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THE PLANI-AS PROGRAM FOR COMPUTERIZED ACQUISITION OF PHOTOGRAMMETRIC DATA

D. Hobbie, Oberkochen

1. Introduction

In 1978 ZEISS started the development of software for computerized photogrammetric measurements on comparators and stereoplotters. The "Assisting Software" for use in compact computers (minicomputers) was first supplied in February 1979 in versions designed for interactive measurements on the ZEISS PK-1 Monocomparator. A report on this AS program system was already presented in September 1979 on the occasion of the 37th Photogrammetric Week. That report and the subsequent publication for the ISP Congress in Hamburg in July 1980 were mainly focussed on the performance characteristics of the PK-1 AS Program.

Since 1980 the PLANI-AS program for interactive measurements on conventional analog plotters has also been used in numerous places. Following a brief description of the systems design of the AS software, this publication will therefore mainly detail the varied possibilities of the PLANI-AS Program.

2. Systems design

Every development project begins with a specification of the planned product. This leads to a so-called specification framework outlining the objectives of the project. Together with the essential structural decisions of the next project phase a description is now available that will later be the nucleus of technical product information once the product comes onto the market.

The description then written for the ZEISS AS Program underlines among others the following essential features:

- program package for the HP 1000 computer system designed as an interactive support for photogrammetric measurements on analog plotters and comparators;
- programs are modular, suitable for multi-user operation in real-time operating systems and coded in the higher programming language Fortran IV;
- support of acquisition, editing, logging and checking of the measured coordinates on the one hand and of processing, storage and output of the edited coordinates on the other;
- flexibility as to generation of point numbers, coordinate transformation and output formats;
- access to available and generally accessible data areas as well as to reprocessing programs of the computer system;
- interactive program management by means of a both transparent and easy to handle command structure;
- program information such as execution acknowledgements, error messages or display of results can be used selectively as to language and wealth of details required and can even be modified subsequently by experienced Fortran users;
- interactive communication via standard computer terminals;
- Data acquisition by means of standard ZEISS digitizing modules and commercially available computer interfaces.

3. Hardware configuration

To ensure an interactive measurement operation supported by the HP 1000 computer, the stereoplotter has to be equipped with a system transmitting coordinates to the computer and a computer terminal to command the interactive communication (Fig. 1). The functional steps of coordinate transmission are analog-to-digital conversion, pulse counting, coordinate storage and coordinate transfer. The instrument equipment for the application of the AS program package contains thus the following components:

3.1 Stereoplotter

All ZEISS analog plotters such as the PLANIMAT, the PLANICART and the PLANITOP can be used for the purpose of an interactive measuring operation. In principle, other conventional plotters equipped with encoders are also suitable.

3.2 Analog-digital conversion

While rotational encoders can only be used for spindle-driven motions, linear encoders are also suitable for instruments without x and y guides. In the interest of accuracy and unrestricted freehanded guiding linear encoders, though more expensive, are very recommendable for planimetric digitizing. Using the encoders offered by ZEISS helps to avoid adjustment problems in respect of the ZEISS modules, as well as maintenance problems.

3.3 Pulse counting/Coordinate storage

For coordinate transmission to desktop computers and minicomputers the ZEISS coordinate acquisition and transfer instruments of the DIREC or ECOMAT series are very well suited. Both instruments are, among others, designed for counting, display and byte-serial transfer of x-, y- and z-coordinates as well as for communication of a key status, e.g. in particular actuation of the connected foot switch. The instruments of the DIREC series are partly equipped with a transfer-control logic based on an INTEL microprocessor. For the ECOMAT-12, a corresponding "computer interface" is available as an option, so that even older instruments used up to now for independent recording can be rebuilt.

DIREC-1, the new DIREC-12 expanded as compared with DIREC-1 and ECOMAT-12 differ only in the possibilities of resetting the coordinate counters as well as in some other potentials not utilized by the AS software.

3.4 Coordinate transfer

With DIREC and ECOMAT the transfer of coordinates to the HP 1000 computer is achieved by means of the transfer control just described; in the computer this is done as a rule via a 16-bit duplex interface. Communication takes place byte by byte in the form of ASCII characters according to an established transfer protocol started by "handshaking". According to the computer interface available, maximum allowable cable lengths between DIREC/ECOMAT and the HP 1000 processor are 5 m (HP 12566B) or 150 m (HP 12930A).

