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THE PLANICOMP FAMILY, CHARACTERISTICS AND INNOVATIONS

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1. Introduction

The Planicomp was introduced at the 1976 ISP congress at Helsinki. Since then, the development aim has been to increase its flexibility, in particular by improving the software tools and the opto-mechanical viewer, and by using the most powerful HP computer model.

The result is a multi-functional "analytical photogrammetric center". Its functions are:

a) Computer control of the Planicomp viewer for data collection and of the DZ 7 tracing table for mapping.
b) Computer support of analog instruments with PLANI-AS and of comparators with PK-AS.
c) Background processing for aerotriangulation and digital terrain models.
d) Parallel program development by the user.
e) Data communication with other systems (DS 1000 network, graphical systems).

In the meantime it has been shown that analytical instruments offer considerable advantages and save time also in the daily photogrammetric routine work (model plotting, mapping).

As a result the need arose for an analytical plotter in the price bracket of analog instruments in addition to the comprehensive system described above.

This need has now been satisfied by the use of a new generation of Hewlett-Packard microcomputers called HP 1000 A series.

The different models of this series and of the F series used up to now together with the known and an expanded opto-mechanical viewer and different software packages form a system family whose members satisfy differing user requirements.

2. Description of the System Components

2.1 Computer Models and Periphery

The HP 1000 A series computer models are newly developed hardware with distributed input/output intelligence and new periphery.

The A series comprises processors with differing capabilities called A600+, A700, and A900.

While the A900 is the most powerful A series model, the A600+ is an extremely low-cost computer which makes it possible to offer a Planicomp system in the mentioned price bracket.

All computer models satisfy the performance requirements regarding real-time control of the Planicomp and the tracing table. In addition they afford background processing of other programs and parallel development of user programs. Since they differ in computing power, the scope of the tasks that can be processed in parallel with real-time operation differs too.

Table 1 shows the technical data of the different computer models. The speed of the A900 processor as illustrated by 3 000 000 instructions per second and 500 000 floating-point operations per second merits special mention. This is about the triple of the F computer performance.

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The maximum memory configuration of the A systems is 4 or 6 MB today and will be considerably larger in the future. The standard memory size of the A600 and A700 is 512 KB, and 768 KB for the A900. "Virtual memory" and "virtual code" for large data fields or large programs have been implemented in the RTE-A operating system.

The A system also supports Winchester disks, i. e. hard disks with a capacity of 10 to 132 MB. Being sealed, they offer better protection against loss of data compared to removable disks. A tape drive is integrated for data backup and data interchange between different systems; its cartridge can store the whole disk content.

A standard FORTRAN IV compiler is now available for program development which facilitates program portability to other systems. The Planicomp application programs have been converted accordingly.

Thanks to its long-term successful use and the continuous improvement of the system, the F computer and the RTE-IVB operating system now offer the widest range of proven system and application programs, interfaces and peripheral equipment. It is the computer most suited to multi-user operation. This is the reason why it is still being offerend and supported within the Planicomp system.

2.2 Viewer

The Planicomp viewer is now available with an unaltered standard lens system and with an expanded lens system (see Table 2).

The expansion comprises:

a) Two independently adjustable zoom lenses with a magnification range of 7.5x to 30x.
b) Halogen illumination lamp.

2.3 Software

The core of the Planicomp application software package with about 80 programs for model plotting and mapping is surrounded by software packages for aero-triangulation, computation of digital elevation models, and support of analog instruments and monocomparators.

Program handling is nearly identical with all systems. Improvements have been implemented for the A systems regarding data file handling (general files). They can be created automatically and protected with security codes.

New software is available for the following fields of application:

a) File handling and transfer (GEFIO, DS/1000)
b) Close-range photogrammetry
c) Interactive measurement of terrain elevations (progressive sampling)
d) Graphical plotting

A detailed description of the major innovations is given in section 4.

3. Members of the Planicomp Family

From the range of components (computers, viewers and software) described in the preceding section, three Planicomp systems have been assembled which are offered by Zeiss under the names C 100, C 120 and C 130.

3.1 C 100 Planicomp

The most comprehensive system is the C 100 Planicomp, a universally applicable photogrammetric plotting center with HP 1000 F or A900 computer (Fig. 1). Further features of the C 100 are:

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- Zoom lens viewer.
- Complete Planicomp software for numerical and graphical plotting.
- Optional PLANI-AS and PK-AS software packages for supporting analog instruments and the PK-1 monocomparator.
- Optional PAT M, PAT B and BLUH software packages for aerotriangulation and HIFI for digital elevation models.

