INTERNATIONAL INSTITUTE

FOR

AERIAL SURVEY

AND

EARTH SCIENCES (ITC)

ENSCHEDÉ,THE NETHERLANDS

DIGITAL MONO PLOTTING SYSTEM
- IMPROVEMENTS AND TESTS

M M RADWAN & B MAKAROVIČ

COMMISSION IV, PRESENTED PAPER

FOURTEENTH CONGRESS OF THE INTERNATIONAL SOCIETY FOR PHOTOGRAMMETRY,HAMBURG 1980

DIGITAL MONO PLOTTING SYSTEM

Improvements and Tests

I . Introduction

The system for digital monoplotting (D.M.P.) from aerial photographs was conceived in the ITC, 1973 (1), with the first experimental tests being carried out in 1975 (2). In the meantime, the system capabilities have been upgraded and extended. Effort has been made to optimize the overall process, in particular the preparation of the input data for digitising. In the main transformation the differential heights between the object-points (or lines) and the D.T.M. surface can be included.

The techniques of D.M.P. are very similar, though somewhat more complex than those applied in automatic cartography (fig. 1). The differences concern the photointerpretation, the associated operations in preparation and digitising, and involvement of additional data (i.e. orientation, D.T.M., and differential heights) in the main process. Other operations, such as data structuring, encoding and indexing, and further: editing, relating, synthesising and generalising information items are identical. The same applies also to automatic drafting.

Thus, when observing D.M.P. from a cartographer's perspective, it may be regarded as an extension of automatic cartography in the realm of digital photogrammetry.

Development of an operational system requires profound testing.

The obtained test results provide the feedback information necessary for optimising the system (fig. 2). To this end some selected tests of limited extent were devised and carried out. Special attention was given to the accuracy of discrete points.

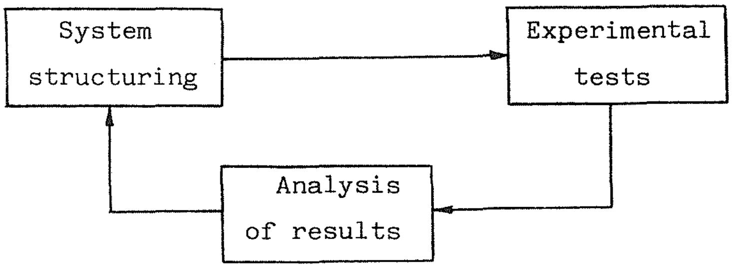


Fig. 2 : Iterative optimisation process in system development

The scope of this report is mainly restricted to the improvements and extensions of the D.M.P. system, and it includes a summary of the experimental tests.

(Fig. 1, see next page).

II. Improvements and extensions

The early experiments (2) confirmed the fact that a thorough preparation of the input data, especially of the photographs, is essential for successful operation. For large scale plotting the differential heights of the objects from the D.T.M. surface should be measured and dealt with in the main transformation.

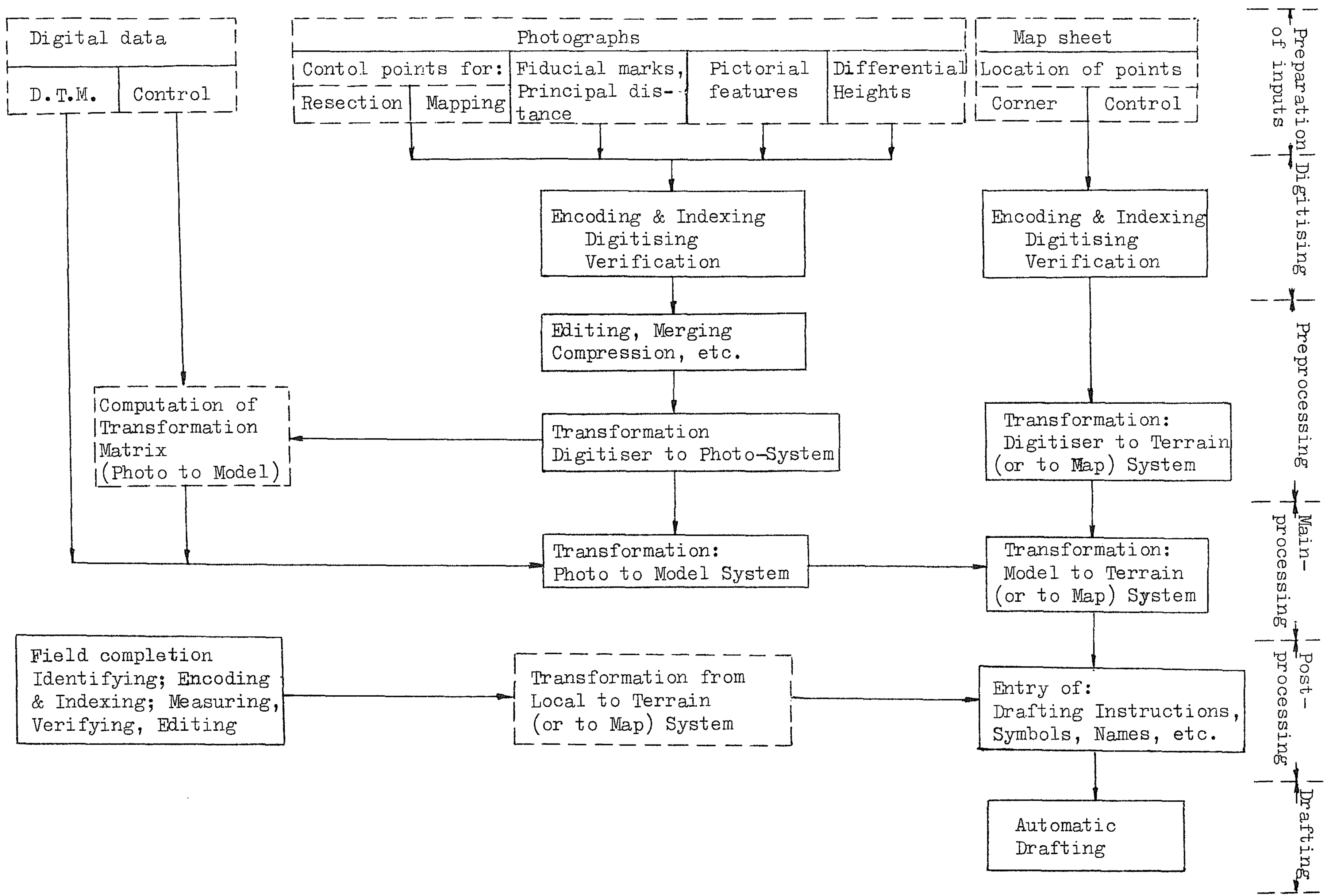


Fig. 1: Phased procedure of D.M.P.

