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ASPECTS OF SYSTEM TECHNOLOGY IN PHOTOGRAMMETRIC PLOTTERS

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1. Introduction

The introduction of the application-oriented analytical Planicomp in 1976 marks the start of a new era in the construction of photogrammetric instruments: the analog stereoplotters are replaced by analytical plotting systems. Whereas it has been possible to produce and supply analog plotters to customers in a practically unchanged design over a prolonged period of time, analytical systems have been subject to continuous modification. This is the result of the progress made in the computer sector, further development of software, new graphical components, and the high adaptability to a wide range of applications and working conditions. Manufacturers and users of the equipment have to meet this challenge by planning ahead and by developing new working methods in order to make full use of the technical capabilities on hand. At the same time, the analytical plotting principle has provided the opportunity of extensive integration of photogrammetry and cartography.

2. Demands to be met by a Photogrammetric Plotting System

The following demands must be made on a modern photogrammetric plotting system for the production of numeric and geometric data and of photomaps:

a) High level of integration, i. e. all hardware and software components employed in the system must be interrelated, all existing data must be compatible and suitable for use in different instruments and for different purpose.

Example: Direct use of aerotriangulation data for orientation in analytical plotters, analog instruments and orthoprojectors;

use of DEM data for contour line plotting and orthoprojector control.

The integration is considerably promoted by fast and reliable data transfer through computer coupling.

b) Subdivision into task-specific work stations and universal central stations.

Example: Acquisition of digital mapping information on several 2-D or 3-D stations; collection, management and output to the central station.

This work station concept increases the flexibility and accurancy of production.

c) Autonomous processing of the data generated in the system, due to high computer performance and optimized software.

Example: Batch and background execution of programs for aerotriangulation, DEM and off-line mapping.

d) Wide range of hardware components available, due to universal operating systems and flexible software for data acquisition and the support of graphical output units.

Example: Use of different processors, mass storages, terminals, plotters and precision tracing tables; use of analytical plotters, analog instruments and digitizing instruments in one and the same plotting system.

e) Optimization of the operational sequence in the individual procedures, due to simple and uniform operation and the use of sophisticated technology.

Example: Input of commands on the command panel; on-line checking of graphical data acquisition by dynamic superimposition (VIDEOMAP).

f) Open interface for systems from other manufacturers and for reformatting the data.

Example: Transmission of PLANIMAP data to the Intergraph IGS system.

g) System continuity by continued, systematic development of the software, with allowance made for the future usability of existing high-grade hardware.

Example: PLANIMAP digital mapping system in conjunction with existing computer and plotters.

3. System Components

Differentiated system modules are a prerequisite for high flexibility and adaptability to the tasks on hand, funds available and working conditions. The acquisition, processing and output components offered by Zeiss are listed in the following tables.

3.1 Hardware (Tab. 1)

a) Measuring Instruments

For numeric and graphical tasks, existing analog plotters can be integrated into a plotting system. For the purchase of new measuring instruments, the general rule is that the new low-cost analytical plotters (C 130 Planicomp) are less expensive than new computer-supported analog instruments.
Another important new component is a flat digitizing table.

b) Computers

The differences between the computer CPUs are the processors, memory capacity (from 515 kB), firmware equipment and number of slots for interfaces. An overview of the different computing times of HP processors, using the example of aerotriangulation (PAT-M), test block, computing time per model in normal operation) is given in Tab. 2, with the addition of the data of further common types of computer. These data, however, can only be regarded as approximate values for pure computation procedures. Zeiss prefers to use the low-priced micro versions (Micro 26, 27, 29) where only a limited number of interfaces can be connected.

The wide range of central units and peripherals has proved helpful and necessary for an optimum system configuration. In particular, it enables the construction of attractively priced work stations and of powerful central stations. For external data storage and data transmission within the HP 1000 A systems, mention should also be made of the magnetic tape with CS 80 backup cartridge (64 MB) for low-priced mass storage normally included in the Zeiss systems.

c) Graphical Output Instruments

The first group of graphical output instruments (VIDEOMAP, drum plotter, graphical terminal) is designed primarily for on-line and off-line test plotting. The particularly powerful VIDEOMAP system for dynamic superimposition may be considered as the instrument of the future for controlled graphical data acquisition.