Because of its high processing power, the C 100 system is particularly suited to applications where analog instruments and several computer workstations have to be supported in parallel with Planicomp operation.

3.2 C 130 Planicomp

In contrast to the C 100, the C 130 Planicomp analytical plotter is the most cost-effective system for computer-controlled data acquisition and mapping (see Fig. 2).

It consists of the standard viewer and a defined minimum configuration of the A600+ microcomputer.

The C 130 system has been designed as a single photogrammetric workstation tailored to data acquisition and storage. It comprises the following standard components:

- Standard viewer without zoom lenses
- HP 1000 A600+ model 6 processor with 512 KB memory and 2 redundant I/O channels
- HP 2622 terminal with integrated thermal printer
- HP 7908 Winchester disk (16 MB) with integrated cartridge tape unit
- Planicomp basic software for orientation and measurement
- Optional software for mapping, data input and output (GEFIO), strip adjustment (STRIM) and program development.

3.3 C 120 Planicomp

The third Planicomp system offered by Zeiss is the C 120 "Analytical Plotting Station", which comprises the new zoom lens viewer and an A700 processor (Fig. 3). Thanks to its floating-point hardware the A700 is significantly more powerful than the A600 in compute-oriented operations so that it is particularly suited to further processing of the collected data. All of the Planicomp software can be used. As with the C 100, the computer configuration and peripheral equipment can be selected freely.

4. Software Enhancements

The software enhancements mentioned in section 2.3 are described in detail in the following.

4.1 GEFIO

The GEFIO software package serves to edit and transfer measured data stored in so-called general files. These files are used by Planicomp, Orthocomp, the AS programs and the PAT M, PAT B, BLUH and HIFI software packages. As in data bases, all general files comprise header information and are created as binary files with selectable record length. GEFIO comprises the GEFIL, GREAD and GWRIT programs.

GEFIO enables

- editing and, with A processors, creation of general files at any terminal.
- tape input and output of data in ASCII or EBCDIC with selectable block length. An internal ASCII file is created in each case which can be edited with the HP editor.

Advantages are high reading and writing rates and simplified data interchange with other computers.

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4.2 DS/1000 Computer Network

The DS/1000-IV network software is an established HP product for data and program transfer in integrated computer systems. It has become significant for the Planicomp family through the introduction of pure data acquisition units such as the C 130. Several minimum-configuration C 130 systems used mainly for mass data collection can be interconnected with a fully equipped C 100 or C 120 system for further data processing and result output.

4.3 Model Formation by Bundle Orientation for Close-Range Photogrammetry

In difficult situations such as occur frequently in close-range photogrammetry it may be necessary to use more sophisticated orientation methode for exterior orientation of a stereo pair, and to use other information because conventional orientation parameters are not available. A program developed by the University of Bonn for single-step model orientation is now available for the Planicomp. The mode of operation and the major performance features are described in the following.

Mode of operation:
The current Planicomp model data is used as initial data for the iterative adjustment process. Conventional relative and absolute orientation before the program start thus results in acceptable initial data for bundle adjustment. After computation, the interior and exterior orientation data can be entered in the Planicomp model data record for model establishment.

Performance features:

- All observations and unknowns can be weighted so that known precision variations in the input data can be taken into account.

- Input data: Control points with individual weights for X, Y and Z
  Control points of local auxiliary coordinate systems
  Distances
  Planes
  Angles (horizontal and vertical)
  Directions (azimuth)
  Coordinate differences $\Delta X, \Delta Y, \Delta Z$

- Output data: Planicomp model orientation parameters
  Adjusted object coordinates
  Variance and covariance matrices of all unknowns

- Unknowns: Apart from the absolute orientation parameters, the interior orientation data (center point shift, focal length) and the distortion parameters can be included in adjustment if there is a sufficient number of observations. The unknowns are treated in the same way as observations.

- Reliability investigation of all observations using Baarda's theory.

The program can thus be called a universally applicable orientation program not only for special applications, but also for standard air photo interpretation using single-step orientation computation, weighting of control point coordinates, and reliablility investigation.