Data structure, codes and indices should be according to the specifications for the desired information products. After sampling, the raw digital data should be pre-edited in the usual manner, i.e. either on-line or off-line. Strings of x,y coordinate pairs, representing continuous lines, may be compressed to an essential data set, prior to recording and thus further processing.
In the following sections the significant facets of the phased process will be portrayed.

1. Preparation

Thorough preparation appears to be most essential to attain accurate and reliable results. The preparation concerns three basic items:

i. The input data: product specifications, control data, D.T.M. data and photographs;
ii. The equipment: measuring and digitising unit, computer (and peripherals), recording device, and X,Y drafting machine;
iii. The output data: map manuscript and digital files.

Specific for D.M.P. is the preparation of D.T.M. data and of photographs. As D.T.M. data serve for multiple purposes they are assumed to be available in the future.
Therefore further considerations will be focussed on the preparation of photographs. Photographs should be observed stereoscopically, e.g. by means of a mirror stereoscope with magnification. This permits easier and more reliable identification and interpretation of the pertinent terrain features. The preparation concerns the control data, the pertinent new (or changed) terrain features, and the differential heights of the objects. The control data embrace the following:

. data on internal orientation
. control points (for resection and mapping)
. parameters of external orientation or external orientation matrix (e.g. from aerial triangulation).

Since the collection of the control data and corresponding procedures are not specific for D.M.P., they will not be further considered in this report. Attention is therefore focussed on the pictorial features to be sampled and further processed. The corresponding preparation is decisive for the efficiency of D.M.P.
For a thorough preparation of a photograph the pertinent pictorial data should be adequately classified. Figure 3 illustrates a few upper hierarchial levels of such a classififcation.

The image parameters are usually specified during the planning stage, i.e. to optimise the overall process. They concern issues like image geometry, photo scale, film-filter combination, etc.
The parameters pertaining to terrain, which are independent of the photogrammetric imaging system, should be involved in the optimisation of the photogrammetric operational procedure. In the following, some consideration will be given to the major parameters pertaining to the terrain features.
Density of detail influences the partitioning of an image into segments, and of segments into basic blocks. A block is the basic areal entity (or working unit) of suitable size for digitising and processing. In the case of dense detail, these entities should be smaller and vice versa. Each block (and thus segment) should be delimited by typical line features in the terrain which may be natural or man-made. In an ideal case, the amount of pertinent data per block should be nearly the same. The blocks and sections should be indexed in an orderly way, e.g. according to the programmed sequence of digitising.

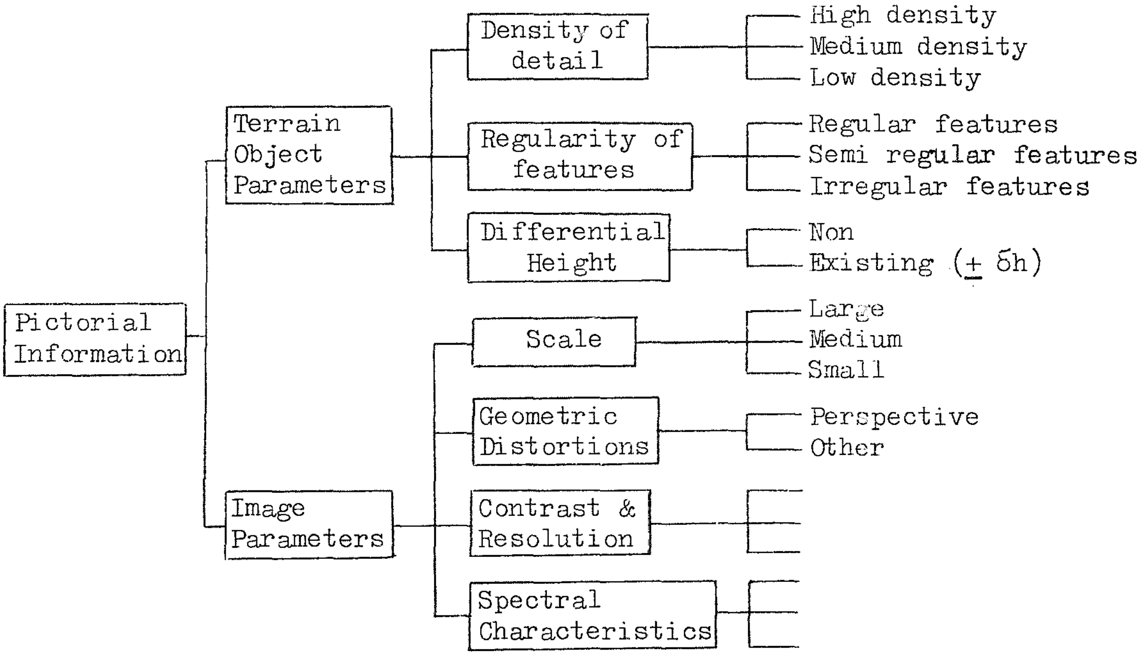


Fig. 3: Classification of pictorial data

The regularity of terrain features depends heavily on their history, in particular whether and how these features were affected by man (e.g. man-made objects, cultivated areas). The boundaries between regular objects, semi-regular and irregular features are sometimes unsharp. Images of regular objects can be digitised in stationary mode, i.e. point by point, whereas for irregular features continuous sampling (stream mode) seems preferable. For semi-regular features (e.g. cultivated areas) it may not be obvious which sampling mode is perferable. A sample test of limited size, considering also mixed stationary-continuous mode, may therefore be justified.
During preparation the features to be sampled should be classified and indexed according to the digitising mode (i.e. into stationary, dynamic, and combined).
The differential heights of object points with respect to D.T.M. surface, should be sampled whenever the corresponding planimetric shifts are significant. The threshold should be adapted to the specified accuracy of the final output, and should therefore be differentiated for the various information products, (i.e. items of information, types of maps).
The planimetric errors caused by differential heights depend strongly on the image geometry, which can usually be selected during the planning stage. The effort of preparation and sampling can be reduced accordingly and/or the accuracy increased. The efficiency of D.M.P. is considerably affected by the number of points for which differential heights have to be determined. When the number is excessive, conventional stereoplotting is preferable.
The preparation should, obviously, be adapted to the type of measuring and digitising equipment.
If the number of object points with significant differential heights is small, sampling of planimetric data can be separate from determination of differential heights. This permits application of the existing equipment components such as a cartographic digitiser and a mirror stereoscope with parallax bar. However, in the preparation stage, all the object points, for

