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INTERACTIVE ACQUISITION AND EDITING OF PHOTOGRAMMETRIC DATA WITH THE ZEISS AS PROGRAM SYSTEM FOR MINICOMPUTERS

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1. Introduction

For many years, electronic computers have had a firm place in general surveying for processing and administrating digital data. Recently, as ever more compact and budget-priced computers have become available, there has been growing interest in using digital techniques and components already for acquiring and editing the information to be measured.

It was above all the pioneering capabilities of the ZEISS PLANICOMP |1| which pointed out the potential of computer support for measurement and direct data checking with the resulting creation of more humane working conditions. Even the use of calculators in conjunction with analog stereoplotters has been very successful. However, the present trend in the development of computers suggests that the compact minicomputer used, for example, in the PLANICOMP will henceforth play the same important role in photogrammetry as in the automation of cartography.

It therefore appeared useful to study the possibilities of on-line connection of minicomputers to conventional photogrammetric plotters (essentially stereoplotters and comparators).

As a result of these considerations, a hardware and software system was conceived, which will be presented in the following. While the hardware consists of ZEISS modules which for many years have been employed for off-line digitization as well as time-tried peripheral units for Hewlett-Packard computers, the ZEISS AS Program System is a completely new development based on experience made in connection with the PLANICOMP.

2. System concept

The guidelines on which the system concept was based today are the outstanding features of the ZEISS AS Program System:

- Software and hardware for acquiring, collecting, checking, editing and storing or output of digital data supplied by mono or stereocomparators and stereoplotters, including the possibility of interactive process control.
- Adaptation of the format of edited data to existing or future processing programs, for instance for block adjustment.
- Data acquisition with the aid of standard ZEISS digitization modules and commercial computer interfaces.
- Communication, that is dialog and display of results, through standard computer terminals.
- Installation and operation without background knowledge (no change of operating system required).
- Program package conceived so that it may be used (as a "byproduct") with real-time operating systems in minicomputers.
- General concept and written in Fortran IV, but designed for computers of the HP-1000 family by Hewlett-Packard.
- Dialog language optionally English, German, Spanish, French or Japanese, change-over from one language to another being possible for users familiar with Fortran.

Additional features which characterize the general efficiency of the system will be mentioned in the description of the hardware and software configurations.

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3. Hardware configuration

A stereoplotter prepared for interactive operation should be equipped for coordinate transfer to the computer and should also have a computer terminal for communication with the computer (Fig. 1).

A connection to the computer is required for coordinate transfer in addition to the linear or shaft encoders for analog-to-digital conversion of the data to be measured and a suitable coordinate-acquisition unit. This connection consists of the computer interface of the coordinate-acquisition unit, a cable and the computer interface proper. Suitable coordinate-acquisition units for ZEISS stereoplotters of the PLANITOP, PLANICART, PLANIMAT and C-8 series as well as for the ZEISS PK-1 Monocomparator |2| are the DIREC electronic interface and control unit |3| and the ECOMAT-12 data-acquisition and transfer system |4|. Either of these allows, among other things, the counting, display and transfer of two or three (or up to four) coordinates, but also the transmission of a switch condition, particularly operation of a suitable foot control. Standard equipment of the units includes a computer interface. The coordinate-acquisition unit for the ZEISS PSK-2 Stereocomparator is the ECOMAT-21 |5| which, among other things, allows the counting (fine and coarse) and display of four coordinates. In conjunction with a special computer interface, this unit can likewise be used for the transmission of coordinates to computers.

DIREC and ECOMAT allow coordinate transfer to a computer by the "handshake" technique, following a fixed transfer schedule with differential or TTL logic via a 16-bit duplex connection with additional control lines. If used with a computer of the HP-1000 series (formerly HP 21 MX), a suitable HP interface has to be inserted into an empty I/O slot in the computer. However, no change of operating system is required.