4.4 Progressive Sampling

This new program belongs to the group of application programs for determining points for the computation of digital elevation models (DEM). Automatic methods (profile or grid measurement) have won over purely manual methods for economical reasons. Statistical grid measurement /1/ was found to be the fastest and most precise method. The planimetric coordinates are used to automatically set the floating mark to the grid points in the model. The floating mark is then kept stationary in X and Y to allow the operator to set the elevation and initiate data recording.

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Different investigations on terrain representation precision in the DEM have shown that the grid density and the terrain features are of decisive importance apart from measuring precision.

To be optimum also for uneven terrain, grid measurement has to be expanded so that the grid mesh is automatically matched to local terrain conditions by means of an objective criterion.

In 1972 already, Makarovic has suggested an interactive measuring method called "Progressive Sampling" which largely satisfies these requirements /2/.

This method starts out with a wide mesh. From the grid point elevations, approximate local terrain curvature data is obtained by computing the second derivations. This data is used to decide whether the initially wide grid mesh should be halved locally.
The procedure is interactive, i. e. any further measured grid points are also analyzed in the next step and used for densification, if applicable, until a lower limit is reached.
In an analytical plotter, automatic setting of the densification points and immediate computation of the second derivations is so fast that the operator will not detect any measurement delays and can concentrate on elevation setting.

In 1980, a software package was developed at the University of Hannover for the AP/C-3 analytical plotter that also allows for break lines and terrain anisotropy /1/, /3/.

The capabilities of this method are illustrated in the following by means of an example.

An uneven test terrain was measured with a basic 32 m grid and additional break lines (Fig. 4). The resulting contour lines[1)] show that this grid mesh is too large for some terrain conditions.

The points used for automatic densification by progressive sampling and the resulting contour lines are shown in Fig. 5. The lower densification limit was 8 m, which was required for precisely representing the most uneven terrain parts.

For comparison, a uniform grid was processed with a constant grid mesh of 8 m (Fig. 6).

The contour lines of the densified 32 m grid and the uniform 8 m grid show good congruence.

The elevation deviations measured at control points do not differ significantly in the two plots.
In the uniform 8 m grid, the number of grid points is 1700; with progressive sampling, less than 1/3, i. e. about 500 points, were measured.

These results were so promising that Zeiss decided to have a progressive sampling program developed by the Technical University of Munich /4/. This program is now available for the Planicomp system.

4.5 Graphics

In the fields of graphical and digital mapping, Zeiss now offers two basically different solutions:

a) PLANIMAP Software
   The name PLANIMAP refers to a new software system which enables both computer-supported direct mapping and digital storage of the graphical information and parallel or off-line mapping.

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1) The TASH DEM program developed by the Topography and Cartography Section of the University of Hannover was used for contour line interpolation.

b) INTERGRAPH Workstation
The second approach consists in the connection of a separate INTERGRAPH graphics workstation to the Planicomp system. The Planicomp then serves as a real-time data acquisiton unit for the Intergraph workstation. An optional optical interface enables superimposition of the graphical representation with the Planicomp stereo image.

All Planicomp systems with HP 1000 A computer can be connected, and all systems with zoom lens viewer afford optical superimposition.

A detailed description of the PLANIMAP software features and of the Intergraph system is contained in /5/.

5. Conclusions

Through the use of the cost-effective yet powerful A series computers on the one hand and of the mature enhanced software and viewers on the other hand, the Planicomp can now be used as a standard photogrammetric system and as a universally applicable system for special tasks.

The enhanced software and the new hardware components of the viewer provide actual and defined implementations of some of the many solutions portended by the vast potential of analytical systems.

Literature:

/1/ Rüdenauer, H.: Zur photogrammetrischen Erfassung von Geländedaten unter Berücksichtigung straßenbaulicher Forderungen. Thesis University of Hannover, No. 101, 1980.

/2/ Makarovic, B.: Progressive Sampling for Digital Terrain Models ITC Journal, 1973-3.

/3/ Rüdenauer, H.: Analytische Plotter-Programme zur objektiven on-line Punktdichtebestimmung in Digitalen Höhenmodellen. Pres. Paper Comm. II, ISP Congress Hamburg 1980.

/4/ Reinhardt, W.: A Program for Progressive Sampling for the C 100 Planicomp 39th Photogrammetric Week, Stuttgart 1983.

/5/ Hobbie, D.: Extended Graphical Plotting with the Planicomp 39th Photogrammetric Week, Stuttgart 1983.