The precision tracing tables DZ 7, PLANITAB T 110 and T 102 are mainly used for the compilation of the final high-quality maps. As a result of its high throughput, the PLANITAB T 102 is excellently suited as a "central automatic mapping instrument".

d) Interfaces

Of particular importance for the operability of the systems is the fourth hardware group: the interfaces. Plotters, computer peripherals and graphical output instruments require specific interfaces which must be supported by the relevant driver in the computer operating system.

These interfaces are normally defined by technical requirements and cannot be selected by the user. By using multi-channel interfaces, Zeiss endeavers to keep the hardware costs as low as possible while compensating for the limited number of slots. Therefore some instruments are connected via an IEC interface (HP-IB), others via an 8-channel multiplexer. Deviations from this standard have purely technical reasons. The user has to make sure that the length of the cables connecting the instruments is such that it guarantees reliable operation. For longer cables, special devices, e. g. HP-IB extenders, must be used. These requirements must be taken into account by the user when planning the installation layout.

In addition to ensuring technical operability, interfaces are gaining increasing importance in data transfer within a system and from one system to another. In LINK 1000 (HP to HP computer) and CONNECT (HP to host computer) the computer coupling hardware consists of the IEC and multiplexer standard interfaces. Data compatibility is dealt with in detail in reference /2/.

3.2 Computer Operating Systems (Tab. 3)

In addition to the hardware, the computer manufacturer supplies a primary operating system with a comprehensive set of modules (e. g. driver, loader, editor etc.). This operating system cannot be run for the specific control of the instrument. It is the job of the instrument and systems manufacturer to generate an instrument operating system on the basis of the primary system modules and his own modules (e. g. LOOP drivers), permitting the control of the complete equipment and further useful applications in multi-user operation.

For Planicomp and Orthocomp standard Zeiss operating systems are available as described in greater detail in section 4, using the example of the RTE A operating system for Planicomp. Besides the control modules for Zeiss instruments, a standard system primarily includes modules for computer peripherals of general interest.Differing systems where, for example, the DS 1000 computer network system or digital image processing for correlation are incorporated, are called special operating systems and must be generated individually, involving a high level of work and expenditure.

For Planicomp alone, for example, Zeiss currently offers

in RTE 4B, revision 2040	4 standard systems 19 special systems
in RTE A.1, revisons 2213, 2203	3 standard systems 15 special systems and
in RTE A, revision 2429	5 standard systems.

which adds up to a total of 46 different Planicomp operating systems.It is evident that the generation, management and updating of operating systems are extremely work-intensive. Computer operating systems are not free from errors. This is one of the reasons why the computer manufacturer issues revisions at regular intervals. It is the policy of Zeiss to introduce new revisions or new modules for CZ systems only if technically necessary or if considerable advantages are expected. The number of operating systems stated above is proof of the efforts made by Zeiss to find a balance between cost-effectiveness, technical progress and the specific interests of the costumers.

3.3 Software (Tab. 4)

The software is of vital importance in modern analytical plotting systems. Apart from the programs for direct instrument control, the application software for preparation, measurement support and further processing is critical for the performance of the entire system. The example of the analytical plotter illustrates how a program for real-time control of the AP photo carriage has been developed into a comprehensive software package for the photogrammetric collection and processing of numeric and graphical data.

Table 4 gives a survey of the 32 software products currently offered by Zeiss. Most of them are available in RTE 4B,RTE A.1 and RTE A which means that Zeiss has to service, manage and deliver approx. 90 different program packages. Zeiss therefore considers itself as one of the biggest software suppliers on the photogrammetric market. Assuming an average of one program revision per year, and considering that part of the previous versions must remain available, and that software must be supplied on different data media (magnetic tape, cartridge, plotter, microfloppy disk), it is quite obvious that software filing, preparation, delivery and installation require their own specific logistics. It also goes without saying that receiving precise information from the user considerably facilitates the updating of the software by Zeiss.

