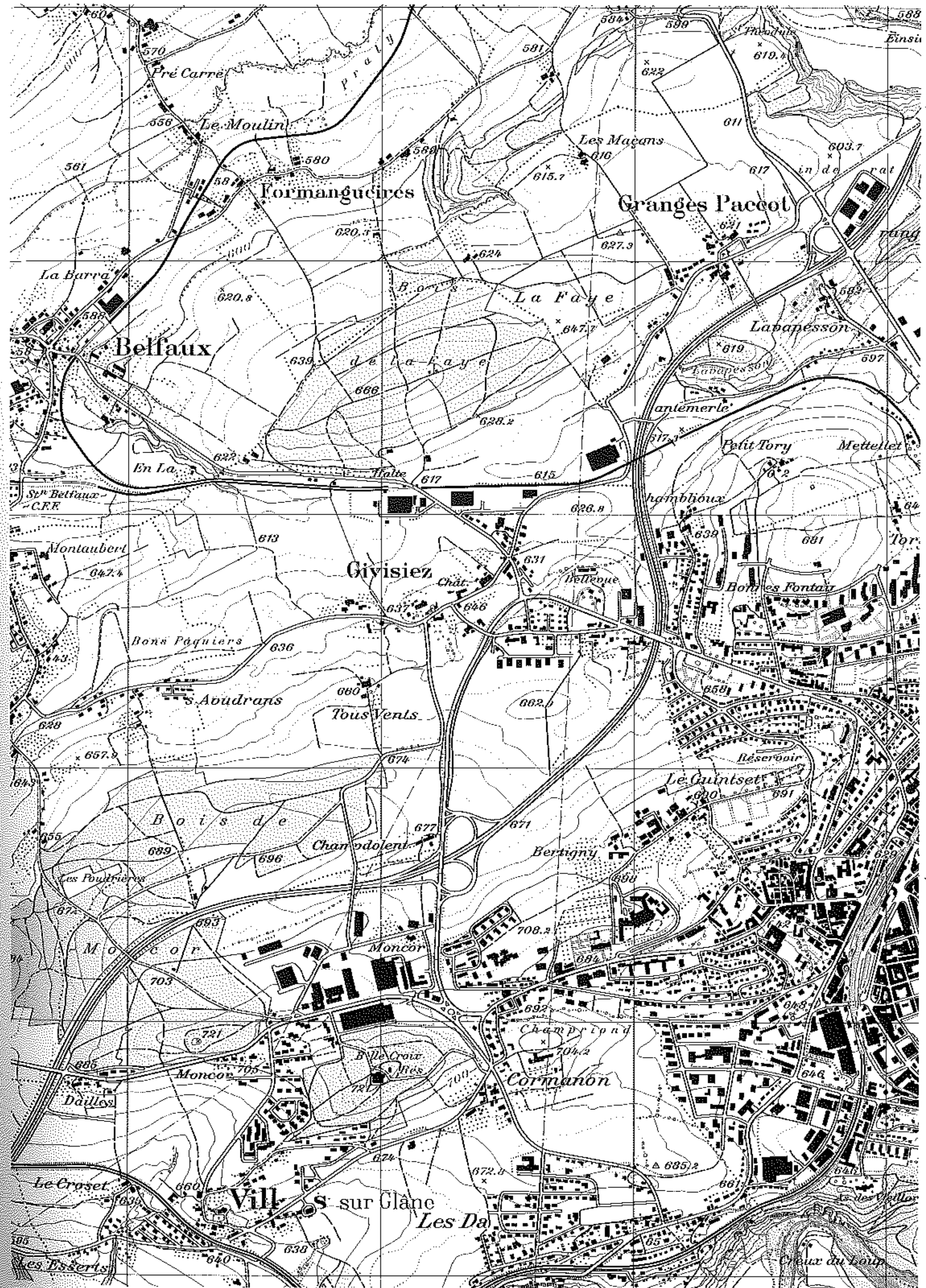


Fig. 97 : Multicoloured map revision test sample, produced on the basis of a stereoplot by the National Board of Survey in Helsinki