The computer terminal for interactive operation may, in principle, be any existing or available terminal with an alphanumeric keyboard, which can be connected to be computer used. In view of the dialog volume and to ensure smooth work, a video display terminal with a bit rate of at least 1200 bauds should be chosen. An additional keyboard and programmable keys are very useful. Of the HP terminals, the models 2621 and 2645 are particularly well-suited. Fig. 2 shows a PK-1 Monocomparator equipped for interactive measurement and connected to an HP-1000 computer.

4. Software configuration

Monocomparator (x', y'), stereocomparator (x', y', x", y") and stereoplotter (x, y, z) require a different data structure and different checking and manipulation of the data for interactive measurement. Consequently, three different programs were conceived (PK-AS, PSK-AS and PLANI-AS), whose basic structure is, however, identical.

The programs have overlay character and consist of the main and 10 segments (Fig. 3) as well as the necessary routines. They call for an operating system with file management (RTE II, III or IV in the case of HP), which is capable of handling programs with a length of at least 13 Kwords. The program-internal data area is a local common which after more important changes is written on a so-called "shutdown" file of the plate memory so that tie-in with the last condition is possible when the program is reused at a later date.

The common data area of the AS programs contains parameters referring, among other things, to the plotter, operator, date (for documentation), camera, orientation (for checking and transformation) and measurement process. A coordinate storage for measurement and "reference data" is likewise included, which serves as a buffer memory before final output of checked data on a permanent file of the plate memory or a peripheral (Fig. 4).

The program is controlled by the menu technique. Input of an instruction at the terminal activates a separate operation or a complex process which may also require additional decisions. In either case, the program returns to the menu after the end of the operation and waits for another instruction. The instructions are generally made up of three letters selected by mnemonic criteria.

The menu instructions serve to activate the following basic functions:

- Separate measurement of points and storage in a buffer memory.
- Manipulation of measured points, such as displays, clearing, skipping, renumbering of individual points or printout or clearing of all points of a group.
- Transfer of measured points between buffer memory and a permanent data file of the disk memory or an output unit of the computer periphery.
- Incremental and individual measurement of large numbers of points for a digital planimetric or contour model (only in PLANI-AS for stereoplotters).
- Orientation calculations for checking and determining transformation parameters.
- Manipulation of printout and control parameters.
- Access to permanent data files for subsequent checking or correction of data.

As an example, the following section gives a more detailed description of the instructions of the PK-1AS program for interactive operation with a monocomparator.

5. Efficiency features of PK-1AS software

The efficiency of the PK-1AS program for interactive monocomparator measurement can be illustrated very neatly by describing the menu commands. Fig. 5 gives a summary of available instructions. The following description is based on an equipment system consisting of PK-1, DIREC-1, HP-2645 terminal and HP-1000 computer (see Fig. 2).

PAR Activation of PARAMETER CONTROL mode. Important printout, transformation and control parameters can be checked and varied (such as project data, camera data, etc.). The dialog in this mode corresponds to operation in the PLANICOMP.

STF Activation of INTERIOR ORIENTATION mode with measurement of fiducial marks and calculation of interior orientation to check on measurement and to determine the transformation parameters for correlation of comparator coordinates with centered image coordinates. Possibility of repetition if unacceptable, similar to operation in PLANICOMP.

n Input of a figure n causes measurement of a point by calling of coordinates and storage of measurement under the point number n in the 100-location buffer memory. This instruction is the one most frequently used in practice. Suitable control parameters determine whether the coordinates are transfered during number output or only after additional depression of the foot control, whether a modified point number should be formed with the aid of fixed number components or whether the coordinates read should be assigned a scale factor and subjected to decimal-point shifting.

ROR Activation of RELATIVE ORIENTATION mode for numerical model formation between measurement points of instantaneous photo and a reference photo - generally measured before - with display of residual errors and display and storage of orientation parameters, if accepted.