4. RTE A Operating Systems for Planicomp

It was only after its revision in early 1985 that the RTE A operating system introduced by Hewlett Packard in spring 1984 became suitable for error-free operation of the Planicomp. The RTE A Planicomp operating system now available allows full utilization of the advantages offered by RTE A, such as

Virtual Memory, Virtual code and Fortran 77,

in particular for the software development and for multi-using. As a result of the different processors, 3 operating systems are initially required which, when used with or without VC+ (virtual code) and with or without connection of the system console to an existing multiplexer, may add up to 27 a total of operating systems. In view of the simple background operation of A 600, the multi-user operation of A 900, and the increased operational reliability if the system console is connected with its own terminal interface, four standard systems have been created:

A 600 without VC+
A 700 with or without VC+
A 900 with VC+.

The structure of all standard operating systems with regard to interfaces and connecting options is shown in Table 5. The IEC interfaces and the multiplexer permit the simultaneous connection of more than one unit.

This enables the Planicomp operating system to control the wide range of computer peripherals and measuring and output instruments, the necessity of which was outlined in 2 d). The performance of the central unit (processor, memory, floating point processor, VC+) must, of course, be reasonable proportionate to the extent of peripheral equipment used. It is remarkable that one and the same system configuration can be employed, in spite of the pronounced variation in the computer performance - from the simple work station computer right up to the complexity of the computer center.

5. Examples for Zeiss Plotting Systems

According to the tasks to be performed, the system components described here can be combined to form complete plotting systems for

aerotriangulation/numeric point measurement
digital mapping and
orthoprojection.

In the following, a brief description is given for the Planicomp configurations and systems for digital mapping as examples.

5.1 Planicomp Systems

In accordance with reference /3/, the standard Planicomp systems comprise

C 140 Planicomp analytical plotter
C 130 Planicomp analytical plotter
C 120 Planicomp analytical plotting station and
C 110 Planicomp analytical plotting system.

The data of the viewers, computers, operating systems and software packages are listed in Tab. 6. The standard configurations - which include the standard computer equipment - can be prefabricated and thus offered at an economy price. Special versions for specific requirements are available, as shown in Tab. 6. Although they are technically more complex, they may present the most cost-effective solution in these specific cases.

5.2 Digital Mapping

The basic possibilities of digital mapping are shown in Fig. 1 and described in detail in reference /4/. As practical examples, an explanation is given here of two systems

Planicomp with HP 1000/A 900 and
E 3 Planicart with HP 1000/A 700

(Figs. 2 and 3).

The controlled acquisition of graphic data is performed with VIDEOMAP. Test plots can be made on-line and off-line, using PLANITAB T 100 or the HP 7585 drum plotter. In the Planicart system a flat precision digitizing table is additionally connected. The collected data can be transferred via the high-speed LINK 1000 computer coupling from Planicart to Planicomp, for example, for final mapping in the PLANITAB T 110. Both systems are equipped for the background execution of processing programs (PAT, BLUH, HIFI). In the demonstration systems described here, the interface and connection possibilities have been virtually exhausted.

6. Parallel Operation

The operating system for the HP 1000 computer is designed for multi-user operation. This means that several tasks appear to be performed in parallel. In reality, however, these tasks are processed in very rapid succession in a predefined sequence of priority. According to the access times required, decreasing priority values are assigned to the tasks

real-time instrument control,
computer controlled measured data acquisition,
editing,
graphical output and
background computation.

The efficiency of a system, in particular the time behaviour, is term-satisfactory if, in a normal working mode, none of the parallel procedures is obstructed. The time behaviour depends on the speed of the computer, the number and type of connected instruments and the tasks to be processed.

In addition to real-time control and instrument-specific measurement support, the Planicomp and Orthocomp in their present versions permit the parallel performance of

editing, graphical output and
background computations.

A new LOOP program for Planicomp eliminates the automatic blocking of the computer during carriage movements.