With a view to the high data transfer rates, in particular in the case of incremental recording, other interface standards such as RS 232 C (also called V 24 in the German-speaking countries) with a cable length of up to 15 m or the so-called 20 mA current loop are not feasible.

3.5 Computer terminal

In principle any terminal with an alphanumerical keyboard, which is already available or connectable to the HP 1000 system, can be used for interactive communication. In order to obtain a smooth operation and with a view to the amount of interactive work to be done, the CRT terminal selected ought to have a minimum transmission speed of 2,400 baud (about 240 characters/sec). An additional numerical keyboard (for input of point numbers) and programmable keys (for allocation of the most common commands) are of advantage. Among the HP terminals of the

model series HP 262x and HP 264x, suitable models are 2622 and 2645 as well as, if "graphic logging" as explained below is used, graphic terminals 2623 and 2648. Fig. 2 shows the simple printing terminal HP 2621 P together with the ZEISS PLANITOP F-3 equipped with x and y linear pulse transducers.

4. Software configuration

The PLANI-AS Program is written in Fortran IV overlay structure and consists at present of 15 segments. It utilizes numerous subroutines of the ZEISS program library started together with the development of PLANICOMP. As internal data area of the program a local common is used, which - after major changes - is written each time on a so-called "shutdown file" of the disk storage to permit going on from what had been the last status in the event of later utilization of the program.

The PLANI-AS common data area contains parameters or storage locations describing among others:

- Working station:	Type/number of instrument, operator, date, calibration parameters
- Input-output:	Addresses, type of transformation, output formats, language extent of interactive communication
- Project:	Model designation, units of measure, scales, area boundaries
- Stereomodel:	Photo numbers, orientation parameters, setting data
- Measurements process:	Generation of point numbers, incremental parameters, use of footswitch
- Point storage:	Measurements for orientation etc., control points

PLANI-AS can be operated in an HP 1000 computer under an RTE-4 real-time operating system provided the memory can be expanded up to a partition of at least 18 K words length. Though the program has to be loaded only once, it can be utilized by several users at a time, if several working stations are available. If the program is called in from a terminal, a work copy of the master program is made in each case. The unambiguous allocation to the current status results from the assignment of different "shutdown files" (e.g. besides FIL090 also FIL091 etc.) to the individual operators or working stations as well as from the designation of the corresponding file number (e.g. 91) when PLANI-AS is called in. Availability of several PLANI-AS working stations on an HP 1000 computer helps to save disk storage capacity and to simplify possible program improvements, as in idle condition the program is stored only once in the computer.

The PLANI-AS Program is controlled interactively via the computer terminal by means of commands consisting of alphanumeric characters, in some measuring steps in addition by operating the footswitch of the DIREC or the ECOMAT. As a rule, the instructions consist of three letters selected with mnemonic considerations in mind. By definition certain numerical entries (e.g. point numbers) can be added to some instructions. Input of the command triggers an individual measure or starts a more complex process, that may also require additional decisions (yes/no) or actions (footswitch actuation, once or repeatedly). Execution acknowledgements, error messages and printouts of results are given in one of four standard languages (English, German, French, Spanish). The selection of language and wealth of details is made by a control parameter. A user with a good knowledge of Fortran can also change the interactive texts of PLANI-AS subsequently, e.g. adding other languages.

Once an instruction is executed, the program will always request for another command to be input. Frequently occurring instruction sequences can be combined into a collective command in the form of programmable macro-instructions.

5. Performance characteristics of the PLANI-AS

Together with numerous control parameters the present set of about 70 instructions supports an extremely vast selection of measures connected with photogrammetric surveys (Fig. 3). The following summarized description sketches in a few words the current range of capacity of PLANI-AS:

- individual point measurements and storage in a buffer (by immediate input of a point number instead of an instruction);
- manipulation of measured points, such as display (DISPLAY), deletion (DELETE), blocking (SKIP), renumbering (RENUMBER) of individual points or listing (LIST) or clearing (CLEAR) of all points in the buffer;
- transfer of the measured points or of the reference data to a general file (SAVE) or vice versa (REENTER);
- in the above instructions the third letter of the instruction indicates the group of points the instruction refers to (e.g. M for measurements, R for reference data (control points), A for M + R, F for perspective centres when independent models are measured in the aerotriangulation, J for job-specific information contained in the work protocol;
- calculation of absolute orientation (AOR) by means of an adjustment with a maximum of 36 points, if need be also as a purely horizontal scaling to the control points or levelling as well as calculation of set values;
- individual (RECORD) or incremental (INCREMENT) recording of a large number of points for a digital elevation or situation model with time, path, coordinates or curvature as increments triggering a recording as well as restriction of the area at user's option;
- for individual measurements and recordings flexible generation of point numbers on the basis of fixed and variable fractions, in the case of a recording being made automatic ahead numbering as well as either graphic logging (TRACE) on a graphic CRT or on a plotter connected via an HP-IB interface;
- real-time display of measuring mark position (POSITION) in ground coordinates on the CRT, with TRACE also graphically by means of the position of the cursor or the plotting tool or display of the deviation from a set nominal position in instrument coordinates, i.e. in millimeters (MOVE TO);
- measurement of derived geometric values such as the centre of gravity or the geometric mean (AVERAGE), oblique, horizontal or vertical distances (DISTANCE S, DISTANCE X, DISTANCE Z), random, e.g. curved lines (LENGTH), areas (AREA) and volumes (VOLUME);
- manipulation of logging, transformation and control parameters (PARAMETER CONTROL);
- access to permanent data files of the general file type for subsequent screening or correction of data or output for or input from peripheral units (FILE EDIT);
- measurement of the perspective centres (STF) by adjusting resection by means of measured photocarrier crosses or by bringing the mechanical guide rods into a vertical position;
- calibration of the planimetric coordinates of the plotting instrument followed by continuous real-time correction by means of a grid measurement with adjusting affine transformation (CALIBRATION);
- utilization of the programmed macro-instructions (NEXT, CONTINUE);
- loading of prepared occupancies of the programmable terminal keys - the so-called soft keys -, thus creating menues (MENUES);
- call-in of system commands as well as independant computer functions and programs from the PLANI-AS Program (SYSTEM COMMAND);

6. Repercussions

The possibilities described above generate photogrammetric data, the structure of which corresponds to the other components supplied by ZEISS for HP 1000 computer systems. This ensures a high degree of comparability with

- the measuring procedures of the PLANICOMP C-100,
- the data base structure, i.e. general files of the C-100,
- the adjustment programs for the field of aerotriangulation (PAT-M, PAT-B) developed at Stuttgart University,
- the transformation programs for the field of digital elevation models (HIFI-P, HIFI-C, HIFI-S) of Munich Technical University,
- the ZEISS Z-2 Analytical Orthoprojector.

As the components mentioned above are widely used by now and as many users dispose of a software of their own, the user programs developed so far are frequently compatible (e.g. the programs of the Universities of Hanover and of Bonn and of the State Topographic Survey Office at Bonn-Bad Godesberg).

The PLANI-AS Program (as well as the PK-1-AS Program) will considerably improve the digital measuring procedures available in photogrammetry. Of prime importance in that respect is the possibility to immediately check the measured data and to give the plotter operator direct access to other programs available in the computer system for further processing. Errors are detected earlier, their causes can be revealed easier, so that measurements become more reliable. Interactive measuring systems are thus faster both directly and indirectly.

The immediate check gives the operator more safety, the possibility of further processing gives him a better insight into the whole operation. The increase in productivity thus achieved does therefore not lead to a worsening of working conditions, contrary to what mostly happens in industry. With a view to the call for a more humane working environment so frequently to be heard nowadays, the situation of the photogrammetric plotter operator is thus really improved.

The success of an interactive software is mainly founded on the manageableness, the flexibility and the transparency of the programmed possibilities. The available program system is based on extensive experience in the fields of software development (PLANICOMP), theoretical photogrammetry and pratical work. The program thus developed can therefore already now be considered mature.

The AS program system has been used intensively in practical work - already since the beginning of 1979 on the ZEISS PK-1 and since the middle of 1980 on analog stereoplotters. Users can no longer imagine themselves working without interactive communication. It can be assumed that only a few years hence off-line methods of digital data acquisition will be a matter of the past.

Abstract

The PLANI-AS Program is a program for interactive support of photogrammetric measurements on analog plotters. This modular program was written in FORTRAN 4 for use on HP 1000 computer systems and has been in practical application for about one and a half years.