which differential heights have to be determined, should be indentified and indexed. Subsequently, in the digitising stage, two separate lists of data will be created, which have to be merged prior to or during the main transformation. Separate sampling is, due to frequent mistakes in identification and indexing, a potential source of trouble.
If the number of points with differential heights is substantial, (e.g. in large scale mapping), it is preferable to use a dedicated stereoscopic device with two photo stages, one for x,y digitising another for measurement of x-parallaxes (the latter to be converted to differential heights). This permits simultaneous sampling of x,y and px, which is a great advantage.
The differential heights of successive object points may be constant or vary regularly or irregularly. In a chain of topologically related points, differential heights should be sampled of the initial point and of all those subsequent points where it changes significantly. This requires a consistent sequence of sampling object points.
Prior to digitising of selected features on a single photograph, the poorly defined pertinent points should be identified and marked, e.g. by means of a mirror steoscope. This applies especially to built up areas, to points obstructed by trees, shadows, etc. The marked points, lines and other information can be plotted on an enlarged paper print or on a transparent overlay. In thematic mapping, skilled photo-interpreters should mark the pertinent features in a similar manner.

2. Sampling

The operation embraces entry of the descriptive information and digitising the locational data, i.e. similar to ordinary cartographic digitising. To enable the sampling of data in an orderly way, the image area has been divided into segments and further into blocks of suitable size in the preparation stage. The data can then be digitised block by block and, further, segment by segment. Each areal entity is preceeded by a header, comprising the descriptive information such as the name, code, index and other. It is appropriate to digitise first all the networks of line features (e.g. communication lines, hydrography, etc.) and then all the areal units (e.g. land use entities, land parcels, buildings, etc.), followed by the point features.
When digitising endpoints of line segments of a chain (polygon), the sequence should be internally consistent. This is in order to simplify and speed up the further processing and automatic drafting.
In built up areas regular blocks of buildings should be sampled systematically, row by row (or column by column), or e.g. in clockwise direction, depending on the pattern of buildings in a block. Corner-points of buildings should also be measured orderly, e.g. clockwise. A well defined sequence of sampling is important for the completness of data, ease of editing and updating, for automatic drafting, and other data handling.
Buildings (and other objects extending in height) should be represented by their roofs (i.e. uppermost surface), together with the corresponding differential heights. This is preferable to a mixed representation (i.e. by points partly from the base and partly from the roof) as it simplifies sampling and reduces the number of failures.
As stated under "preparation" the differential heights can be measured either time-delayed or simultaneously with sampling of planimetric features, depending on the number of points with differential heights and on the equipment available. In the former case two seperate lists are formed, which have to be consistently cross-referenced. For this

purpose a simple, clear index map is very helpful. Nevertheless, the time-delayed variant is less time-efficient and represents a source of operational failures.
A differential height needs to be measured only for the first (significant) point of an object - and subsequently for those points where the height changes significantly. Thus, for a symmetric building on nearly horizontal terrain, the differential height should be determined only for the first corner point of the roof (in the sequence of digitising). The same height can then be allotted to all other corner points of the building in the processing stage.

3. Preprocessing

Preprocessing concerns editing of the raw data, merging of lists (when sampling was time-delayed), compression of the x,y-coordinate strings, coordinate transformation from the digitiser to the photo-system, and computation of the main transformation matrix.
Editing routines are intended for detection and removal of gross errors, conversion of x-parallaxes into differential heights, allottment of differential heights to successive points of an object, and refinements for small disturbing effects in digitising, e.g. smoothing, correcting joints and intersections of lines, etc.
Merging of the x,y-list with the list of the corresponding differential heights implies automatic search for the corresponding points and allottment and/or interpolation of differential heights for other points of the same object. Subsequently a new list is formed, which contains all the relevant data.
Compression of x,y coordinate strings (obtained by digitising of continuous-usually irregular lines) can be effected by means of suitable data filter. A relatively simple technique is to apply a modified Laplacian operator (3), though other techniques of vectorisation are also feasible. By compression, the amount of data to be stored, retrieved, and further processed, can be substantially reduced.
Coordinate transformation from the digitiser system to the photo (and map or field) system can be a similarity or an affine transformation. At the same time corrections for the known deterministic errors can be applied.
Prior to the main transformation (i.e. photo to model), however, the transformation matrix has to be determined, e.g. by resection in space.

The preprocessed data represent the adequately conditioned input for the main process, which is outlined in the following section.

4. Main process

The process comprises two successive transformations, i.e. from photo to model, and further from model to map (and/or field) coordinate system. In each stage the corresponding corrections for known deterministic errors can be applied (fig. 4). The two successive transformations may also be merged into a single one, which is simpler for computation but less flexible with regard to implementation of corrections.
The transformed locational data can be stored directly in the form of digital files for later use, and/or supplemented with the field (completion) and other relevant data, and the instructions for automatic drafting.

ii. Orientation module

The aim of this module is to determine the matrices for tranformation from:
- the digitiser to the photo coordinate system
- the photo to the model coordinate system.

In the latter case resection in space is used. When the photo tilts are considerable a special algorithm is applied to ensure a correct solution and to speed up the iterative process.

iii. Data preparation module

The preparation of raw data comprises five subroutines, i.e.
- reformatting the data for further processing
- data editing, e.g. deletion, replacement, etc.
- assignment of differential heights to the planimetric points: The differential heights of discrete points or of related point-groups may be constant or variable. Whenever the differential height of a feature changes, and therefore is measured, the feature code and index are reentered. This permits cross-referencing of the planimetric feature list with the list of differential heights.
- grouping of the points according to their function, i.e. fiducial marks, control points, and reference points on the map
- storing the feature point coordinates and the differential heights and the compilation of the "address tables" to link the different items of information.

iv. Transformation module

The module serves for transformation of the feature data into the coordinate system of the model (or field), where corrections for deterministic errors can be included.