For the simultaneous measured data acquisition with analog instruments, using the program packages

PLANI-AS (N) for numeric work or
PLANI-AS (NG) for numeric and graphical work

the following rules are applicable: Planicomp with

A 900 1x PLANI-AS (NG) + 1x PLANI-AS (N) or
2x PLANI-AS (N)

A 700 1x PLANI-AS (NG) or
1x PLANI-AS (N).

The above mentioned number of PLANI-AS can also be operated parallel to a digitizing table by DIGI-AS instead of Planicomp. Parallel operation of these AS programs with A 900 may be considered to be unobstructed if the intervals between recordings triggered automatically in the incremental or tracing mode are not less than 0.5 mm in the photo or less than 0.3 s. Recording sequences of this type are considered as a standard working mode. Due to time lags in A 700, 2 - 5 % of the automatic recordings are data obtained by interpolation. For manually triggered single points measurements there are also no restrictions in A 600.

The question whether

to use an automatic work station with its own computer or
to connect the work station to a central computer

cannot be answered with respect to time behaviour alone. Further essential decision parameters are investment costs, operational reliability and orientation towards the future. It is generally recommended to use autonomous work stations for demanding, expansive work (graphical data acquisition) and the connection to a central computer for "simple" work (numeric data acquisition). Since the central computer also has to cope with a constantly increasing volume of work (e. g. PAT MR as compared with PAT M, high-speed off-line mapping with PLANITAB), there is a limit to the parallel acquisition of measured data.

7. System Communication

An operational system is characterized by compatibility, easy data transfer within the system and by open interfaces for outside systems.

7.1 Communication with Zeiss Systems

On the introduction of Planicomp, general files were created for the storage and management of the measured data. The most different types of measured data (e. g. photo or ground coordinates, geometric quantities, graphical data) can be stored in the general file in a standard form so as to be available for direct further use (e. g. DEM grid data for orthoprojection) or for further processing within the Zeiss systems.

Physically, either

- direct access can be made to the data in the mass storage of the system computer or
- the data can be transferred from computer to computer on data media (MT, CS 80) or
- they can be transferred from computer to computer by computer coupling with LINK 1000

Depending on the intended use, the data records are supplemented by information necessary for further processing.

Example: Program Save ATM data in Planicomp for processing with PAT M,
or they are reformatted
Example: GEFIO program package for blocked or unblocked input and output on magnetic tape,
or converted.
Example: conversion of PLANIMAP data records for revision 84/11 into PLANIMAP data records of revision 85/9 with complete geometry.

Computer coupling is of vital importance in the work station - central station concept. The LINK 1000 computer coupling is particularly suitable for the rapid and simple file transfer. More exacting requirements, such as the common use of mass storages or high-speed computer peripherals, are met by the DS 1000 computer network offered by HP. This computer network designed for universal use is demanding regarding both the space required and handling, and it should therefore be installed only where its use is justified. Zeiss makes every effort to supply turnkey systems, but in view of the complex technical problems involved it is not always possible to achieve this in one single step, particularly since nowadays existing equipment must usually be integrated in the new systems.

7.2 Communication with Outside Systems

Data transfer to outside systems is gaining increasing importance especially in the graphical field. Physically, the data transfer is performed by

magnetic tape with the GEFIO program or
by coupling the HP 1000 A computer with the
host computer, using the CONNECT program.

CONNECT runs in HP 1000 and emulates a terminal to the host computer, thus establishing access to outside systems.

The formatted transfer of point data does not generally present major problems; the transfer, interpolation and conversion of graphic data to IGS outside systems are more complex procedures. As described in reference /4/, an exemplary solution has been found in the transfer of PLANIMAP data to the Intergraph system. It is evident that the solution of these communication problems calls for the close cooperation between Zeiss, the users and the manufacturers of the outside systems. Zeiss is prepared to do its share in achieving this goal.

Literature:

/1/ Saile, J.: Graphical Plotting with Zeiss PLANIMAP system, XVth. ISPRS-Congress, Rio, 1984, Comm. IV

/2/ Menke, K.: Standards zum Austausch kartographischer Daten, Vortrag 40. Photogrammetrische Woche, Stuttgart, 1985.