	A600+	A700	A900	F-Series
Base instr. set. execution speed	1 mill.ips	1 mill.ips	3 mill.ips	1 mill.ips
Floating point process. speed	53 000 ops/sec	204 000 ops/sec	500 000 ops/sec	180 000 ops/sec
Memory cycle time	454 ns	500 ns	181 ns	420 ns
Memory size Planicomp stand. Maximum	 512 kb 4 Mb (32)	 512 kb 4 Mb (32)	 768 kb 6 Mb (32)	 256 kb 2 Mb
Direct memory access rate	4.3 Mb/sec	4.0 Mb/sec	3.7 Mb/sec	2.7 Mb/sec
Virtual memory	12.6 Mb (128 Mb)	12.6 Mb (128 Mb)	12.6 Mb (128 Mb)	--
Virtual code	-- (7.9 Mb)	-- (7.9 Mb)	-- (7.9 Mb)	--
Main storage medium	CS/80 Winchester	CS/80 Winchester	CS/80 Winchester	Disc Cartridge
Operating system	RTE-A.1 (RTE-A)	RTE-A.1 (RTE-A)	RTE-A.1 (RTE-A)	RTE-IVB
Multi-user	-- (VC+)	-- (VC+)	-- (VC+)	Session Monitor
Batch and I/O spooling	-- (outp. only)	-- (outp. only)	-- (outp. only)	full
Language support	Fortran 77 Pascal Basic Macro-Assembler	Fortran 77 Pascal Basic Macro-Assembler	Fortran 77 Pascal Basic Macro-Assembler	Fortran 4 Pascal Basic Assembler

Tab. 1: C O M P U T E R D A T A

(Data enclosed in perentheses () refers to the future RTE-A operating system, an enhancement of the RTE-A.1 operating system.)

Viewer	Standard Version	Enhanced Version
Measuring range	250 mm x 250 mm	
Focal length	0 to oo	
Distortion correction	random (digital)	
Magnification	8x 16x optional	7.5 x to 30x contisuously adjustable (zoom)
Filed of view with 8x eyepiece magnific.	27 mm	26 mm to 6.5 mm
Illumination	normal	halogen lamp
Floating mark Diameter	Black point or illuminated mark 40 µm 20 µm (optional)	
Image rotation	± 105°	
Viewing modes (manual or program-controlled switchover)	Binocular left or right, orthoscopic, pseudoscopic	