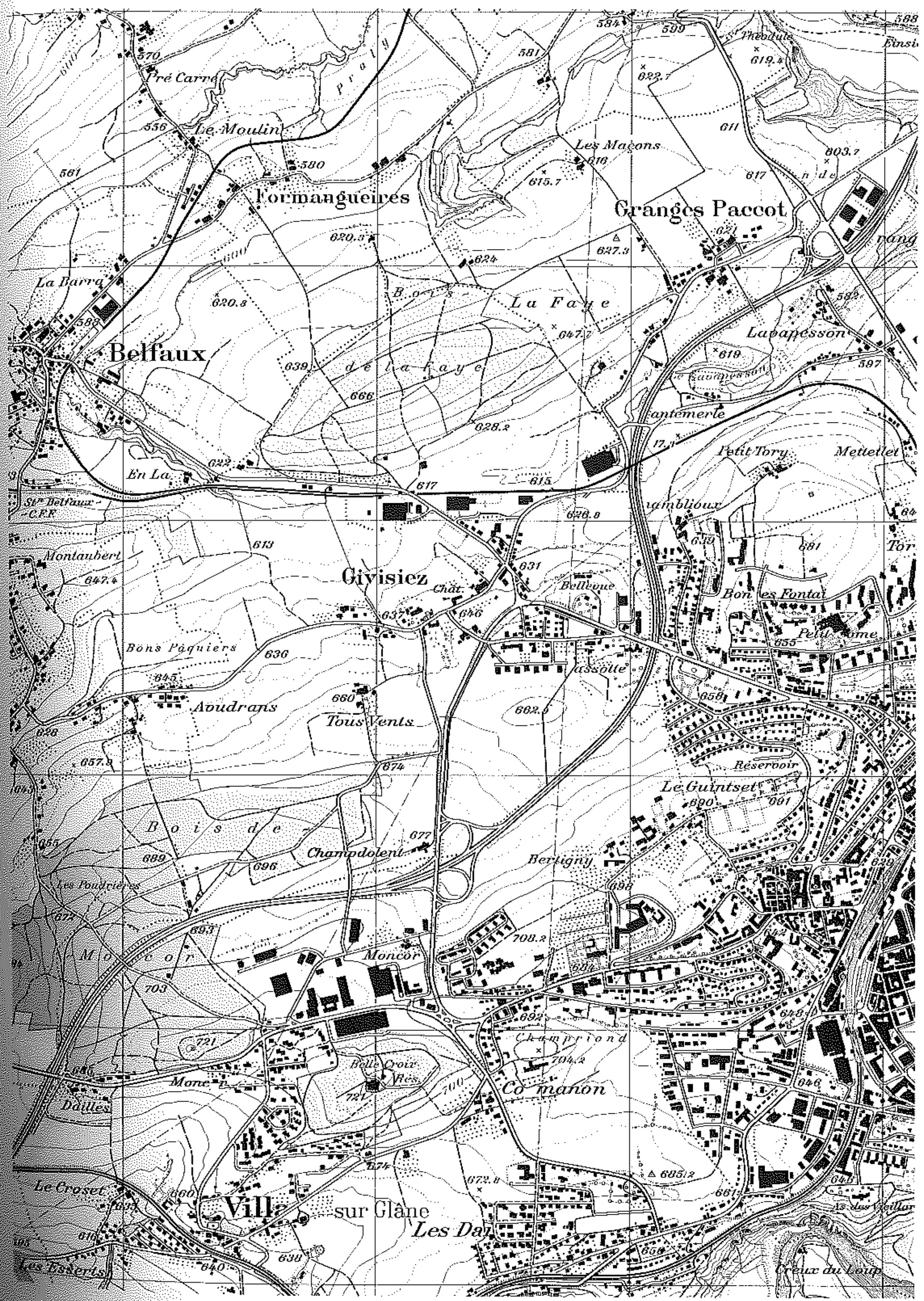
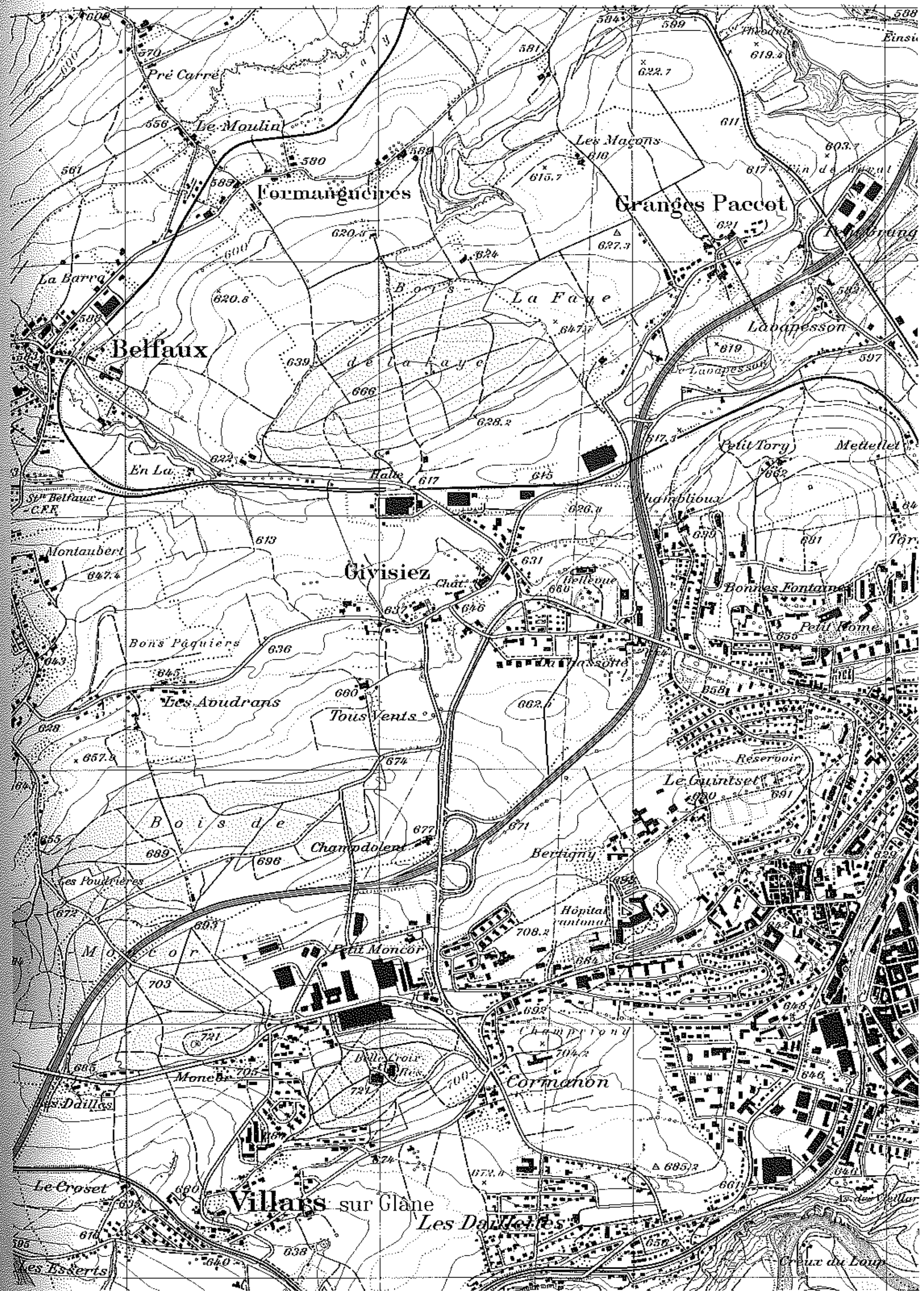