As the transformation is iterative, the effort and speed depend on the local terrain slope, the accuracy of the initial height of the point concerned and its location in the photo-plane, and the required planimetric accuracy.

The most crucial is the initial height (derived from the DTM). Therefore the layout of the DTM patches (defined under DTM partitioning) is projected digitally on the photo plane, and subsequently the approximate height can be directly determined for any pertinent photo-point.

When transforming a string of points, representing a line feature, the rate of updating the height from the DTM is adapted to the local terrain slope (i.e. maximum slope per patch; see DTM partitioning).

The underlying transformation algorithm leads to fast convergency in any practical situation.

The resulting planimetric data are reformatted, i.e. to provide for compatibility with the plotting module.

For the purpose of the accuracy analysis (vide "Experimental tests") the transformed coordinates of check points have been listed separately.

v. Plotting module

This module effects the transformation of the planimetric data from the model to the map coordinate system, and provides for addition of the instructions for automatic drafting. The instructions are assigned according to the feature codes, e.g. for joining end points of line segments, closing polygons, curve fitting, squaring up buildings, symbolising, etc.

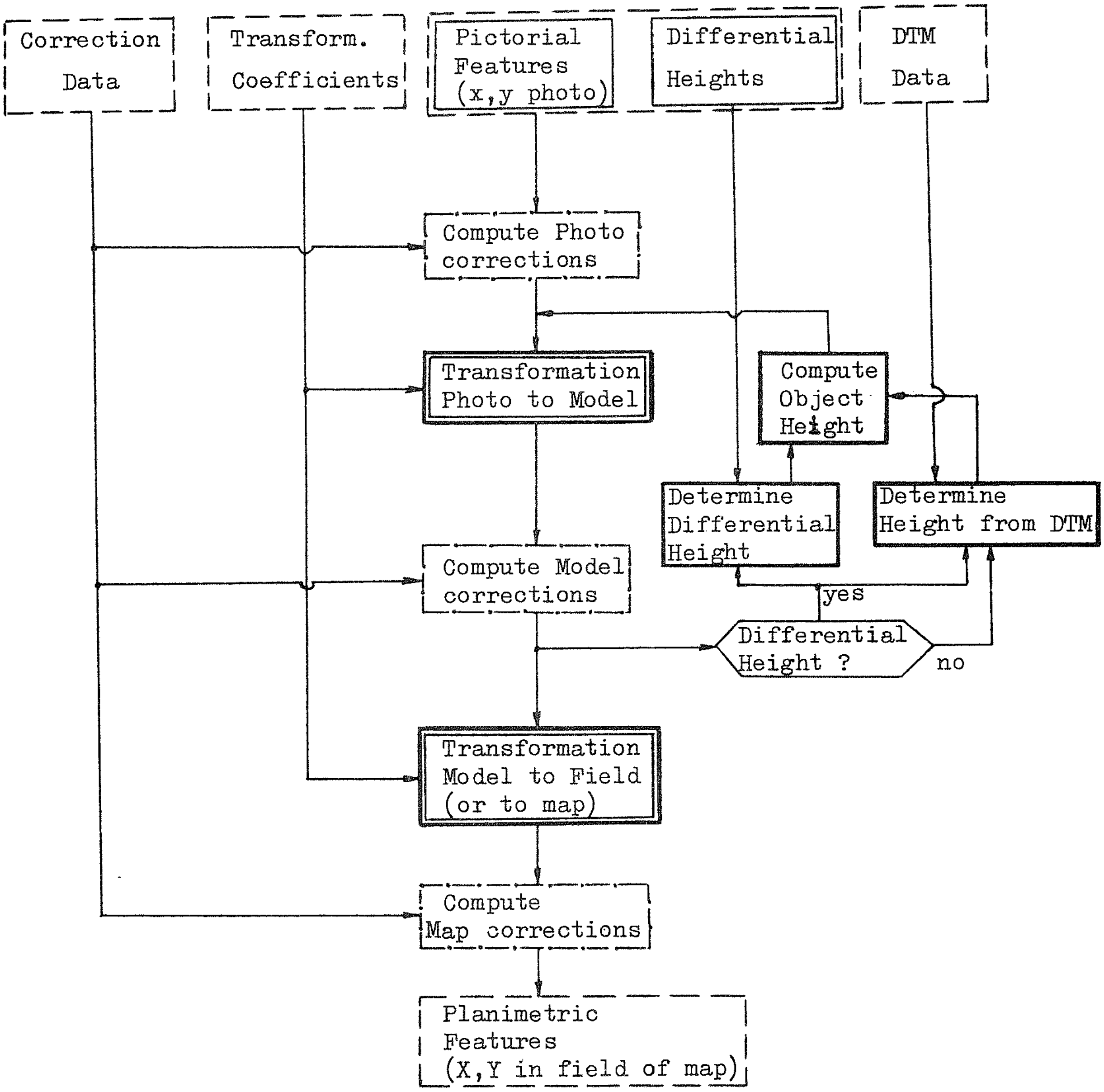


Fig. 4: Computational scheme of D.M.P.

5. Software

The Software is modularly structured, though some of the modules can be implemented either sequentially or integrally as one unit. The required C.P.U. storage capacity per module is less than 10 K (16 bit) words. The entire system comprises five basic modules which will be outlined in the following paragraphs.

i. D.T.M. partitioning module

The module concerns partitioning of D.T.M. data into overlapping patches according to specifications. The patch size and the grid density can be constant or variable. During processing an "address file" is compiled according to the layout of patches (location and size), determining for each patch the storage location of the D.T.M. data, the mean height, and the maximum terrain slope.
The input D.T.M. (for partitioning) can either be data of parallel profiles with constant or variable increments, or of contour lines. In the latter case a regular D.T.M. grid is constructed first by interpolation. The subroutine permits also entry of spot heights.

III. Experimental tests

The primary aim of the tests has been to verify the feasibility of the method for operational use, rather than to produce extensive data for broad statistical assessment. Therefore several small but diversified local sample areas have been selected, i.e. to extract some significant conclusions. The accent was placed on the planimetric accuracy of data obtained by D.M.P., in particular for the stationary mode of operation. Such tests have been necessary in order to detect the shortcomings, which are otherwise difficult to isolate, and subsequently to optimise the operational procedure and select suitable equipment.
The following summary of the tests contains a description of the inputs, the information pertaining to digitising, main processing, outputs, data analysis, and the corresponding conclusions.