PLANI-AS can be used on any stereoplotter equipped with ZEISS linear or rotational encoders (e.g. PLANIMAT, PLANICART, PLANITOP) which is connected to an HP 1000 computer via a ZEISS coordinate acquisition and interface unit of the DIREC or ECOMAT type and to which a computer terminal is allocated for interactive control.

The various possibilities of PLANI-AS are called in by means of mnemonically structured three-character commands. Each time the program confirms execution and displays the results, if necessary. For all printouts the language (English, German, French, Spanish) and the wealth of detail can be selected and can even be modified by users having a sufficient knowledge of programming.

The current set of about 70 instructions support the following operations:

- acquisition, gathering, checking, editing, storage and output of x, y and z measurements;
- flexible generation of point numbers on the basis of fixed and variable fractions;
- measurements in the ground coordinate system;
- absolute orientation including control point management and calculation of set values;
- individual and incremental recording of large numbers of points;
- measurement of derived geometric values, such as lengths, angles, areas and volumes;
- "graphic logging" of measurements;
- measurements of perspective centres by means of resection or by bringing the mechanical guide rods into a vertical position;
- instrument calibration.

This gives full support to measurements of aerotriangulations and digital elevation models. Thus the connection to an HP 1000 system gives the operator also access to all existing background programs for further processing, such as PAT-M, HIFI, etc.

Das Programmpaket PLANI-AS zur rechnergestützten photogrammetrischen Datenerfassung

Zusammenfassung

Das Programm PLANI-AS ist ein Programm zur interaktiven Unterstützung von photogrammetrischen Messungen an Analogauswertegeräten. Das modular aufgebaute Programm wurde in FORTRAN 4 für die Verwendung auf HP 1000-Computersystemen geschrieben und steht seit ca. 1 1/2 Jahren im praktischen Einsatz.

PLANI-AS kann an jedem, mit Linear- oder Rotationsimpulsgebern von ZEISS ausgestattetem Stereoauswertegerät (z.B. PLANIMAT, PLANICART, PLANITOP) eingesetzt werden, welches mittels eines ZEISS-Koordinatenerfassungs- und Interfacegerätes vom Typ DIREC oder ECOMAT an einen HP 1000-Rechner angeschlossen ist und dem ein Rechner-Terminal zur Dialogsteuerung zugeordnet ist.

Die verschiedenen Möglichkeiten des PLANI-AS werden mit Hilfe von aus jeweils 3 Zeichen bestehenden, nach mnemotechnischen Gesichtspunkten gebildeten Kommandos aufgerufen. Vom Programm wird die Ausführung jeweils bestätigt,und gegebenenfalls werden Ergebnisse angezeigt. Alle Textausgaben sind hinsichtlich Sprache (englisch, deutsch, französisch, spanisch) und Ausführlichkeit wählbar und vom Benutzer mit Programmierkenntnissen gegebenenfalls veränderbar.

Der zur Zeit ca. 70 Befehle umfassende Instruktionsvorrat unterstützt:

- Erfassung, Sammlung, Prüfung, Aufbereitung, Abspeicherung, Ausgabe von x-, y-, z-Messungen;
- flexible Punktnummernbildung aus variablen und festen Anteilen;
- Messen im Gelände-Koordinatensystem;
- absolute Orientierung einschließlich Paßpunktverwaltung und Berechnung von Einstelldaten;
- individuelle und inkrementelle Registrierung großer Punktmengen;

- Messung abgeleiteter geometrischer Größen wie Längen, Winkel, Flächen- und Rauminhalte;
- "graphische Protokollierung" von Messungen;
- Messung der Projektionszentren mittels Rückwärtseinschnitt oder Senkrechtstellen der mechanischen Raumlenker;
- Gerätekalibrierung.

Damit werden die Arbeitsbereiche Aerotriangulationsmessung und DHM-Messung voll unterstützt. Wegen des Anschlusses an ein HP 1000-System hat der Auswerter damit auch Zugang zu allen vorhandenen Hintergrund-Programmen zur Weiterverarbeitung, wie z.B. PAT-M, HIFI, etc.