Tab. 2: Planicomp Viewer

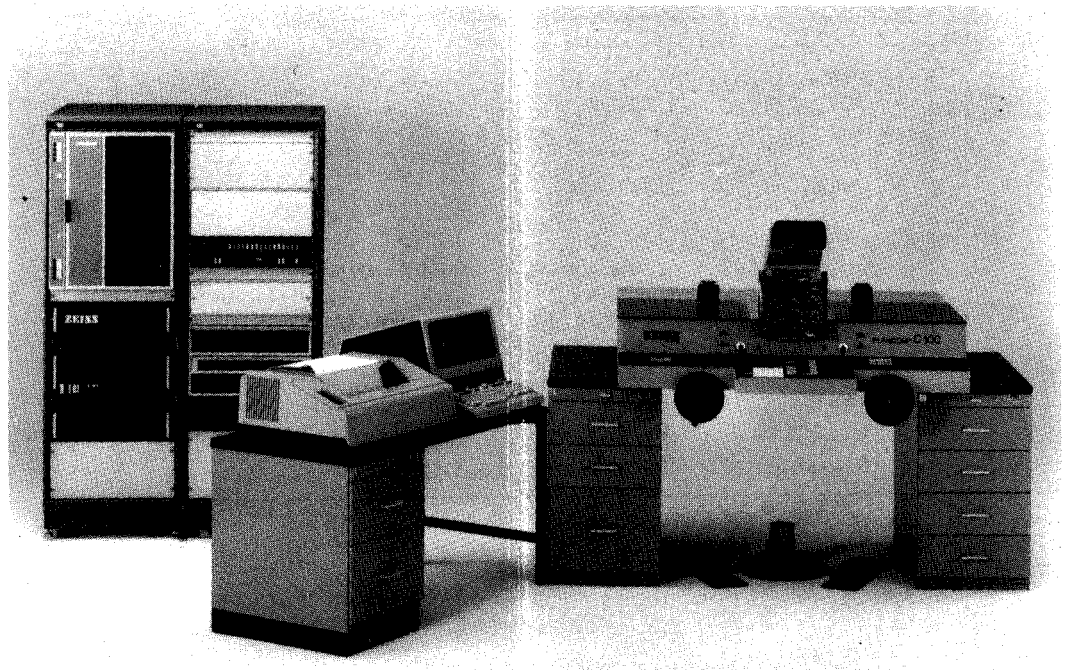

Fig. 1: C 100 Planicomp with Zoom Viewer and HP 1000 F Computer

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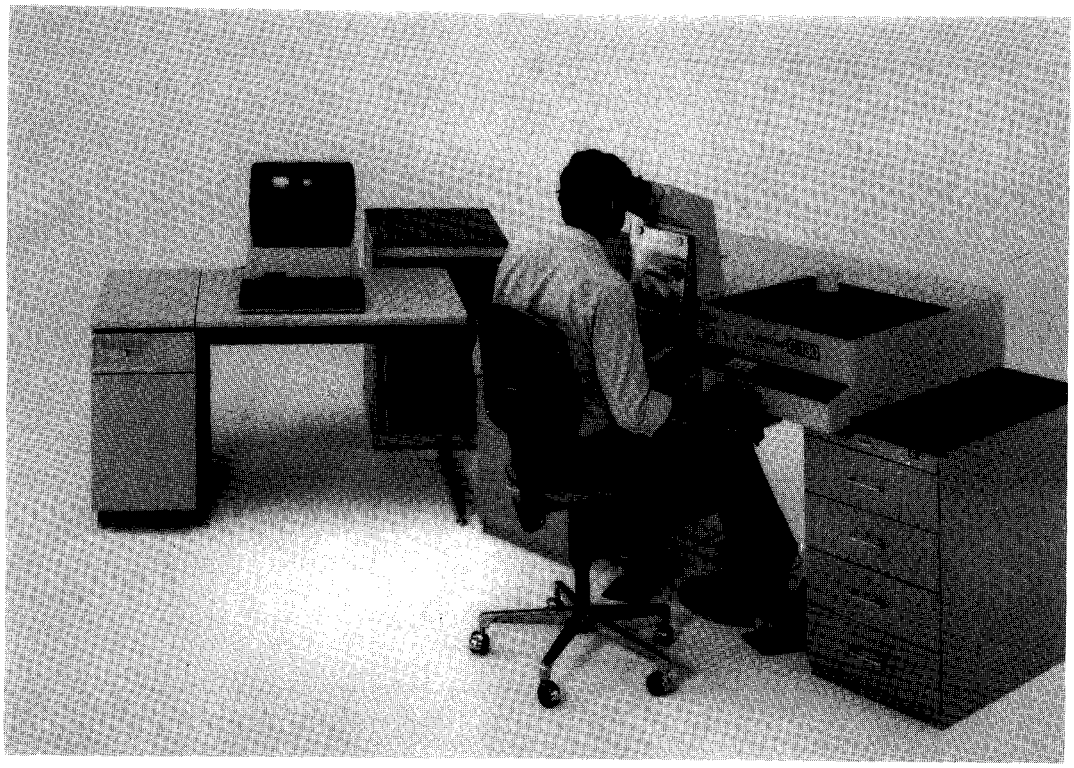