1. Inputs

Terrain	Area	Oberschwaben	Pecny
	Relief	smooth and flat	undulated
	H max.	63 m	120 m
	Max. slope	33° (for d=20 m)	45° (for d=12 m)
Photographs	Format	23 x 23 cm	23 x 23 cm
	Principal distance	153 mm	152 mm
	Scale	1 : 28000	1 : 6000
	Flying height	4300 m	900 m
Control data	Ground control	4 points (X,Y,Z,)	4 points (X,Y,Z)
D.T.M. data	D.T.M. type	20 m square grid (Fig. 5a)	12 m square grid (Fig. 5b)
	Recorded on	paper tape	mag-tape
	Accuracy	see figs. 6a, 6b	see figs. 7a, 7b
Reference data	Radial zones	3 (fig. 8)	3 (fig. 9)
	Sample areas	No.1: X=400m Y=700m 2: 1000 800 3: 900 960 4: 1000 880 5: 1100 920	whole photograph
	Type	In total 116 check points: zone 1: 42 points zone 2: 74 points	100 check points: zone 1: 20 points zone 2: 48 points zone 3: 32 points Plot of planimetric features
	Recorded on	paper tape	mag-tape

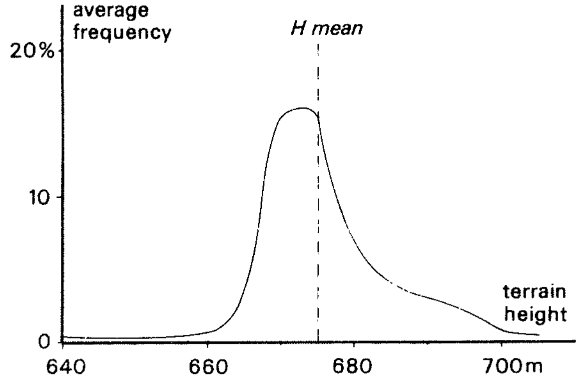


Fig. 5a : Frequency distribution of heights for 20 m grid D.T.M. : Oberschwaben

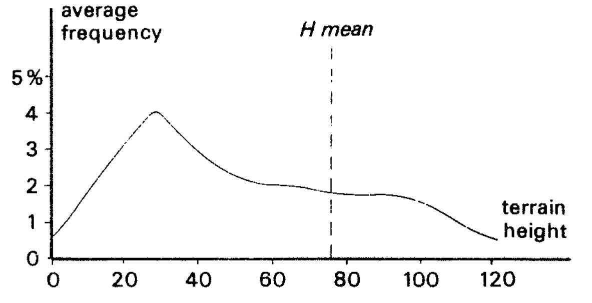


Fig. 5b : Frequency distribution of heights for 12 m grid D.T.M. : Pecny

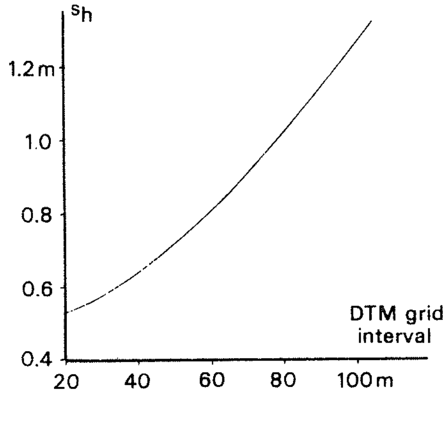


Fig. 6a : Standard errors of D.T.M. : Oberschwaben

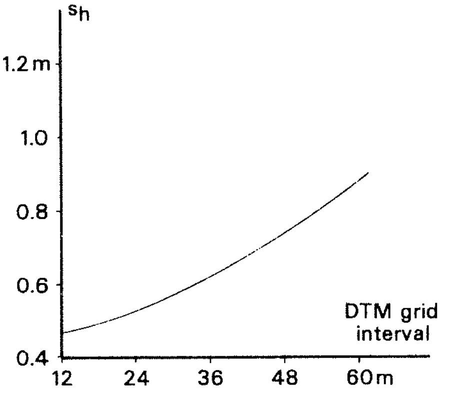


Fig. 7a : Standard errors of D.T.M. : Pecny

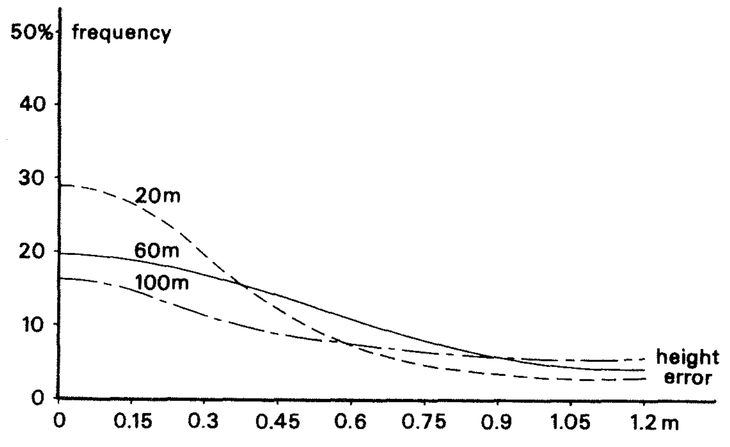


Fig. 6b : Frequency distribution of height errors for 20m, 60m, and 100m grid D.T.M.'s (Oberschwaben)

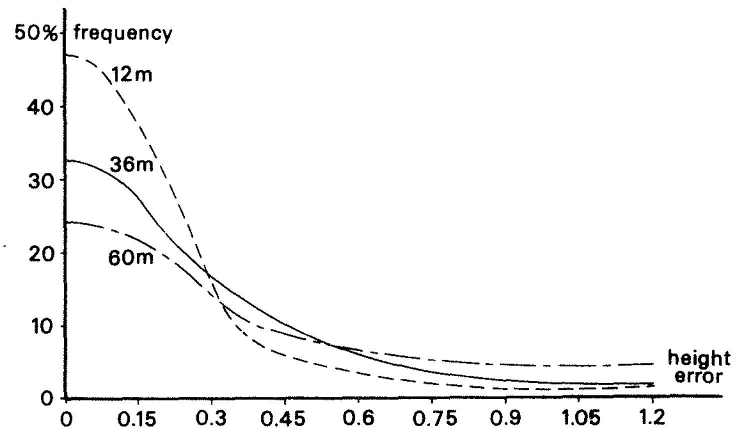


Fig. 7b : Frequency distribution of height errors for 12m, 36m, and 60m grid D.T.M.'s (Pecny)

