THE USE OF ANALYTICAL PLOTTERS FOR THE ESTABLISHMENT OF LAND INFORMATION SYSTEMS

Ulrike Stampa-Wessel
Institute of Photogrammetry and Engineering Surveys
University of Hannover
Federal Republic of Germany
Commission II, WG II/2

ABSTRACT

The use of an analytical plotter for the establishment of a land information system is shown by means of the project "Neustadt". Described are those hard- and software components which are necessary for the improvement and combination of aerial photographs in the scale 1:3300 with existing networks . Problems of the visible and non-visible matters are discussed.

1. Introduction

The application of an analytical plotter for the establishment of a land information system (LIS) is examined in the Institute of Photogrammetry and Engineering Surveys (IPI) at the University of Hannover. For this project the small town of Neustadt near Hannover was chosen. The multitude of informations in the urban area, collected and more or less updated by different administrations and companies, requires a LIS. Numerous, already existing maps have to be correlated on a geometrically correct basis. Therefore aerial photographs in a scale of 1:3300 were taken with a RMK 30/23 on a colour diapositive film. Signalized control points correlate the photographs with the local coordinate system.

2. Description of the Utilized Analytical Plotter

All measurements from the aerial photographs are processed with the analytical plotter Kern DSR-1 (see fig.1).
The electronic architecture of this instrument bases on a distributed concept. Several microprocessors are working on divided applications (see fig.2). The main control computer is a PDP 11/23 of the Digital Equipment Corporation (DEC). This microprocessor computes all programs for the DSR-1 operating system and communicates with all other processors. The task of the processor P2 is to control the moving of the plates. Therefore the transformation parameters are down-loaded from the P1 into the plate processor P2. All motions of the operator are causing an order from P2 to the servo-mechanisms to move the plates 50 times per second.
The processor P3 has to supervise the operator control panel (OCP). Informations from the P1 can be shown on the OCP, from where orders are transmitted by the P3 to the P1.
The communication between user and the P1 proceeds by using an alphanumeric CRT and a keyboard.
For storing of programs and registered data a 20 Mbyte Winchester disk is available. For transferring data, a floppy disk unit is used. Connected by a telephone cable the facilities of a DEC VAX 11/750 and from there those of the computing center RRZN may be applied.
Output units are the precision plotting table Kern GP-1, the interactive graphical screen of the IMLAC-terminal and a printer.