Fig. 2: C 130 Planicomp with HP 1000 A 600 Computer

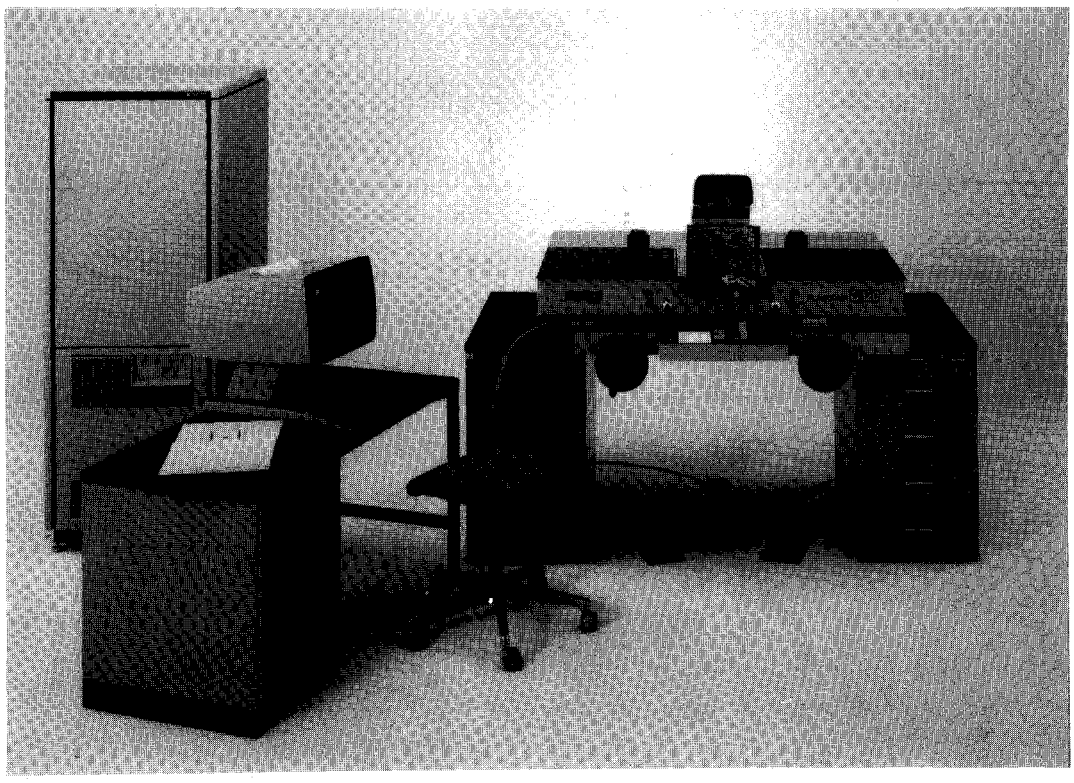

Fig. 3: C 120 Planicomp with Zoom Viewer and HP 1000 A700 Computer

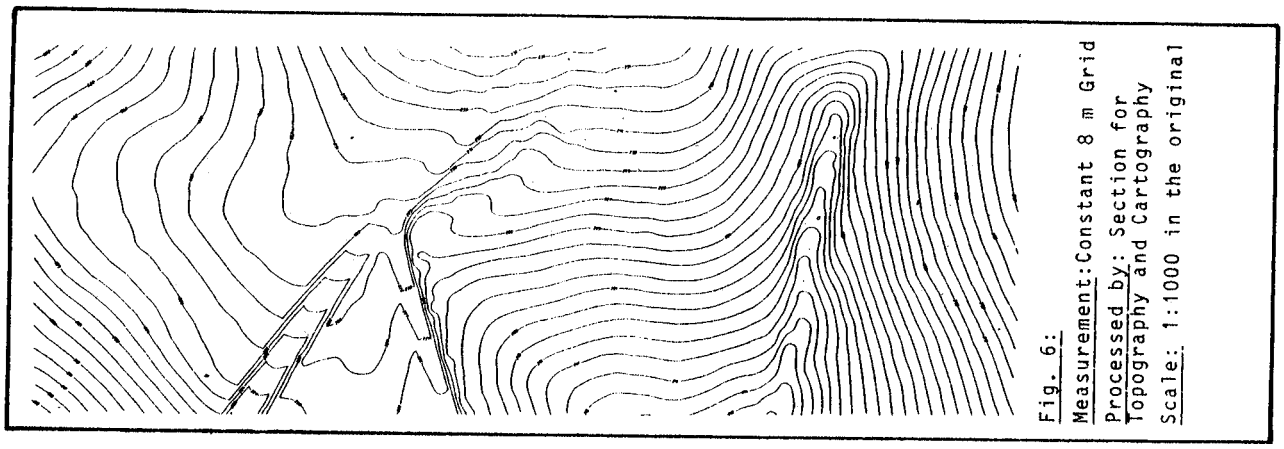

Fig. 6:
Measurement: Constant 8 m Grid
Processed by: Section for Topography and Cartography
Scale: 1:1000 in the original