Système de programmes PLANI-AS de saisie des données photogrammétriques assistée par ordinateur

Résumé

Le programme PLANI-AS est prévu pour l'assistance interactive de mesures photogrammétriques sur des appareils restituteurs analogiques. Le programme à structure modulaire a été écrit en FORTRAN IV pour l'emploi sur des systèmes d'ordinateur HP 1000. Il est utilisé depuis un an et demi environ.

PLANI-AS peut être mis en service sur chaque appareil stéréorestituteur équipé de générateurs d'impulsions linéaires ou d'impulsions de rotation (p.e. PLANIMAT, PLANICART, PLANITOP); cet appareil stéréorestituteur est raccordé à un ordinateur HP 1000 par l'intermédiaire d'un appareil de saisie des coordonnées avec interface du type DIREC ou ECOMAT; un terminal pour le dialogue avec l'ordinateur lui est assigné.

Les différentes possibilités du PLANI-AS sont appelées à l'aide d'instructions qui sont constituées par 3 caractères et qui se composent d'après des points de vue mnémotechniques. Le programme confirme chaque exécution d'une opération de calcul et les résultats sont affichés le cas échéant. La sortie de tous les textes relative au langage (anglais, allemand, français, espagnol) et à l'étendue des indications s'effectue au choix; elle peut être changée par l'utilisateur avec des connaissances de programmation.

Le stock d'instructions comprend actuellement environ 70 ordres, à savoir:

- la saisie, le collationnement, le contrôle, l'élaboration, la mise en mémoire et la sortie des mesures x, y, z;
- l'entrée flexible de numéros de points à partir de parties variables et fixes;
- la mesure dans le système des coordonnées-terrain;
- l'orientation absolue y compris la gestion des points de contrôle et le calcul des données de réglage;
- l'enregistrement individuel et incrémental d'une grande quantité de points;
- la mesure de grandeurs géométriques dérivées telles que longueurs, angles, superficies et volumes;
- la représentation graphique de mesures;
- la mesure des centres de projection par intersection spatiale ou par mise à la verticale des guides mécaniques;
- le calibrage de l'appareil.

Ainsi la mesure de l'aérotriangulation et la mesure DHM sont soutenues par l'ordinateur. En raison du raccordement à un système HP 1000, l'opérateur acquiert l'accès à tous les programmes "background" pour le traitement ultérieur, tels que PAT-M, HIFI, etc.

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El paquete de programas PLANI-AS destinado a la recopilación de datos fotogramétricos, apoyada por computadora

Resumen

El programa PLANI-AS sirve para el apoyo interactivo de mediciones fotogramétricas en restituidores analógicos. El programa de tipo modular ha sido escrito en FORTRAN 4, para ponerlo en ejecución en sistemas de computadora HP 1000 y se lo utiliza prácticamente desde hace aprox. año y medio.

El programa PLANI-AS puede emplearse con cualquier estereorrestituidor provisto de generadores de impulsos lineales o rotatorios de ZEISS (p.ej. PLANIMAT, PLANICART, PLANITOP) que está conectado a un minicomputador HP 1000 por un instrumento de recopilación de coordenadas y de interface ZEISS del tipo DIREC ó ECOMAT y al cual está coordinado un terminal para el mando por diálogo.

Las varias posibilidades que ofrece el PLANI-AS se llaman con ayuda de instrucciones de tres caracteres, compuestos de acuerdo con conceptos nemotécnicos. El programa confirma cada vez la ejecución de la instrucción y, si se lo desea, se indican los resultados. En cuanto a la salida de textos, puede elégirse el idioma (inglés, alemán, español, francés) o la amplitud de los mismos, asimismo y si hace falta, podrán ser modificados por el usuario que dispone de conocimientos de programación.

Actualmente, existen 70 instrucciones que apoyan:

- Las recopilación, compilación, comprobación, preparación, memorización y salida de medidas x, y, z;
- la formación flexible de números de puntos con ayuda de elementos variables y fijos;
- la medición en el sistema de coordenadas terreno;
- la orientación absoluta inclusive la gestión de los puntos de apoyo y cálculo de datos de ajuste;
- el registro individual e incremental de grandes cantidades de puntos;
- la determinación de magnitudes geométricas derivadas tales como longitudes, ángulos, áreas y volúmenes;
- la representación gráfica de mediciones;
- la medición de centros de proyección por resección inversa o puesta vertical de las barras-guía espaciales mecánicas;
- el calibrado de los instrumentos.