DPMn
DLMn
SKMn
RNMn$_{\text{old n}_{\text{new}}}$

Instructions for displaying (DISPLAY), deleting (DELETE) and skipping (SKIP) of measured points, giving one or up to 10 point numbers separated by a decimal point, or renumbering (RENUMBER) measurements, giving the old and new numbers. Skipping involves a change in point-number sign so that skipped points (negative point number) cannot be used for checking and storing.

The instructions in the form DPR, DLR, SKR and RNR refer to the reference data (generally measurements made in the preceding photo) or as DP# together with a single register number directly to an address in the point memory. This makes searching for and correcting errors very simple.

LIM
CLM

Instructions for printout of all measurements (LIST) or clearing of all measurements (CLEAR) of the instantaneous photo. The corresponding instructions are LIF/CLF for the fiducial marks of the instantaneous photo, LIR/CLR for the reference data, LIA/CLA for the entire point memory (ALL) and LIJ/CLJ for all job data (JOB).

SAJ

Instruction for storage (SAVE) of the entire record of a photograph on a specified general file: photo number, fiducial marks, image points. Depending on whether comparator coordinates or image coordinates are involved, with optional correction for affine or homogeneous film shrinkage and radially symmetric distortion. The output of model coordinates for the reference picture is likewise possible in the order: model number, perspective centers and model points. In this case, the direct processing and strip adjustment by models (with the C-105 program of PLANICOMP, equivalent to STRIM) or block adjustment (with PATM) is possible. The image (or comparator) coordinates can be applied to the bundle programs available for PLANICOMP or HP-1000 computer. This allows manipulation up to adjustment so that only the final result would have to be output for transfer to other computers or into a data bank.

The instruction SAJ terminates with the conversion of these instantaneous data into reference data for the following photo. If only the photo number and fiducial marks or the model number and perspective centers or only measured image or model points have to be output, the instructions SAF/SAM will be used.

RERn

Instruction for searching a record (only for output in the form of image coordinates) with the photo number n in the general file and reentering it (REENTER) as a reference record. This allows the adjacent photograph from the preceding flight strip to be used for subsequent relative orientation.

REM also allows reentering a record in the instantaneous measurement area so that repeat measurements or supplementary measurements become possible or a relative orientation may be calculated between two adjacent photos measured earlier.

FIL

Activation of GENERAL FILE EDITING mode for searching and manipulating general files regarding header information and data content. The possibilities are here greater than in the PLANICOMP program A 56 and correspond to the GEFIL program. In other words, data transfer between general files and computer periphery is also possible.

NEX

Activation of a series of previously given separate instructions to simplify operation at successful end of a photo.

END

Termination of PK-1 program.

These menu commands can also be triggered by key depression if the computer terminal has programmable keys.

6. Outlook

As is evident, above all of the example of the PK-1, the ZEISS AS Program System for interactive plotting on comparators and stereoplotters will considerably improve digital measurement work. This is largely due to the possibility of directly checking the measured data and to the direct access to other programs available for further processing in the computer system. Errors are detected earlier and their causes rectified more easily so that measurement reliability will increase. This is why interactive measurement techniques are faster even indirectly.

Instantaneous checking gives operators greater security, the access to further processing makes the entire process more transparent. Greater productivity here is not attained at the cost of general working conditions. In fact, the new technique creates more humane working conditions and thus will be received with relief by plotter operators.

The success of interactive software is essentially a function of the handiness and flexibility of program possibilities. The program system described here is based on extensive experience both in the development of software (PLANICOMP) and in photogrammetric problems and practical photogrammetric work. As a result, these programs may be considered as well-proven even today.

In conjunction with the ZEISS PK-1, the AS Program System has been intensively used in practice ever since the beginning of 1979. Experience up to this date is exclusively positive. Even now users would not wish to miss interactive operation. In general, it may be expected that off-line techniques of digital data acquisition in photogrammetry will be a matter of the past within just a few years.