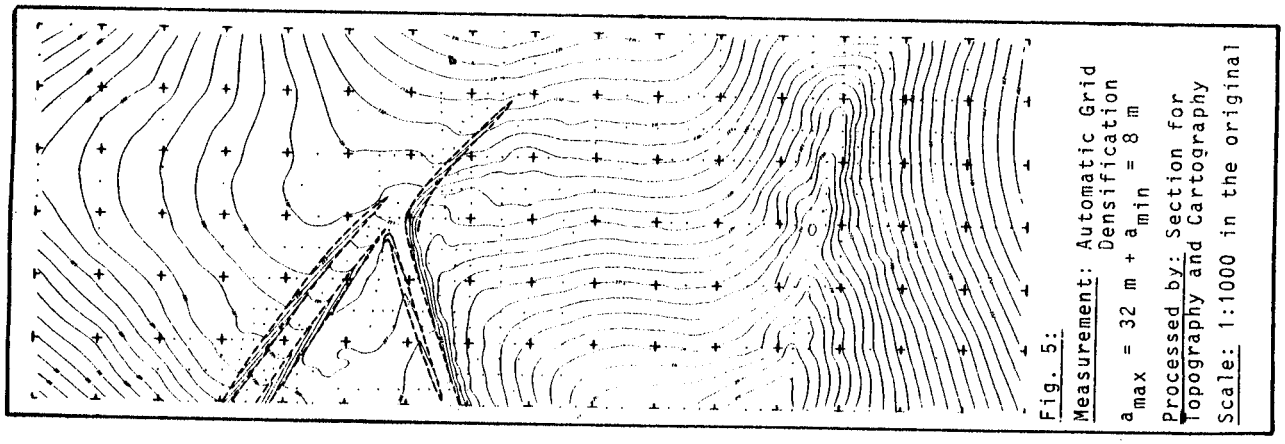

Fig. 5:
Measurement: Automatic Grid Densification
a_{max} = 32 m + a_{min} = 8 m
Processed by: Section for Topography and Cartography
Scale: 1:1000 in the original

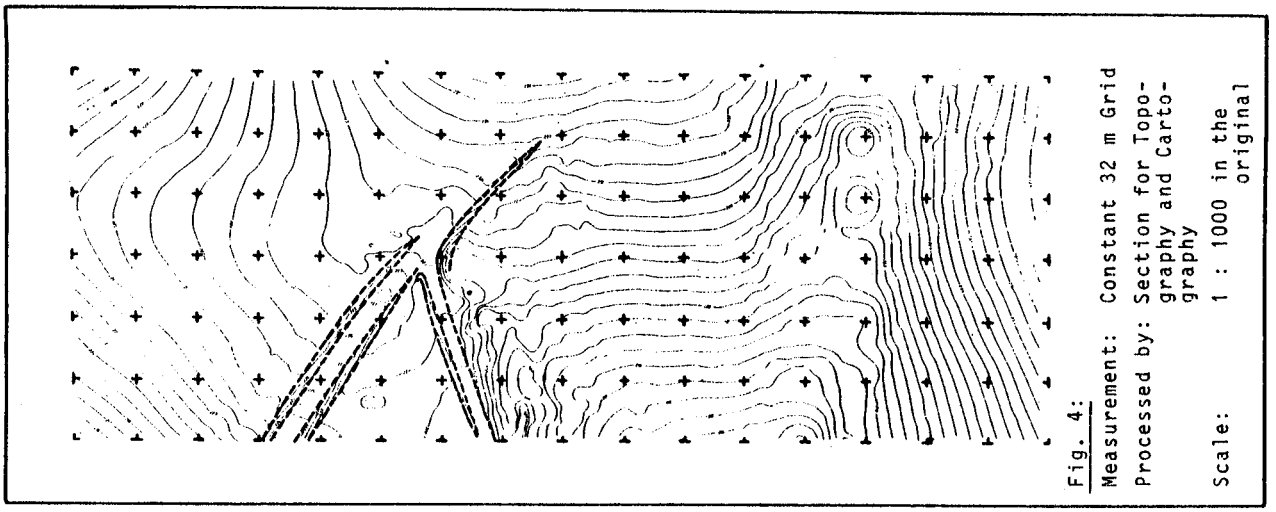

Fig. 4:
Measurement: Constant 32 m Grid
Processed by: Section for Topography and Cartography
Scale: 1 : 1000 in the original

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Abstract

The Planicomp family - characteristics and innovations

The ZEISS-PLANICOMP analytical plotting system has been expanded to a comprehensive system family. Typical configurations are the

C 100 Analytical Plotting Center with versatile measured data processing facilities and computer support for further workstations

C 120 Analytical Plotting System with versatile measured data processing facilities

C 130 Analytical Plotter - a cost-effective single workstation.