De este modo, se apoyan totalmente los sectores de trabajo "medición de aerotriangulación" y "medición de modelos digitales de terreno". Gracias a la conexión a un sistema HP 1000, la persona que efectúe la restitución tiene acceso a todos los programas de fondo de proceso ulterior, tales como PAT-M, HIFI, etc.

Dr.-Ing. D. Hobbie, Messrs. CARL ZEISS, Abt. V-PE,
Postfach 13 69/13 80, D-7082 Oberkochen, West Germany

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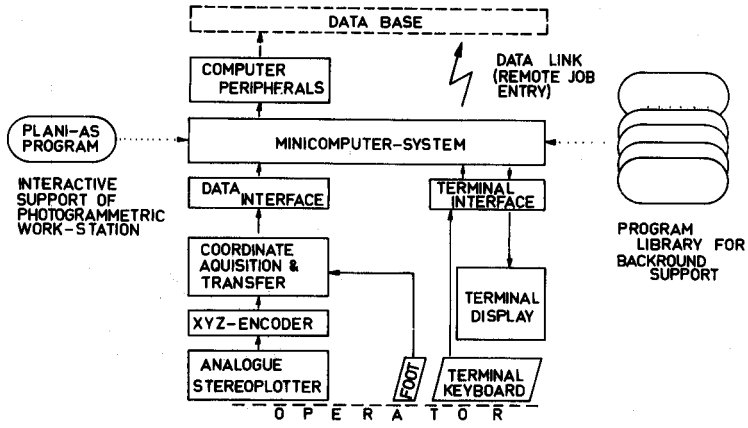

Fig. 1: System configuration for interactive photogrammetric measurements

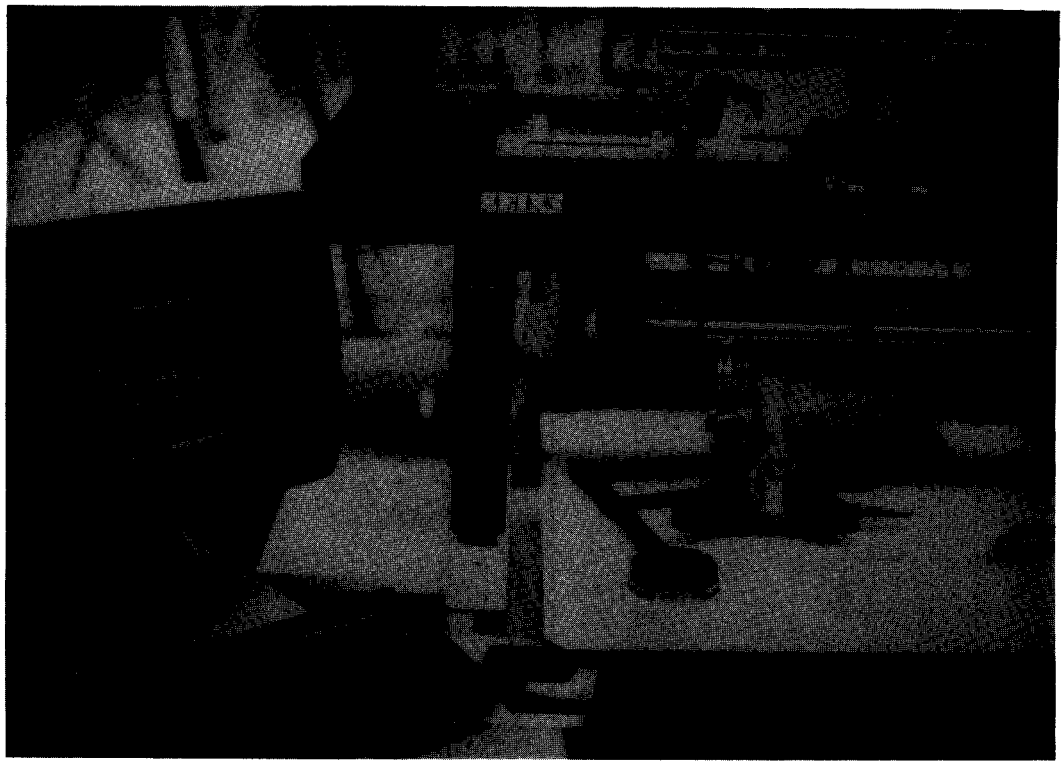

Fig. 2: Interactive photogrammetric working station consisting of ZEISS F-3 PLANITOP with linear x-, y-encoders and HP 2621 P printing terminal