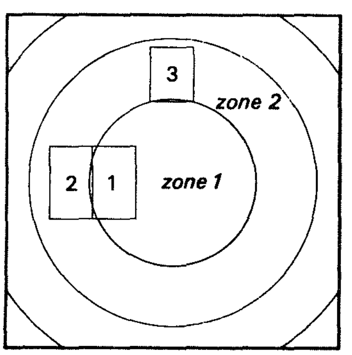


Fig. 8 : Lay-out of sample areas for Oberschwaben test

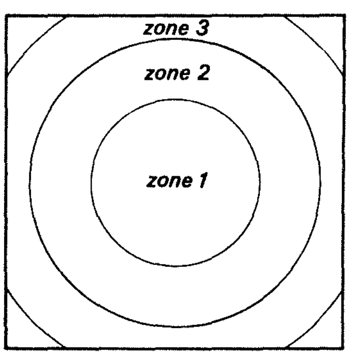


Fig. 9 : Lay-out of radial zones for Pecny test

2. Digitising

Area	Oberschwaben	Pecny
Check points: - operation: - equipment:	Stationary . Gradicon digitiser: resolution 10 μm accuracy = 0,15 μm fallibility F=3,2% paper tape unit . Wild STK-1 Comparator: resolution 2 μm accuracy = 3 μm fallibility F=2,4% paper tape unit	Stationary the same fallibility F=4% mag-tape unit
Planimetric features: - operation: - equipment:		dynamic Gradicon digitiser mag-tape unit

3. Main processing

Area	Oberschwaben	Pecny
Verification of raw data:	. Interpolating heights for check points from D.T.M. . Graphic display and inspection	the same
Transformations inherent in D.M.P.	. Digitiser to photo . Photo to model . Model to terrain	the same . Model to map (affine)
Mapping		. Preparation for drafting . Automatic drafting

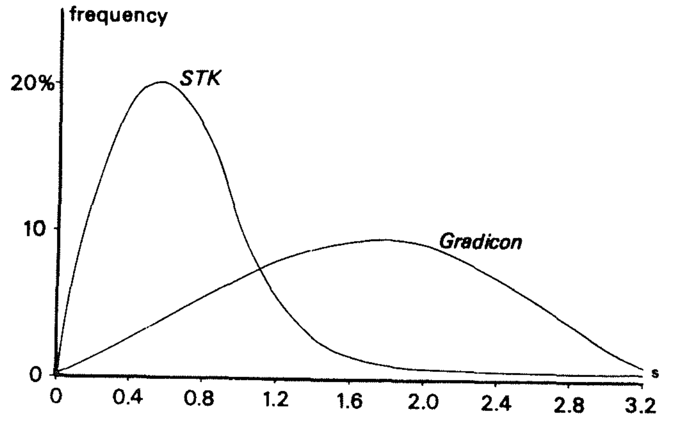


Fig. 11a : Distribution of planimetric errors for 20m grid D.T.M. (Oberschwaben)

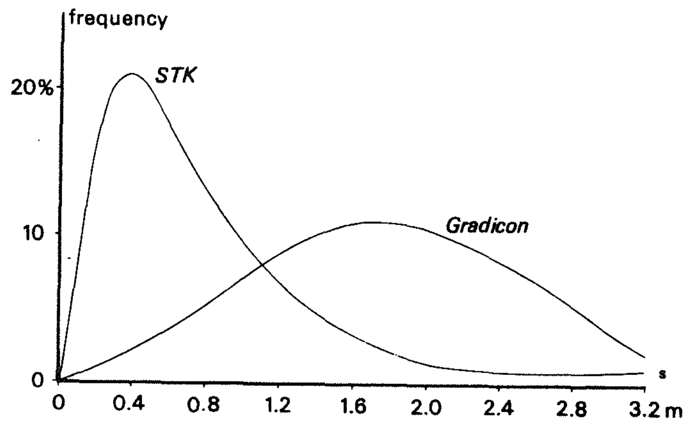


Fig. 11b : Distribution of planimetric errors for 100m grid D.T.M. (Oberschwaben)