Fig. 98 : Multicoloured map revision test sample, produced on the basis of a stereoplot from aerial photographs at 1 : 30 000 by the National Geographic Institute in Brussels



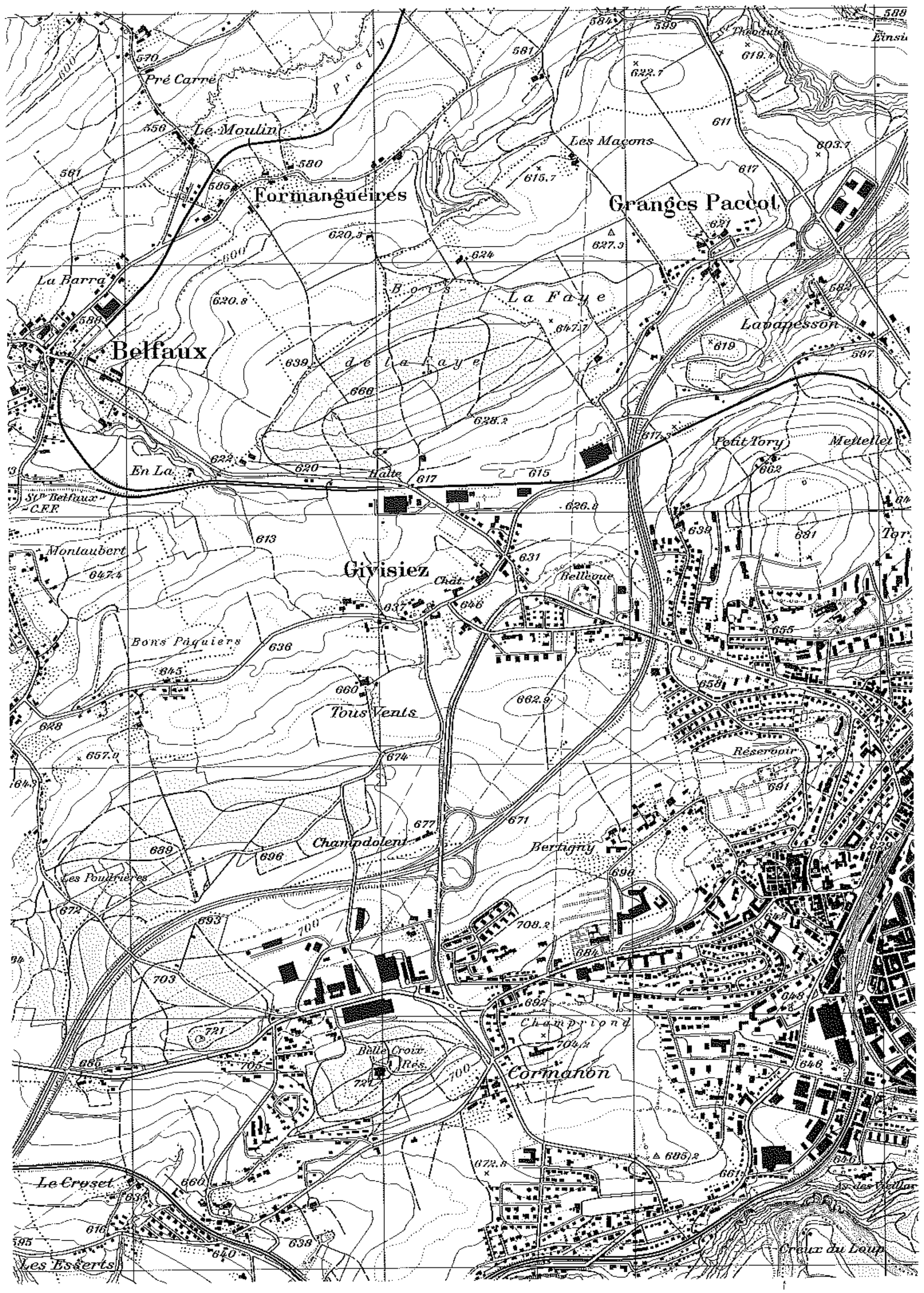


Fig. 99 : Multicoloured map revision test sample, produced on the basis of a stereoplot from aerial photographs at 1 : 30 000 by the Geographical Survey in Oslo

Fig. 100 : Multicoloured map revision test sample, produced on the basis of a stereoplot from aerial photographs at 1 : 18 000 by the National Geographic Institute in Brussels