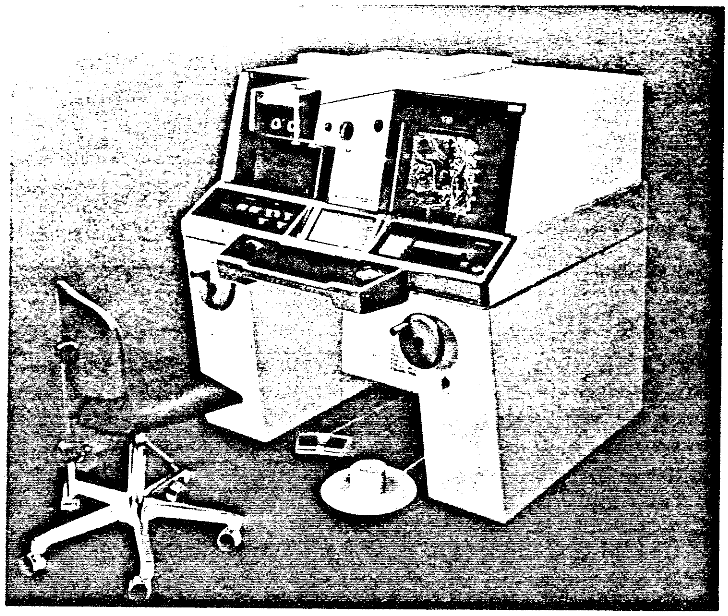


Fig.1: Analytical Plotter Kern DSR-1

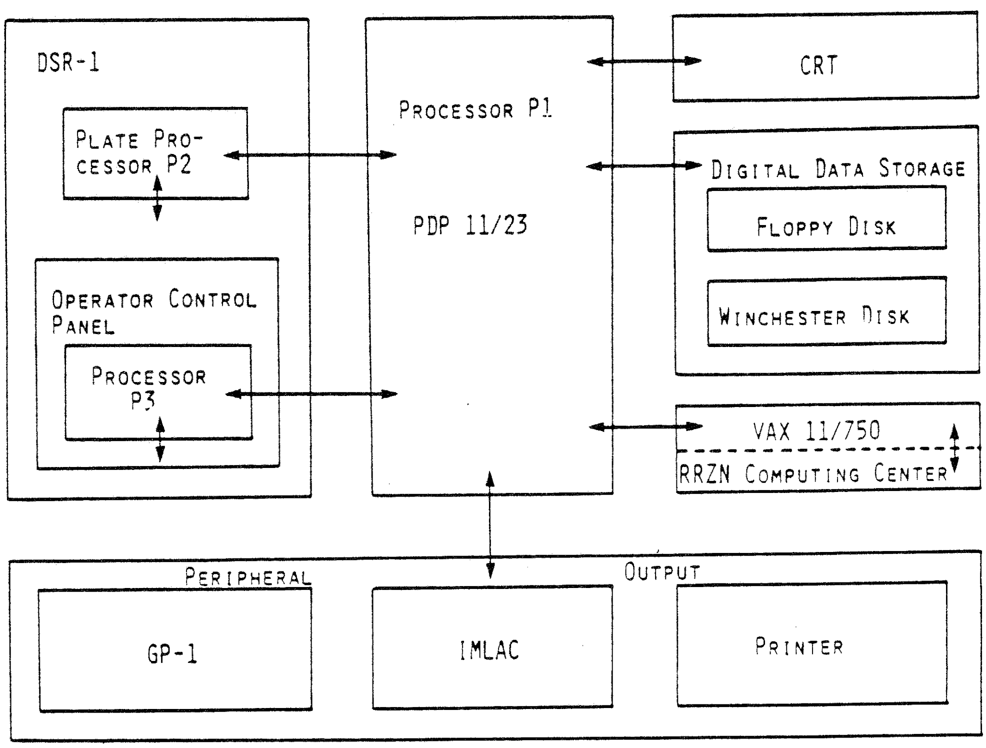


Fig.2: Scheme of the distributed concept of the analytical plotter Kern DSR-1 and the connections to utilized peripherals

In addition to standard settings of eyepiece base, individual interpupilary distance and squint adjustment, image reversal and rotation,the optical viewing system allows the binocular viewing of each plate and an individual zoom magnification. The floating mark is individually adjustable in size and brightness, as it is possible for the photographs. Moving of the plates can be caused either by an order from the P1 or by the operator. The operator himself may cause movings in the x-y direction by handwheels or a

trackball and in the z-direction by using a footdisk or a height drum.
As well as the hardware, the DSR-1 operating system is based on a distributed concept. All programs are working with the menu-technique and may be user-combined in the main menu. For the project Neustadt, the following programs were permanently applied and defined in the main menu:

- inner orientation
- relative orientation
- aerotriangulation.

Other programs, overlapping the whole project, were

- project definition
- camera calibration input
- control point input
- BLUH (see chap.3)
- MAPS 200 (see chap.4).

To find out it's accuracy the DSR-1 was examined. The plate system is moving on spindles, thus often causing systematic errors during measurements. Therefore a calibration was performed with an extremely accurate 120-point-grid plate. The pointing accuracy was calculated as being ± 1.0 µm and the square means of the differences of the grid being ± 1.8 to ± 2.6 µm, depending on the upper and lower plate in x- and y-direction. After calculating a suggestive polynom function, those results were improved to ± 1.4 to ± 2.0 µm (see fig.3).