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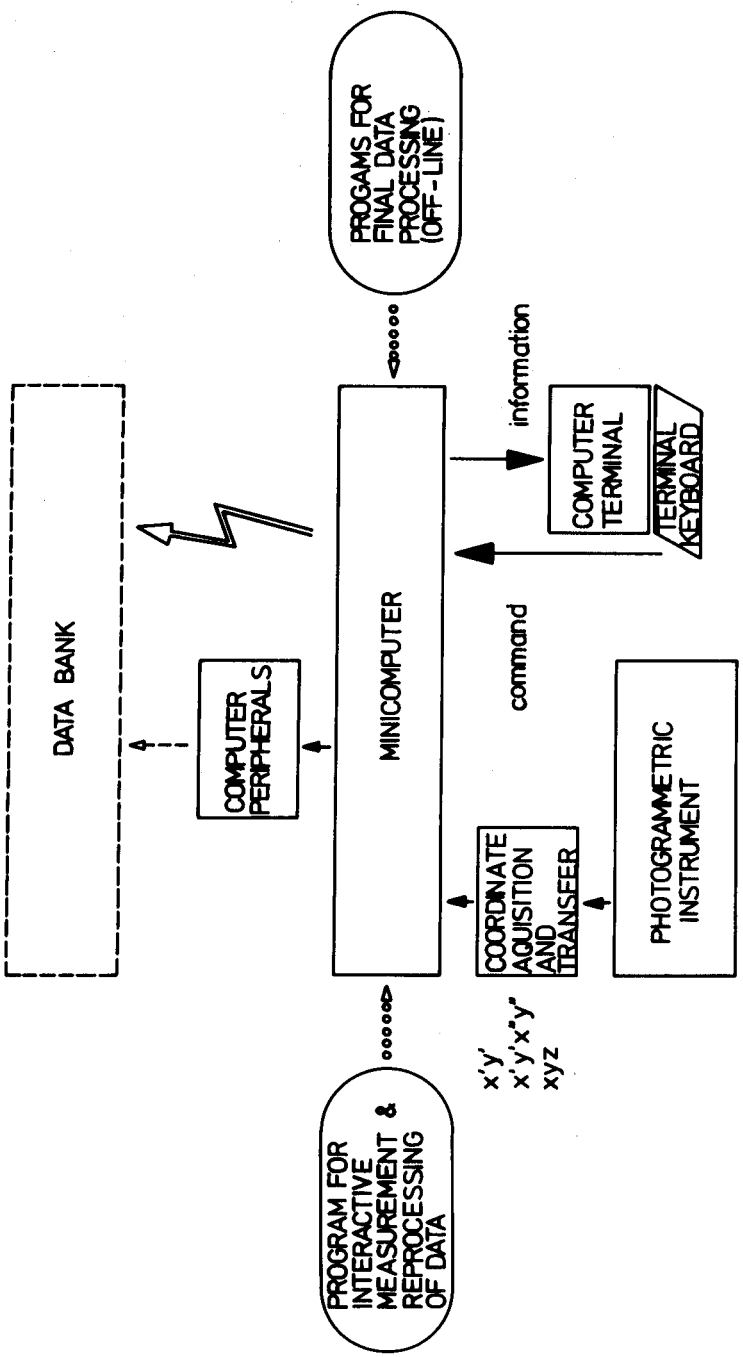