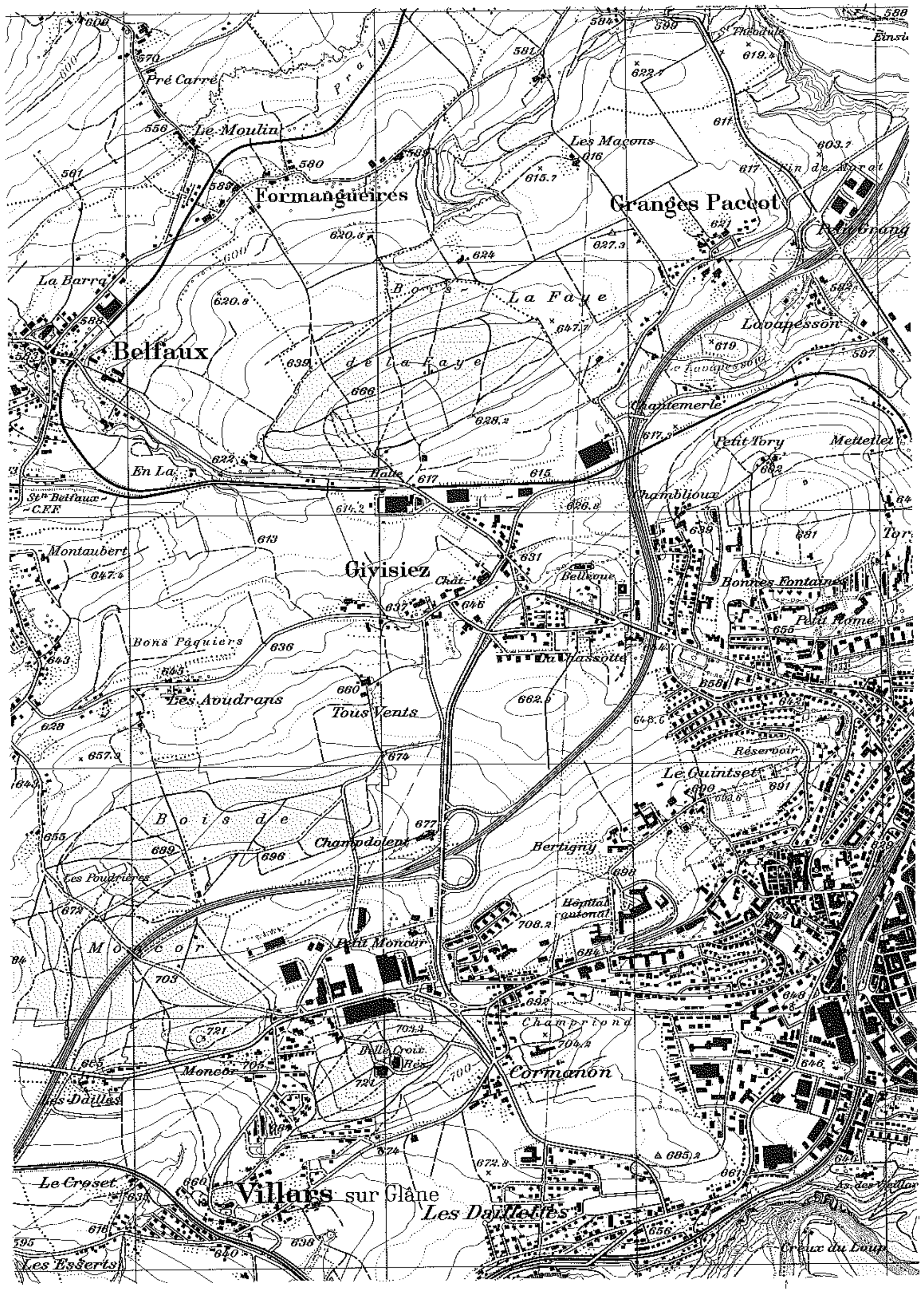


Fig. 101: Multicoloured map revision test sample, produced on the basis of a stereoplot from aerial photographs at 1 : 18 000 by the Geographical Survey in Oslo