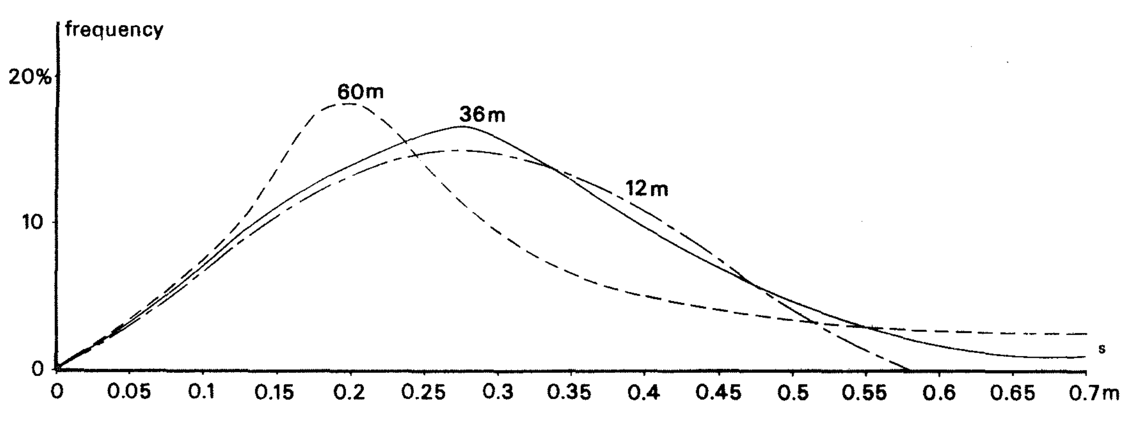


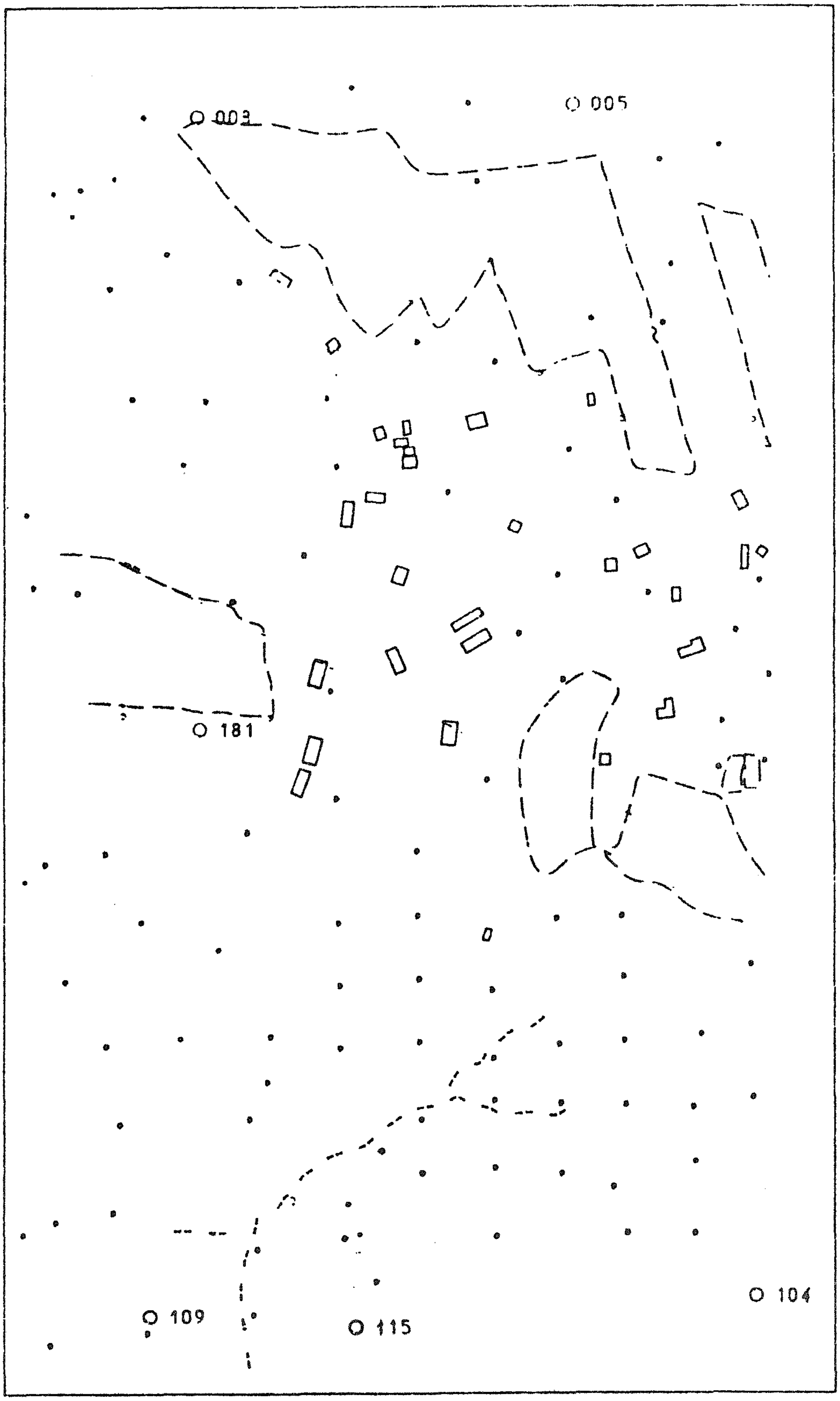
Fig. 12 : Distribution of planimetric errors for 12m, 36m, and 60m grid D.T.M. (Pecny)

4. Outputs

Area	Oberschwaben	Pecny
Check points - Digital files for:	• Heights determined by bilinear interpolation from: 20, 40, 60, 80 and 100 m square grid D.T.M. • Planimetric locations determined by the D.M.P. system	• Heights determined by bilinear interpolation from 12, 24, 36, 48 and 60 m square grid D.T.M. • Planimetric locations determined by the D.M.P. system
-Accuracy estimates for:	• Planimetric locations (overall and zonal): • standard and max. errors • distributions of discrepancies	the same
Planimetric features:		• Digital files (prepared and supplemented for drafting) • Planimetric plot (fig. 10)

5. Data analysis

Area	Oberschwaben	Pecny
Check points	- Discrepancies in planimetry of points determined by D.M.P. - Standard and max. errors (zonal and overall; table 1) - Error frequency distributions (overall; figs. 11a,b)	the same the same (table 2) the same (figs. 12)
Planimetric features:		Visual comparison of the plot from D.M.P. system with the reference plot



O Reference points
. Check points

Fig. 10. Example of planimetric features plotted by the D.M.P. system (Pecny area)

Digitiser	Zone	20m grid		60m grid		100m grid	
		s	max.	s	max.	s	max.
Gradicon	No. 1	2.00m	3.2	2.05	3.2	2,02	3.2
	No. 2	1.79	6.6	1.80	6.7	1.87	6.8
	Overall	1.80	6.6	1.88	6.7	1.95	6.8m
Wild STK-1	No. 1	0.94m	3.3	0.99	3.3	1.04	3.6
	No. 2	0.90	3.6	0.81	3.6	1.02	3.2
	Overall	0.92	3.6	0.97	3.6	1.02	3.6m

Table 1: Standard and maximum errors (Oberschwaben)

Digitiser	Zone	12m grid		36m grid		60m grid	
		s	max.	s	max.	s	max.
Gradicon	No. 1	0.20m	0.32	0.20	0.30	0.21	0.33
	No. 2	0.32	0.50	0.34	0.51	0.38	0.78
	No. 3	0.29	0.47	0.32	0.51	0.33	0.57
	Overall	0.30	0.50	0.32	0.51	0.35	0.78m

Table 2: Standard and maximum errors (Pecny)