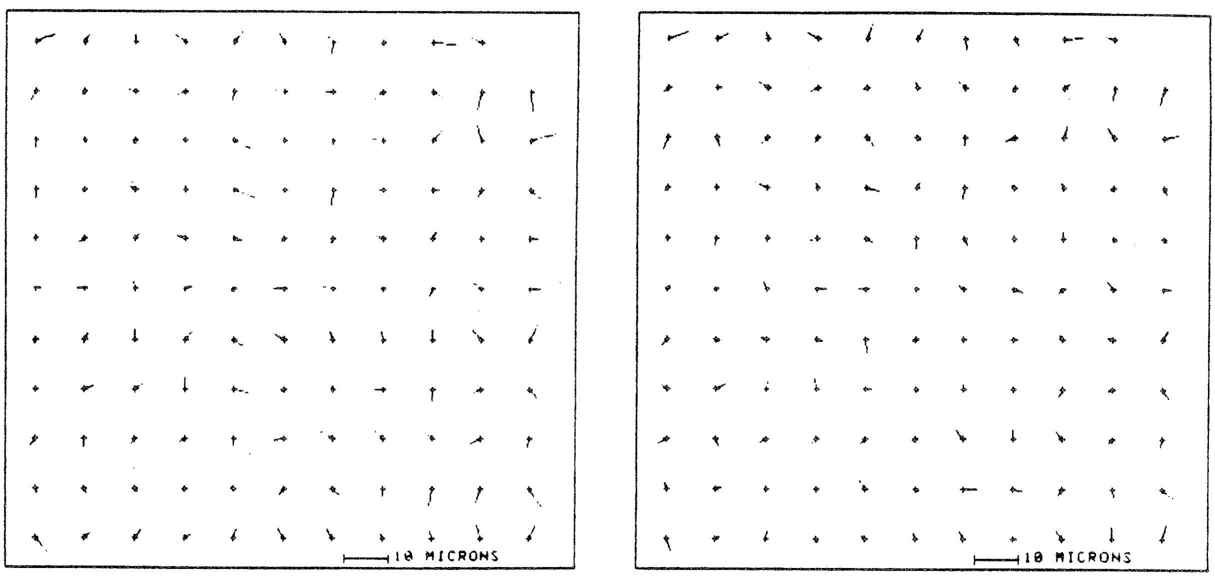


Fig.3: Results of the calibration and its improvement of the lower plate.
left: calibration results; right: results after transformation with a polynom function

Measurements with calibrated grids at different temperatures (+ 18°C to + 26°C) were causing no significant shift and no significant changing of scale.
The improvement of systematic errors may be calculated in an on-line program.
Those differences are small, but should not be neglected for precise measurements. Especially by using suggestive orders and methods of measurements plenty of error causing effects can be eliminated. Those effects can be time, temperature or just the relative orientation.

3. Aerotriangulation and Bundle Block Adjustment

For the establishment of the LIS coulour diapositives were taken during flights over the project area Neustadt in the scale of 1:3300. Four strips with altogether 72 pictures were evaluated. The measurements were carried out with the aerotriangulation program of the DSR-1. Thus 255 object points were recorded by 1300 measurements.
The calculation of the bundle block adjustment was accomplished by the program BLUH with robust estimators and additional parameters (see Leonhard, Jacobsen, Stampa-Weßel). The amount of the standard deviation sigma 0 did not exceed 4.5 µm.

4. MAPS 200 - Program for Data Acquisition

The program MAPS 200 (Microcomputer Aided Photogrammetric Station) is a program for the acquisition of any photogrammetric data,combined with an on-line plotting and their registration in a data base system. An orientation of a stereomodel is necessary for the measurements with MAPS 200. In the project Neustadt the orientation parameters were calculated during the bundle block adjustment. After an inner orientation is performed the transformation parameters can be downloaded to the plate processor P2.
It is the on-line compilation part of the program, which combines measured information with predefined features. Therefore a useful library, containing all those features, has to be installed. In this case, the library contains 199 different linetypes and 199 different symbols. The library depends on the project, it will be used for. It should be established as logical as possible. Linetypes and symbols with the same feature should be on following linetype- and symbol-numbers.
For the project Neustadt all gas-utilities got numbers form 61 to 70, all electricity-utilities those from 71 to 80, while all connections between the main lines and the individual supply are ending with ..5; i.e. gas supply is defined by no.65, electrical supply by no.75. Even the combination between linetype and symbol should be as logical as possible as well. Corresponding to linetype 72 high-voltage-cable, the symbol 72 is defined as a high-voltage-mast.

The definition of the single linetypes and symbols offers a variety of combinations (see fig.4). Different hardware-linetypes and hardware-symbols may be combined. In addition

1	SYMBOL CODE NUMBER	=	72	1	LINE TYPE CODE NUMBER	=	72
2	ALPHA DESCRIPTION	=	STAHLGITTERM	2	ALPHA DESCRIPTION	=	HOCHSPANNUNGSLTG
3	AUTOMATIC PEN SELECTION	=	4	3	AUTOMATIC PEN SELECTION	=	4
4a	HARDWARE SYMBOL NUMBER	=		4	HARDWARE LINE TYPE NUMBER	=	3
4b	SYMBOL FILE NAME	=	MAST.SYM	5a	STANDARD LINE SIZE	=	5.0
5	STANDARD SYMBOL SIZE	=	2.0	5b	LINE RATIO	=	
6	ANNOTATION	=	VARIABLE	6a	INCLUDED SYMBOL NUMBER	=	
7	ANNOTATION SIZE	=	2.5	6b	SYMBOL ROTATION	=	
8a	TEXT SLANT	=	50.0	7	NODE SYMBOL NUMBER	=	
8b	TEXT ROTATION	=		8	LEVEL NUMBER	=	172
9	RELATIVE TO	=	H				
10	LEVEL NUMBER	=	72				