/3/ Hobbie, D. Rüdenauer, H.: The Zeiss Planicomp Family: A user oriented solution to practical requirements, XVth ISPRS-Congress, Rio, 1984, Comm. II.

/4/ Hobbie, D.: Fortschritte im Instrumentenbau für digitale Kartierung, Vortrag 40. Photogrammetrische Woche, Stuttgart, 1985.

Abstract

With the introduction of the analytical plotter, photogrammetric equipment has advanced from the simple analog stereoplotter to an integrated plotting system. The system components comprise the plotting instruments, computers, operating systems, graphical output units, software and interfaces. A wide range of components permits the construction of systems for graphical and numerical data acquisition and for the processing and representation of these data - all optimally matched to the tasks concerned, the funds available and the existing general and working conditions. For this, autonomous work stations for data acquisition and upgraded central stations are combined and coupled by a computer network. Larger central stations can be simultaneously used in multi-user operation for control, computer-supported measured data acquisition, off-line mapping and background computations. In the product design, Zeiss has developed from an instrument manufacturer into a system supplier through a combination of organizational changes and the extension of the know-how in systems technology.

Zusammenfassung

SYSTEMTECHNISCHE GESICHTSPUNKTE BEI PHOTOGRAMMETRISCHEN AUSWERTEGERÄTEN

Mit der Einführung des analytischen Plotters hat sich das photogrammetrische Instrumentarium vom einfachen analogen Stereoauswertegerät zum integrierten Auswertesystem entwickelt. Systemkomponenten sind Meßgeräte, Rechner, Betriebssysteme, graphische Ausgabegeräte, Software und Verbindungsteile. Mit einem breitem Spektrum von Komponenten lassen sich Systeme für die Erfassung von numerischen und graphischen Daten, für die Verarbeitung und Darstellung dieser Daten bilden, die den jeweiligen Aufgaben, den Investitionsmitteln und den Arbeits- und gegebenen Umgebungsbedingungen optimal angepaßt werden. Dabei werden autarke Arbeitsstationen für Datenerfassung und ausgebaute Zentralstationen miteinander kombiniert und durch Rechnerverbund gekoppelt. Größere Zentralstationen können im Multi-User-Betrieb gleichzeitig für Steuerung, rechnergestützte Meßwerterfassung, off line-Kartierung und Background-Berechnung eingesetzt werden. Zeiss hat sich bei der Produktkonzipierung, durch den Aufbau von Know How im Systembereich und durch organisatorische Maßnahmen von einer geräteherstellenden Firma zu einem Systemlieferanten entwickelt.

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PLOTTERS/PROJECTORS		COMPUTERS/HP 1000 A	GRAPHICAL OUTPUT INSTRUMENTS	CONNECTION COMPONENTS
ANALOG PLOTTERS	PLANIMAT PLANICART PLANITOP	PROCESSORS A 600 A 700 A 900	VIDEOMAP DRUM PLOTTERS HP 7580 HP 7585	DIGITAL. DIREC 2 INTERFACES IEC RS 232 MUX
PLANICOMP ANALYT. PLOTTER	STANDARD VIEWER ZOOM VIEWER CORREL. ATTACHMENT	MASS STORAGES 15 MB, 24 MB 55 MB,132 MB TERMINALS ALPHANUMERIC GRAPHICAL	GRAPH. TERMINAL PRECISION TRACING TABLES DZ 7 PLANITAB T 110 PLANITAB T 102	EXTENSION COMP. IEC EXTENDER MODEM
2-D DIGITIZATION	ARISTOGRID 100	PRINTERS HARDCOPY SUBSYSTEM LINE PRINTER		COMPUTER LINKS LINK 1000 CONNECT DS 1000
COMPARATOR	PK 1			
ORTHOPROJECTOR	Z 2 ORTHOCOMP	EXT.MEMORY: MAGNETIC TAPE BACKUP-CARTR.		