Fig. 1 System configuration for interactive photogrammetric measurement

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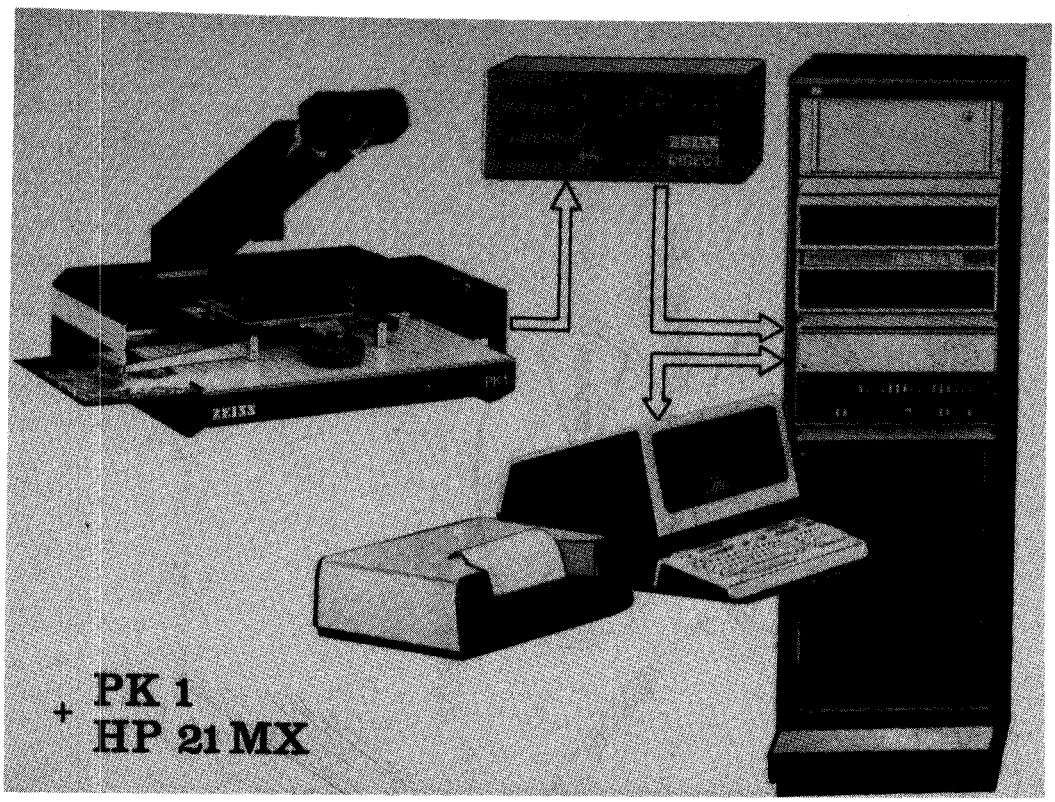

Fig. 2 ZEISS PK-1 Monocomparator connected to an HP-1000 computer for interactive measurement with the PK-1AS Program