Fig.4: Linetype and symbol description

user-defined symbol-files may be used. Size, rotation and ratio as well as different pens or annotations can be defined. The relation to a level can precombine symbols and linetypes for a special task. For the measurements the operator needs a catalog including the connections between number, alpha description, existing maps, the on-line plot and, if necessary, the photograph (see fig.5).
Nevertheless, plenty of objects like public and private houses cannot be differentiated by the operator during measurements. Therefore it is necessary to define a level for unde-

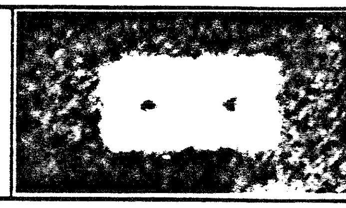
SYMBOL			PTD 81 - 90	
No.	Alpha Description	Presentation in maps 1:1000	on-line GP-1	Notes
⋮	⋮	⋮	⋮	⋮
86	HATCH.PTD	□	⊡	

Fig.5: Plot of the operator's catalog. Combination between number, alphadescription, map, on-line plot and photograph

fined objects for each group; i.e. no.60 for undefined gas-pipes and no.70 for undefined electricity-lines.
In addition to the feature-codes, fixed in the library, it is possible to add some geometrical information to the measurements. These information may be straight line, curve, arc or symbol.
Some special functions like squaring and hatching of buildings, drawing parallel lines and the possibility to change the line- and symbol-size scale factor make this program universal for this task.
Generally the registration is executed by use of the two foot-pedals: the left one for the pen-up motion, the right one for the pen-down motion. During registration the operator has to take care of starting and ending segments in a useful manner and has to registrate every intersection point, even those on a long straight line.
The coordinates of the points are used to be stored in an ASCII-file together with the additional information on linetype or symbol number, scale-factor, mode and, if necessary, time.
The ASCII-format requires quite an amount of space, but it is selfdescriptive and easy to edit.

5. Applicable Information from Aerial Photographs

Compared to all other measurements those made by use of aerial photographs have one main advantage: They are topical. This should be taken into account for the project Neustadt. As it is not possible or meaningful to get all required information for a LIS from the aerial photographs, a solution has to be found to combine the information from existing maps with those from the photographs. Therefore the geometric correct base for all sections was taken from the photographs and was correlated with the dependent details from the graphic sources. The data can be classified in different kinds of visibility:

- the signalized points
  For the correlation of the local coordinate system and the aerial block system about 70 points were signalized. 28 of them were used as control points, the others as tie- and pass-points. The results of the bundle block adjustment did not require any improvement of the local survey points.

- cadastral and planning information
  Boundary and other cadastral information can usually not be seen in aerial photographs. The same problem occurs with planning data. Exceptions may be buildings and other topographic elements, being located right on a parcel boundary, as you can often find them in urban aeras with single-unit houses (see fig.6). This fact causes that the ca-

dastral and planning maps have to be digitized completely. They have to be reviewed and completed by those points, being visible in the photographs. Those areas with an already existing coordinate cadastre can take that over into the LIS.