Table 1: Hardware system components

COMPUTERS	COMPUTING TIME / MODEL
IBM 370/168	0.8 s
UNIVAC 1110	0.9
HARRIS 100	3.1
DIGITAL VAX 11/780	3.3
HP A 900	3.3
DATA GENERAL ECLIPSE C	4.8
HP A 700	6.0
HP 1000 F	8.1
HP A 600	12
DEC PDP 11/70	14
HP 1000 E	23
DEC PDP 11/23	55

Table 2: PAT M computing times

INSTRUMENT SYSTEM	COMPUTER OPERATING SYSTEM		
	RTE 4B	RTE A.1	RTE A
PLANICOMP	F-COMPUTER SM MTM E-COMPUTER SM MTM	A 600/C 130 A 600 A 700, A 900	A 600 A 600/15 MB A 700 A 700 WITH VC+ A 900 WITH VC+
ORTHOCOMP	F-COMPUTER SM MTM		A 700 A 700 WITH VC+ A 900 WITH VC+

Table 3: Standard operating systems for Planicomp and Orthocomp

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BASIC SOFTWARE	S O F T W A R E - O P T I O N S				
	COLLECTION / MAPPING		ORTHOPROJECTION	FURTHER PROCESSING	COMMUNIKATION
	PLANICOMP	ANALOG PLOTTERS			
C 140 PACKAGE	PROSA	PLANI-AS (N)	TSCA 2 / HIFI S	STRIM	LINK 1000
C 130 PACKAGE	BUNDLE ORIENT.	PLANI-AS (NG)	OR 1 DA	PAT M	CONNECT
C 120 PACKAGE	EXTENDED CALIBR.	DZ 7 - AS		PAT MR	GENSIF
C 110 PACKAGE	PLANIMAP	PLTAB-AS		PAT B	GEFIO
PLANIMAP PACKAGE	GRAPH F 1, 2	GRAPH F 1, 2		BLUH	
(F. ANALOG PLOTTERS)	VIDEOMAP	VIDEOMAP		HIFI P	
	GEFIO	GEFIO		HIFI C	
Z 2 PACKAGE		DIGI-AS			

Table 4: Software system components (RTE A 01.10.85)

B A S I C				O P T I O N			
1	2	3	4	5	6, 7	8	9
IEC 12 009 A	PARALLEL 12006 A	ASYNCHRONOUS 12 005 B	PARALLEL 12 006 A	IEC 12 009 A	ASYNCHRONOUS 12 005 B	MUX 12 040 B	IEC 12 009 A
HIGH-SPEED INSTRUMENTS		SYSTEM CONSOLE		LOW-SPEED INSTRUMENTS			LOW-SPEED INSTRUMENTS
7908 WINCHESTER DISK 16 MB 7911 " " 28 MB 7912 " " 65 MB 7914 " 132 MB 7942 " " 24 MB 7946 " " 55 MB 9121 FLEXIBLE DISC 7974 MAGNETIC TAPE UNIT 7970 MAGNETIC TAPE UNIT	L O O P	26xx 2645/48 CARTRIDGE LEFT CARTRIDGE RIGHT PRINTER-SUBSYSTEM	PANEL	PRINTER DIREC 2 DZ 7 VIDEOMAP LINK HP-PLOTTER	TERMINAL 26xx PLANITAB PLANIMAP-PANEL PRINTER ARISTOGRID	4 TERMINALS PLANITAB ARISTOGRID PRINTER	DIREC 2 VIDEOMAP

Table 5: Interface configuration and connection options with Planicomp RTE A system

T Y P E	VIEWER	COMPUTER	OPERATING SYSTEM	SOFTWARE PACKAGE
STANDARD C 140	NORMAL	MICRO 26	A 600/15 MB	C 140: BASIC
STANDARD C 130	NORMAL	MICRO 26	A 600	C 130: C 140+PLANIMAP+GEFIO
STANDARD C 120	ZOOM	MICRO 27	A700,A700 VC+	C 120: C 130 + STRIM
STANDARD C 110	ZOOM	MICRO 29	A 900 VC+	C 110: C 120+PROSA+C007+ EXT.CALIBR.
SPECIAL 1	NORMAL	MICRO 27	A700,A700 VC+	C 130
2	NORMAL	MICRO 29	A 900 VC+	C 130
3	ZOOM	MICRO 26	A 600	C 130