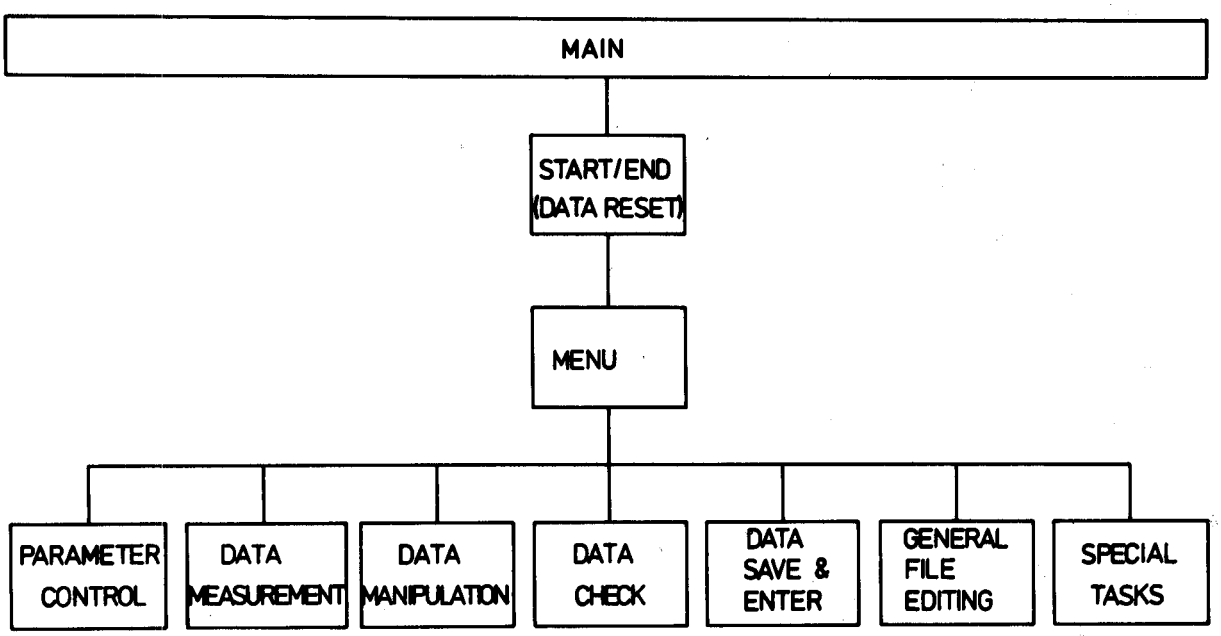

Fig. 3 Structure of ZEISS AS Programs

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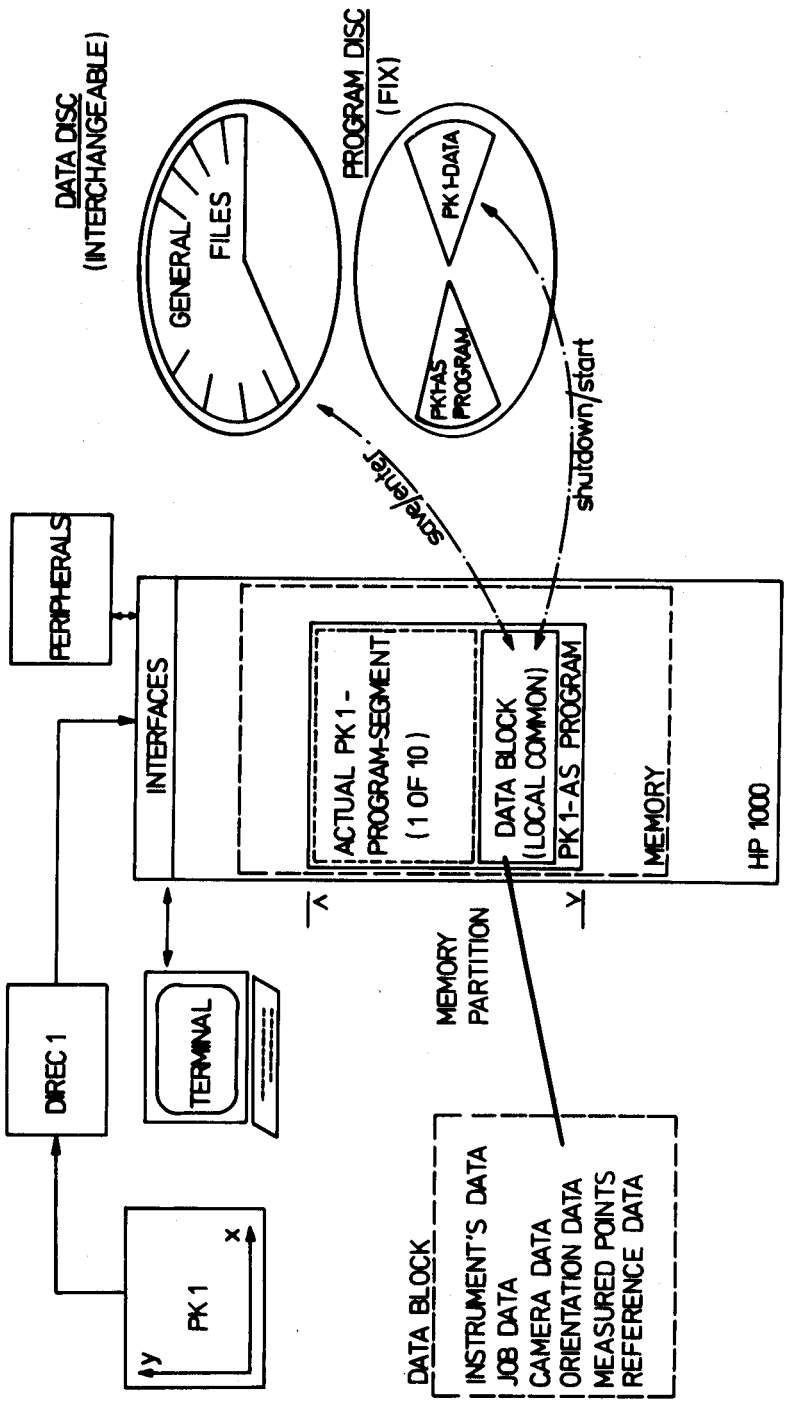