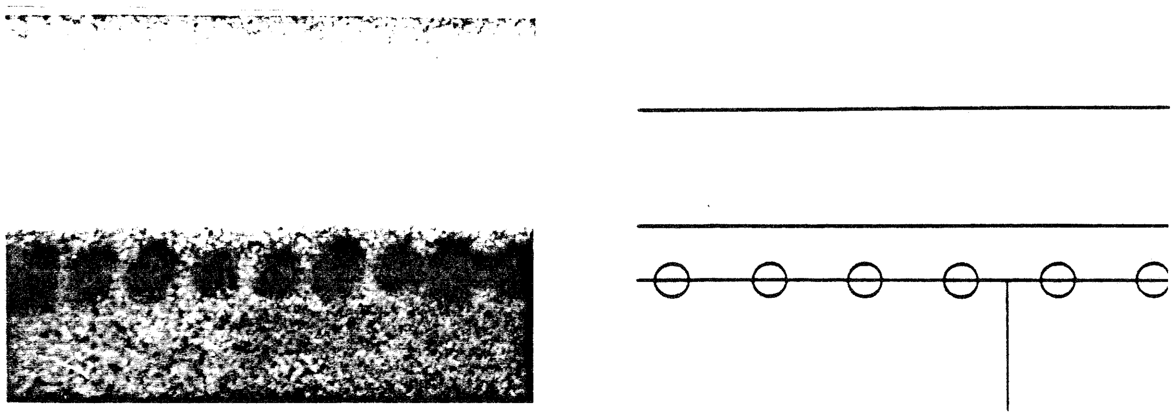


Fig.6: Presentation of parcel boundaries combined with a hedge in a photograph and the map.

- topography
  The topography in existing maps is not paid that much attention to as it should be in a LIS. By use of colour diapositive film it is possible to collect all topographic data with the analytical plotter.

- utility
  The visibility of utilities in the aerial photograph is quite different. Primarily it depends on the difference between an overhead line and a subterranean one. Overhead lines are clearly visible and can be measured with the DSR-1. But in this case, the relation to the correct linetype (symbol) is often diffi cult. Therefore the undefined levels are used and will be changed interactively during the final treatment.
  The secondary group consists of those utilities with quite a number of visible details on the surface, being connected by pipes. Generally those utilities are water-, sewage-, rainwater-sewage- and gas-pipes.

  The most difficult kind of utilities are those being connected by cables like telephone and cabl e-TV. Visible facilities, like hatches, are seldom to be found and connecting lines are not always straight. In those cases, the lines themselves have to be digitized from graphical sources and have to be reviewed by measured distances.

  Alghough a colour diapositive film was applied, plenty of superficial details are not visible because of their size or their similarity to their surroundings.
  Therefore those details have to be signalized.

Together with the existing maps it is much easier for the operator to find small details of the utulities, because they enable him to know where to look for them. In addition but only fo r this performance, sites of road works are other good advices (see fig.7).

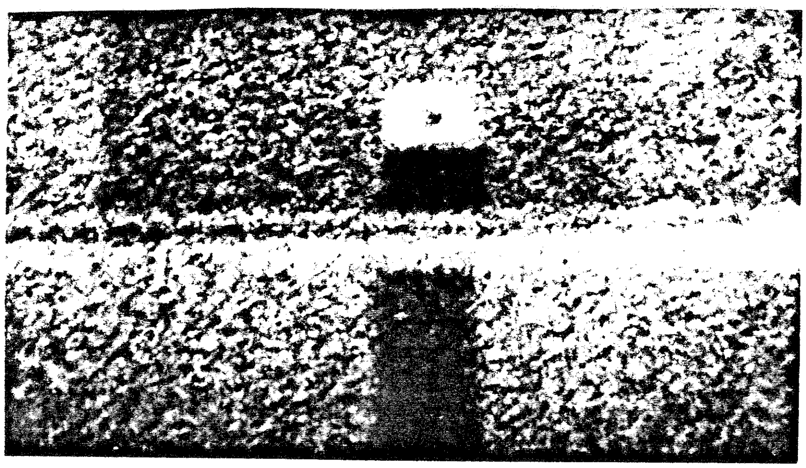


Fig.7: Often an advice for finding of a utility is the site of road works

6. Final Treatment

Those data, produced by the analytical plotter can be combined with the digitized data of graphic sources on the interactive graphical screen IMLAC with the program MAPS 300. Thereby the measurements from the DSR-1 should be the basis for all other data, correlated with them. Merely the correct linetype and symbol number has to be assigned to those data which are on an undefined level. In some cases new fieldwork will be indispensable. The drawing of the new maps proceeds on the precision plotting table Kern GP-1 in any required combination of the different levels.

7. Conclusion

With the utilized hard- and software an establishment of a LIS for the project Neustadt on the fundamentals of photogrammetric measurements is possible. First experiences were successful with this total workstation. This system should be used for the registration and editing of smaller areas like Neustadt, but not as an universal data base system for a whole country. For this task it is intended to send the finally edited data to another, larger interactive graphical data base system.

References

J.Leonhardt, K.Jacobsen, U.Stampa-Weßel: Establishment of a Land Information System - Project Neustadt. XV ISPRS Congress 1984, Rio de Janeiro

J.Klaver: Hardware and Software for digital data collection for Land Information Systems. XV ISPRS Congress 1984, Rio de Janeiro