The major innovations of the different configurations are:

- Zoom lens in the opto-mechanical viewer
- Use of the new HP 1000 A series of microcomputer models
- Program for simultaneous bundle orientation in particular for closerange and industrial photogrammetry
- Program for DHM measurement by the progressive sampling method
- Data I/O with blocked tapes or DS 1000 computer networks.

These features combined with the separately described extended graphical plotting capability have considerably increased the versatility of the Planicomp system.

Zusammenfassung

Die Planicomp-Familie, Merkmale und Neuerungen

Das Analytische Auswertesystem ZEISS-PLANICOMP wurde zu einer vollständigen System-Familie ausgeweitet. Typische Ausstattungen sind

- C 100 Analytisches Auswertezentrum mit vielseitiger Meßdatenverarbeitung und Rechnerunterstützung für weitere Arbeitsplätze

- C 120 Analytische Auswertestation mit vielseitiger Meßdatenverarbeitung

- C 130 Analytisches Auswertegerät als preisgünstiger Einzel-Arbeitsplatz.

Die wesentlichen Neuerungen der verschiedenen Ausstattungen sind u.a.:

- Zoom-Betrachtung für das optisch-mechanische Grundgerät
- Verwendung der neuen Mikrocomputer-Modelle der HP 1000 A - Serie
- Programm zur einstufigen Bündelorientierung, insbesondere für die Nahbereichs- bzw. Industrie-Photogrammetrie
- Programm zur DHM-Messung nach der Methode des Progressive Sampling
- Daten I/O mittels geblockter Magnetbänder oder DS 1000-Rechnernetzwerken.

Zusammen mit den - getrennt beschriebenen - erweiterten Möglichkeiten im Hinblick auf graphische Auswertung wurde damit die Vielseitigkeit des Planicomp-Systems erheblich erweitert.

Résumé

Système de restitution Planicomp, caracteristique et innovations

Le système analytique PLANICOMP a été développé en une gamme complète d'équipements de stéréorestitution dont les versions typiques sont les suivantes:

C 100, un centre de stéréorestitution analytique avec un traitement de données très performant et l'assistance de l'ordinateur pour des postes de travail satellites

C 120, une station de stéréorestitution analytique avec un traîtment de données très performant

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C 130, un stéréorestituteur analytique comme poste de travail unique et bon marché.

Les principales innovations qui touchent toutes les versions sont les suivantes:

- Optique zoom dans le système d'observation de l'appareil de base opto-mécanique
- Utilisation des plus récents mini-ordinateurs de la série HP 1000 A
- Programme pour l'orientation par la méthode des gerbes perspectives en une seule opération, en particulier pour la photogrammétrie industrielle ou la photogrammétrie à courtes distances
- Programme pour la mesure des modèles de terrain digitaux selon la méthode d'acquisition progressive des données dite "Progressive Sampling"
- L'entrée et la sortie des données au moyen de rubans magnétiques structurés en blocs ou bien d'une configuration d'ordinateurs reliés entre eux par le système de transfert des données DS 1000.

Avec les nouvelles possibilités de restitution graphique qui font l'object d'un exposé à part, ces innovations prennent une part considérable dans l'extension du système de stéréorestitution PLANICOMP.

Resumen

La familia de los Planicomp, características e innovaciones

El sistema analítico de restitución Planicomp ha sido ampliado para formar una completa familia de sistema. Citamos como equipos típicos:

C 100 Centro restituidor analítico que admite el procesamiento versátil de los datos medidos así como el apoyo por computadora de otros instrumentos.

C 120 Estación restituidora analítico que admite el procesamiento versátil de los datos medidos.

C 130 Instrumento restituidor analítico, puesto de trabajo individual, de precio económico.

Las innovaciones esenciales de los varios equipos consisten en:

- Observación zoom con la unidad básica óptico-mecánica
- Utilización de los nuevos modelos de microcomputadora de la serie HP 1000 A
- Programa para la orientación en una sola etapa de haces de rayos, sobre todo para los fines de la fotogrametría a distancia corta y en la industria.
- Programa para la medición de modelos altimétricos digitales según el método del muestreo progresivo.
- Entrada y salida de datos por cintas magnéticas con agrupación por bloques o redes de computadora DS 1000.

De este modo y conjuntamente con las posibilidades ampliadas para la restitución gráfica, descritas por separado, se ha incrementado considerablemente la versatilidad del sistema Planicomp.

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