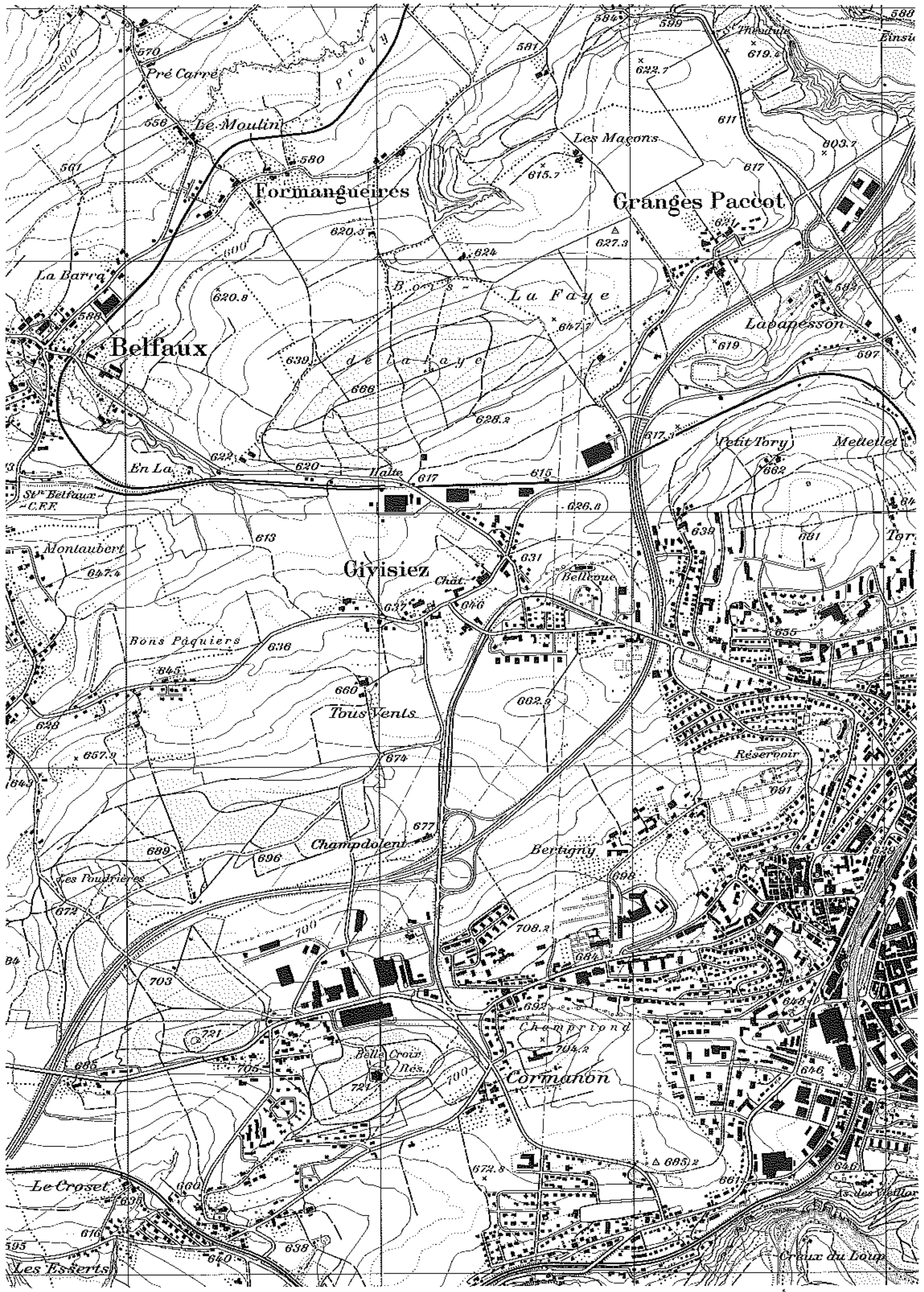