Fig. 4 Use of hardware and software for interactive measurement with the PK-1

PK 1 - MENUE	RAHMENMARKEN FIDUCIALS .. F	MESSUNGEN MEASUREMENTS .. M	REFERENZ REFERENCE .. R	REGISTER REGISTER ..#	ALLE ALL .. A	JOB JOB ..J
STORE ST.	STF	n	---	ST ,reg,n,x,y,stat	---	---
DISPLAY DP.	---	DPM,n_1,n_2..n_{10}	DPR,n_1,n_2..n_{10}	DP# reg	---	---
DELETE DL.	---	DLM,n_1,n_2..n_{10}	DLR,n_1,n_2..n_{10}	DL# reg	---	---
SKIP SK.	---	SKM,n_1,n_2..n_{10}	SKR,n_1,n_2..n_{10}	SK# reg	---	---
RENUMBER RN.	---	RNM,n_{alt},n_{neu}	RNR,n_{alt},n_{neu}	---	---	---
LIST LI.	LIF	LIM	LIR	---	LIA	LIJ
CLEAR CL.	CLF	CLM	CLR	---	CLA	CLJ
SAVE SA.	SAF	SAM	---	---	---	SAJ
REENTER RE.	---	REM$_{reference}$	RER$_{reference}$	---	---	---
RELATIVE ORIENTATION	ROR					
PARAMETER CONTROL		PAR				
EDIT GENERAL FILE			FIL			
END OF PROGRAM			END			
NEXT PHOTO	NEX = LIJ + LIF + LIM + SAJ + CLF + CLM + PAR$_{(NOPH)}$					

Fig. 5 List of menu commands of PK-1AS Program

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Abstract

The CARL ZEISS company of Oberkochen presents the AS Program System for minicomputers, which allows interactive operation during digital measurement in the on-line mode with mono and stereocomparators as well as stereoplotters. Operation is based on the menu technique. By comparison with the off-line technique, interactive operation reduces transfer errors, allows direct checking of measured data by computation and gives direct access to further programs for processing or on files.

Interaktive Erfassung und Aufbereitung photogrammetrischer Daten mit dem ZEISS-AS-Programmsystem für Minicomputer

Zusammenfassung

Die Firma CARL ZEISS, Oberkochen, stellt das Programmsystem AS für Minicomputer vor, das bei digitalen Messungen an on-line angeschlossenen Mono- und Stereokomparatoren und Stereoauswertegeräten eine interaktive Arbeitsweise ermöglicht. Die Handhabung geschieht nach Art der Menütechnik. Im Vergleich zur off line-Technik wurden Übertragungsfehler verringert, eine unmittelbare Kontrolle der gemessenen Daten durch Rechnung möglich und ein direkter Zugriff auf Programme zur Weiterverarbeitung bzw. auf Dateien erreicht.

Résumé

La maison CARL ZEISS, Oberkochen, présente le système de programme AS pour mini-calculateurs qui permet de travailler de façon interactive lors des mesures digitales sur les mono- et stéréocomparateurs et sur les appareils stéréorestituteurs raccordés on-line. La manipulation correspond à la technique dite "au menu". Comparé à la technique off-line, ce mode de travail permet de réduire les erreurs de transfert, d'avoir par calcul un contrôle immédiat des mesures données et de disposer d'un accès direct aux programmes pour le traitement ultérieur, ou bien aux fichiers de mémoire.

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