6. Tests conclusions.

As the scope and extent of the tests have been limited, the corresponding results have relative significance.
In the Oberschwaben area, the terrain is smooth and flat, and the corresponding D.T.M. data are comprehensive and accurate. Therefore the accuracy of the results has been governed primarily by the accuracy of digitising planimetric features. The latter depends on the definition of the points on the photograph and on the precision of the measuring and digitising equipment. For the Gradicon digitiser an average accuracy of $s_p = 67\mu m$ (reduced to the photoplane) has been attained in contrast to the Wild STK-1 (which was used merely for the comparison), where the average accuracy has been $s_p = 33\mu m$.
The effect of the different grid densities of D.T.M. up to 100m interval is hardly significant. Also the radial distance from the nadir point (i.e. zones 1 and 2) has practically no effect on the accuracy.
The reliability is quite satisfactory; although the operator was not experienced in D.M.P. the failure rate was 3%.
In the Pecny area terrain is undulated and predominantly smooth.
As the corresponding D.T.M. data are also comprehensive and accurate, the attained accuracy of the planimetric features is determined mainly by the accuracy of digitising by means of the Gradicon digitiser.
The average planimetric accuracy, reduced on the photo-plane, is $s_p = 58\mu m$.
The density of D.T.M. grid, up to the interval of 60m, hardly influences the accuracy. The same holds for the radial distance (i.e. zones 1, 2 and 3).
Hence, the results of the two tests are comparable, though they are not generally representative. In more rough terrain the circumstances are obviously less favourable.

IV. Problem areas and possible solutions

Associated with D.M.P. are two main problem areas:

1. Identification of:
   - the pertinent new and changed terrain features
   - the locations of characteristic points and lines of these features (when obscured or poorly defined).
2. Disposal with satisfactory D.T.M. data. Some related problems are:
   - sufficiently comprehensive and accurate coverage of the terrain relief (e.g. optimal grid density)
   - presence of gross errors
   - changed terrain relief (due to earth works).

For identification of the new and changed terrain features a new photograph is compared with the corresponding old source (map or photograph), and differences are identified and interpreted. For the comparison it is convenient to superimpose (virtually or physically) the two sources of information and to bring them into register. This can either be optically or graphically, e.g. by plotting a perspective graph of the old map on a transparent overlay, which is then registered with the corresponding new photograph (4). Subsequently the differences can be manually identified and interpreted (automatic identification and feature extraction are beyond the scope of this paper).

The obscured and poorly defined characteristic points and lines can be identified better when observed stereoscopically. They should be marked prior to digitising; otherwise field completion may be required.

The problems concerning D.T.M. data are more involved. Usually the specifications for D.T.M. are established for other fields of application rather than for the purpose of D.M.P. (though, in principle, such specification can be made). Therefore the more realistic situation is to adapt other specifications pertaining to D.M.P. (e.g. angular field of camera, flying height, etc.) to the properties of given D.T.M. data.

The gross errors in D.T.M. data should be considered differentiated. Large gross errors can be easily identified and eliminated during or after sampling. The actual problem is therefore to isolate "small" gross errors, which, in D.M.P., cause radial shifts proportional to the distance from the nadir point. The corresponding distortions in planimetry can often be detected by visual inspection of the plotted features. If these distortions cannot be explained by the errors originating in D.M.P., the errors in the D.T.M. data may be traced back.

Changes of terrain relief, e.g. due to the earth works, call for updating the D.T.M. data and thus for the usual stereoplotting technique. However, if such changes are minor, the differential heights of the object characteristic points can be acquired, and subsequently entered in the process of D.M.P.

V. Conclusions

The conclusions have been drawn partly from the logical considerations, partly from the previous tests, and partly from the tests summarised in this paper. They concern mainly the work management and the accuracy of D.M.P. However, the technique of D.M.P. will also be compared with the alternative technique, i.e. mapping planimetric features from orthophotographs.

The advantages of D.M.P. are, from the viewpoint of the work management, the following:

- Phased process and thus operation can be parallel and de-centralised
- The already existing equipment components can be used efficiently

- In each phase personnel with specific skill can be employed, which requires a minimum of training
- A great data throughput can be achieved.

Some of the less favourable properties are:
- Suitable D.T.M. data must be available
- Communication between groups or individuals involved in different process phases may not be satisfactory
- Correction of erronous data may be more involved when operation is off-line.

In principle the planimetric accuracy is not homogenous as the errors tend to increase with the radial distance from nadir point. These errors depend on the terrain roughness, which is not covered by the D.T.M., and on the angular field of the camera. Another potential source of error is the digitising of planimetric features. Therefore a profound planning of the entire process and thorough preparation for digitising are essential.
In smooth terrain, where D.T.M. is accurate, the digitising of planimetric features by means of a cartgraphic digitiser may dominate the overall accuracy. Hence, a dedicated measuring and digitising unit may better serve the purpose. Such a unit should permit stereoscopic observation with magnification, x-parallax measurement and recording, and it should be equipped with a simple device to trace the digitised features in real-time. The latter device enables the operator to inspect his work.
The achievable accuracy meets the requirements for updating topographic maps and thus also for compilation of various thematic maps. As the output information is initially in digital form, it can be made compatible with an existing or future data base. It can be graphically displayed for editing or for other purposes, and/or fitted into an existing map by a suitable transformation (e.g.affine or linear least squares).
The D.M.P. should be regarded as a supplementary technique rather than a substitute of the conventional stereoplotting. The actual alternative of D.M.P. is compilation of line maps from orthophotographs or from rectified photographs of flat terrain. Therefore a comparison of the two alternatives seems purposeful; it leads to the following conclusions:
- The entire process of D.M.P. is shorter and simpler as the orthophotographs need not be made;
- The image quality of the "original" photographs is better than that of the orthophotgraphs. Hence, the pertinent features can be more reliably identified and interpreted, and more accurately located;
- The accuracy of D.M.P. can be higher if the D.T.M. data are satisfactory.

In general it may be stated that D.M.P. is a useful technique for updating various maps - when the amount of new information is not excessive, and for compilation of different thematic maps - where the required accuracy is less stringent.

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Abstract

The procedure of D.M.P., intended for updating maps and for thematic mapping, has been refined and made operational. The refinements concern the capability for continuous plotting and inclusion of the correction for differential heights of objects with respect to the corresponding D.T.M. surface.
With minor modification, the method may be adapted for non-metric images. The overall process, which comprises preparation of photographs, specifications for D.T.M., digitising photographs, data processing, and preparation for automatic drafting, has been optimised.
The feasability of the developed D.M.P. procedure has been assessed by means of experimental tests.