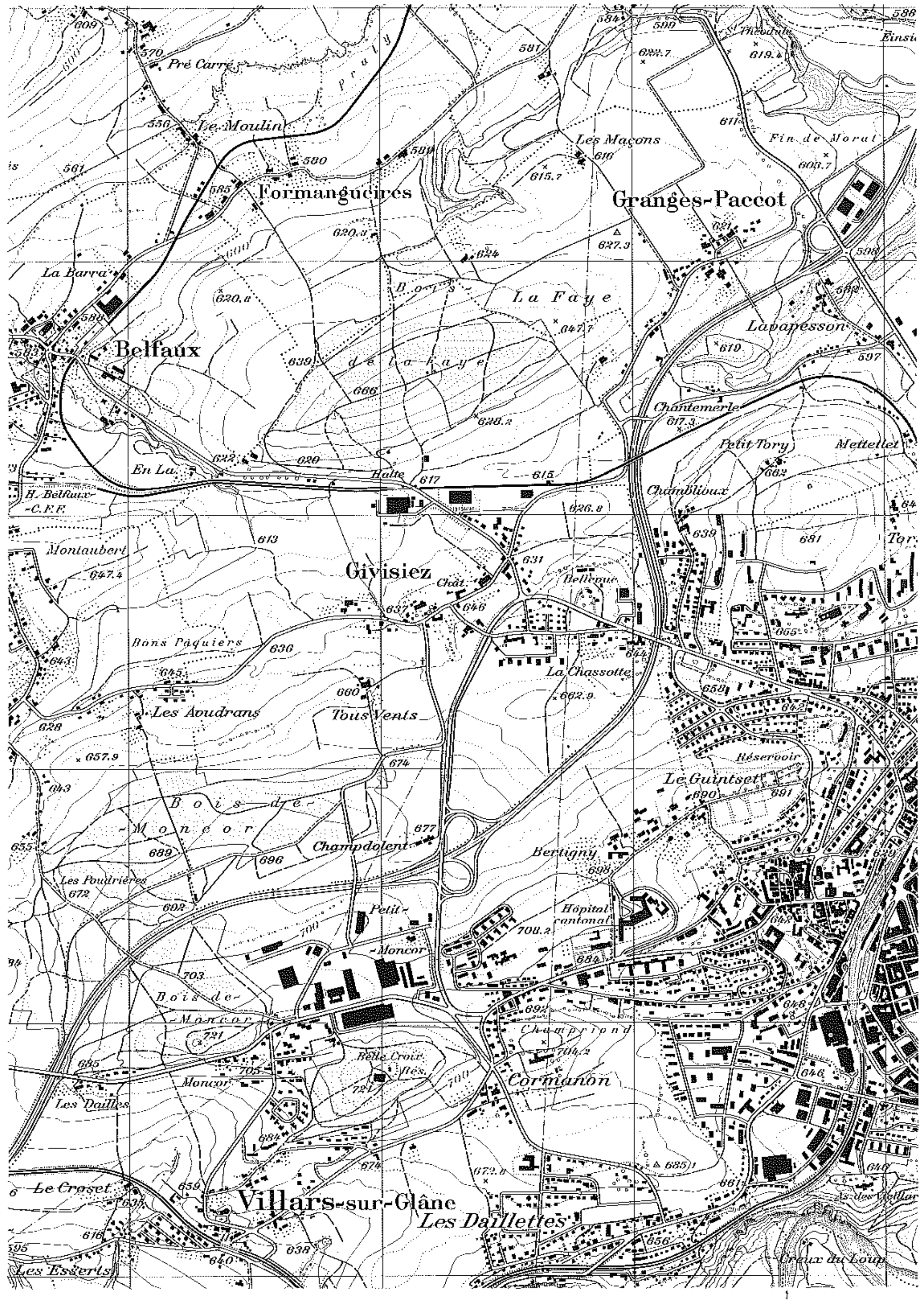