Table 6: Standard and special versions of Planicomp

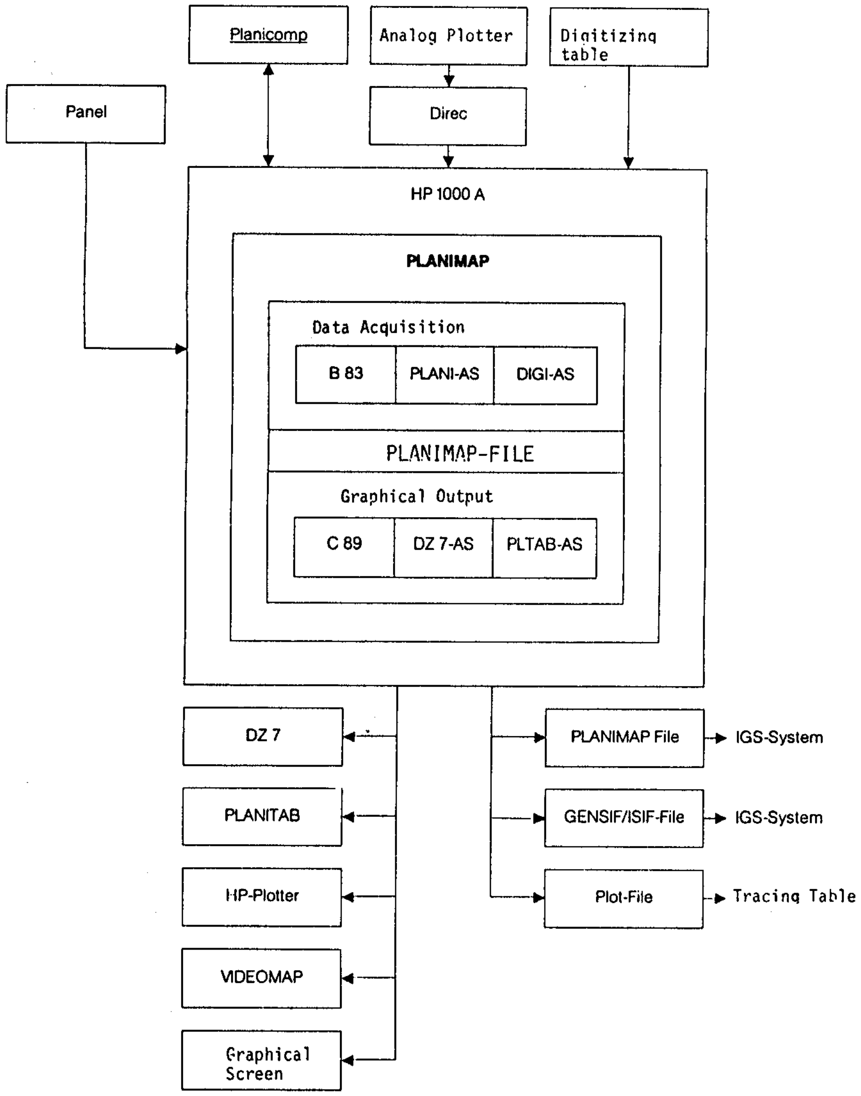

Fig. 1: Schematic overview of the PLANIMAP digital mapping system

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