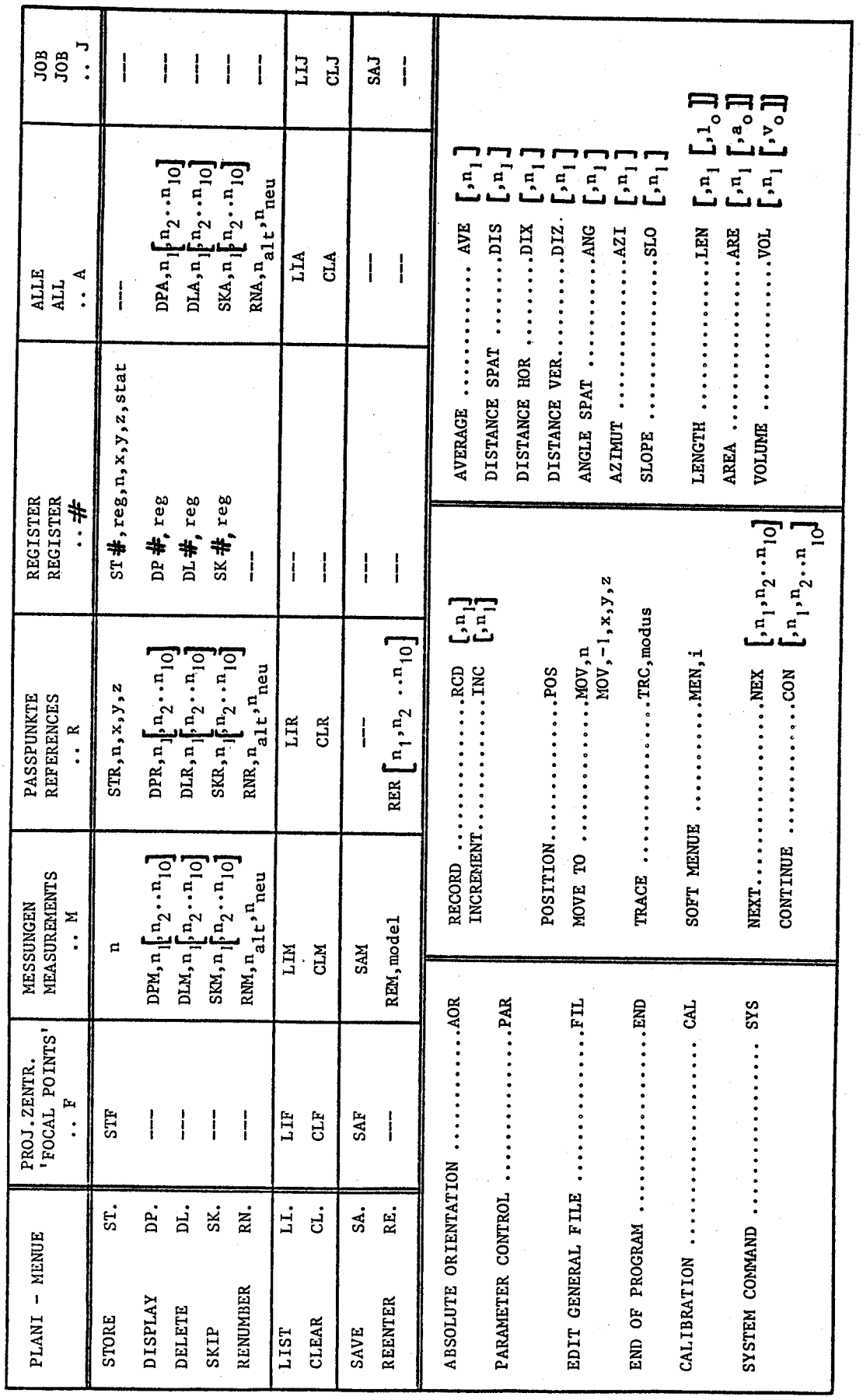

Fig. 3: The instructions of the ZEISS PLANI-AS program