Fig. 102 : Section of the multicoloured edition of the Swiss National Map Series at 1 : 25 000, revised 1975 on the basis of a stereoplot from aerial photographs at 1 : 27 000 by the Swiss Federal Office of Topography in Wabern–Berne



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.

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.
- *Cunietti, M.:* Résultats des recherches expérimentales organisées par la Commission B de l'OEEPE au cours de la période 1959–1966. Résumé du Rapport final. – Présenté à l'XI^e Congrès International de Photogrammétrie, Lausanne 1968, Comm. III (en langues française et anglaise), 9 pages.
- *Förstner, R.:* Résumé du Rapport sur les résultats de l'essai de Reichenbach de la Commission C de l'OEEPE. – Présenté à l'XI^e 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, $XIII^{th}$ 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, $XIII^{th}$ 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.
- *Waldhäusl, P.:* The Vienna Experiment of the OEEPE/C. Proceedings – Standards and Specifications for Integrated Surveying and Mapping Systems. – Schriftenreihe HSBw, Heft 2, München 1978.
- *Bachmann, W. K.:* Recherches sur la stabilité des appareils de restitution photogrammétriques analogiques. – Vermessung, Photogrammetrie, Kulturtechnik, Zürich 1978, pp. 265–268.
- *Parsic, Z.:* Untersuchungen über den Einfluß signalisierter und künstlicher Verknüpfungspunkte auf die Genauigkeit der Blocktriangulation. – Vermessung, Photogrammetrie, Kulturtechnik, Zürich 1978, pp. 269–278.
- *Waldhäusl, P.:* Der Versuch Wien der OEEPE/C. – Geowissenschaftliche Mitteilungen der Studienrichtung Vermessungswesen der TU Wien, Heft 13, Wien 1978, pp. 101–124.
- *Waldhäusl, P.:* Ergebnisse des Versuches Wien der OEEPE/C. – Presented Paper for Comm. IV, XIV^{th} Congress of ISP, Hamburg 1980.
- *Timmerman, J.; Förstner, R.:* Kurzbericht über die Ergebnisse des Versuchs Dordrecht der Kommission C der OEEPE. – Presented Paper for Comm. IV, XIV^{th} Congress of ISP, Hamburg 1980.

– *Bachmann, W. K.:* Elimination des valeurs erronées dans un ensemble de mesures controlées. – Papers written in honor of the 70th birthday of Professor *Luigi Solaini* – Richerche di Geodesia Topografia e Fotogrammetria, Milano 1979, pp. 27–39.

– *Visser, J.:* The European Organisation for Experimental Photogrammetric Research (OEEPE) – The Thompson Symposium 1982. – The Photogrammetric Record, London 1982, pp. 654–668.

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