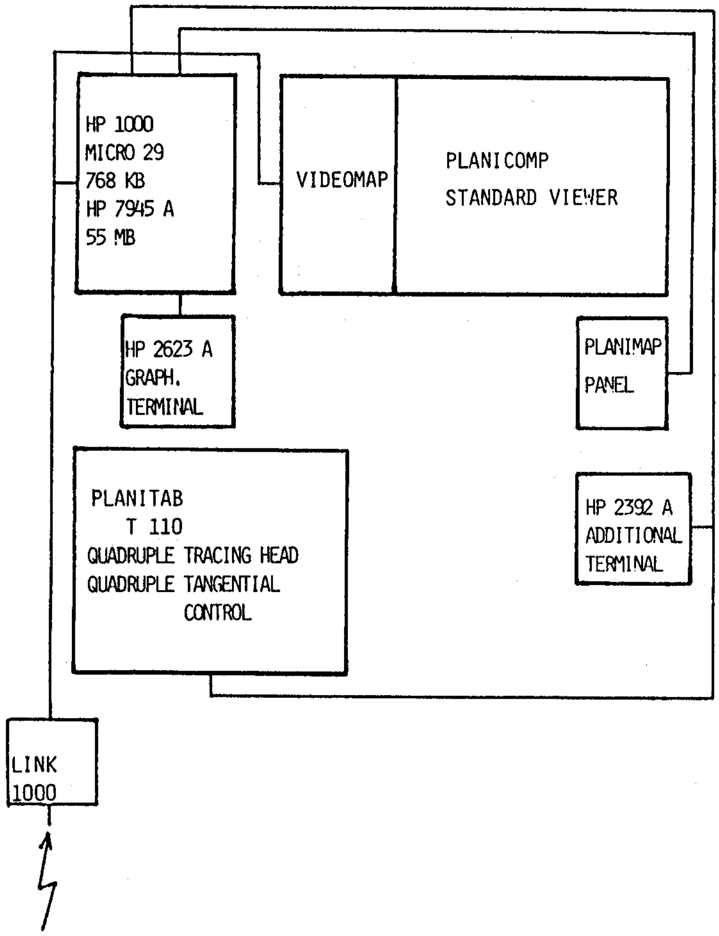

Fig. 2: Photogrammetric plotting centre with Planicomp

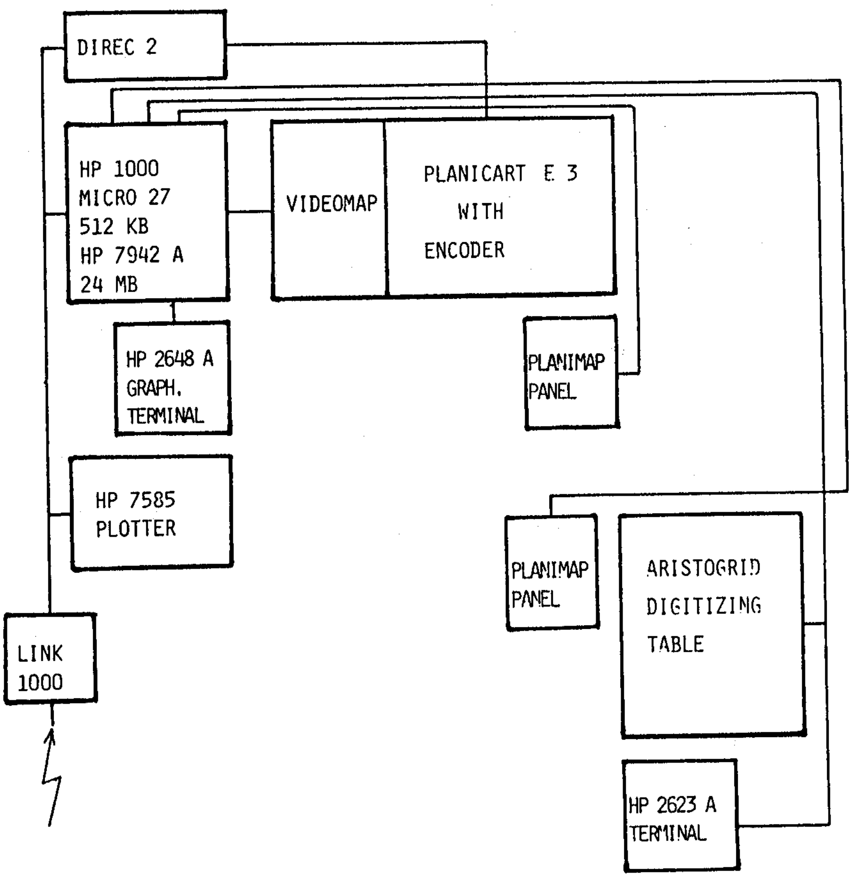

Fig. 3: Digital mapping system with Planicart