The Zeiss Planicomp Family: A User-oriented solution to practical requirements

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1. Introduction

The C100 Planicomp analytical stereoplotting system from Carl Zeiss, Oberkochen, has met with worldwide success since its presentation at the 13th International Congress for Photogrammetry and Remote Sensing in Helsinki in 1976. The versatility of the computer and the software as well as the application-oriented handling and measurement support are the major reasons for the success of the C100.

From the outset, the objective was to improve the Planicomp in close cooperation with the users and to adapt it to new market requirements. Even though it is being shown for the third time at Rio de Janeiro after Helsinki and Hamburg, the Planicomp is still the main attraction for all experts. This is due to major enhancements of both the hardware and the software for all important Planicomp applications: aerotriangulation, DEM measurement, close-range photogrammetry, and planimetric mapping in particular.

The huge variety of hardware and software components and configurations now available have resulted in the creation of a system family /1/. The components and configurations of this family are described in the following, with the major innovations being emphasized. Detailed descriptions of the basic Planicomp principles are given in /2, 3/.

2. Description of the System Components

2.1 Viewer

The viewer is the basic stereoplotter; its appearance and control elements determine the overall characteristics of the analytical plotter. In the Planicomp the typical characteristics are the compact self-supporting design with the efficient photogrammetric panel (Fig. 1), the smooth progressive-motion joystick for fast floating-mark movement, the prism system which can also be switched by the computer for orthoscopic, pseudoscopic and binocular viewing, the combination black-and-white and illuminated floating mark and the optical output port for connecting e. g. an additional TV monitor for further observers.

At the Planicomp of the Institut für Photogrammetrie (Prof. Ackermann) of the University of Stuttgart, Hamamatsu type C1000-35 CCD cameras were connected to this output port for both photos for the first time in an analytical stereoplotter. Their data outputs were connected with the HP 1000 computer of the C100 /4/. The cameras use geometrically stable CCD matrices with 320 x 244 pixels of 27 micron. 1.35x reduction allows 20 micron size picture elements of a 6 mm x 5 mm field of view to be digitized and to be passed on to further processing programs in the HP 1000 as grey shade matrices.

This allows application software to be developed with the Planicomp for nearly all digitial picture processing applications both in realtime (parallax measurement, point correlation, point setting etc.) and for background operation after raster scanning (planar correlation, grey shade manipulation etc.).

The major investigation targets in Stuttgart are point transfer in aerotriangulation applications and structural deformation measurement.

The Planicomp viewer has in the meantime also become available in another version with halogen lamp illumination and variable viewing magnification in a zoom range of 7.5x to 30x as an alternative to the fixed magnification of 8x or 16x depending on the interchangeable eyepieces, the magnification range is 15x to 60x for special applications, which affords a resolution of 200 line pairs per mm and more in the image.

A new optical interface is now available with both viewers which affords optional CRT display superimposition. This superimposition option is currently being used for superimposing graphical line images during digital and interactive mapping (see section 2.3.4).

2.2 Computer

New semiconductor components, processors and computers are being developed at an amazing rate. New products are introduced which are cheaper even though their performance is increased. This trend also applies to the Hewlett-Packard HP 1000 computers and thus to the Planicomp in general.

In 1976, the Planicomp prototype was introduced with the M processor with 32 K words and a 5 MB dual disc drive. After the E processor, the F processor with 128 K words and the 20 MB dual disc drive was used. In the future, the new HP 1000 A series computer models will be used. Their processors feature higher integration, i. e. more compact design and higher speed, and distributed I/O intelligence in the form of interfaces with separate processors.

Within the A series, processors differing in processing power are offered under the designations A600+, A700 and A900. The essential performance data of these processors are compared with those of prior processors in the following table:

	M	E	F	A600+	A700	A900
Memory cycle time (nanoseconds)	650	420	420	454	400	181
Execution speed (base instr., 1000 per sec.)	50	1000	1000	1000	1000	3000
Processing speed (floating-point instructions, 1000 per sec.)	20	40	200	53	204	500

All models satisfy the performance requirements for real-time control of the Planicomp and the tracing table and in addition offer the possibility of background computation and of parallel program development. Because of their performance variations, they differ considerably in the amount of work that can be done in parallel with real-time processing. While the A 900 is the top model of the A series, the A600+ is an extremely low-cost computer which enables a Planicomp system to be offered in the price bracket of analog instruments.

Among the associated real-time operating systems, the RTE II was a simple foreground/background system. The later RTE IVB operating system with its multi-partition, multi-user and timesharing modes has been the preferred choice for the Planicomp. The new RTE A operating system for the A series, which has been expanded again, offers further options such as "virtual memory", "virtual code" and "FORTRAN 77". With a view to program development and installation, it may be mentioned that program editing and loading, file management and operating system modification are now simpler and much faster.

On the peripheral equipment side, the dual disc drives have been replaced by Winchester discs, i. e. maintenance-free fixed disc drives with a storage capacity of 10 to 132 MB. Being sealed, they should offer higher data security than interchangeable discs. For data filing and data interchange between different systems there is an integrated tape drive whose cartridges can store the whole disc content, or an intergated micro-floppy drive.

The variety of I/O devices has been reduced by the elimination of the originally favored paper tape and punched card equipment; magnetic tape equipment is now being used. On the other hand, computer interconnection is rapidly gaining in importance. The following hook-ups are currently being supported:

- Connection of the HP 1000 to mainframe computers such as the IBM 370 with the HP RJE 1000 product.

- Interconnection of HP 1000 computers or with HP 3000 computers with the HP DS 1000 product.

- Data transfer between HP 1000 and HP 85/86, HP 9834/45 or HP 20 series computers with the HP IB interface.

- Data transfer between two HP 1000 computers via the HP IB interface and a coupler.

- Connection of an HP 1000 computer with an INTERGRAPH IGDS workstation and thus with a DEC VAX 11 computer with a processor-controlled serial interface.

Further interconnection options will be provided.

2.3 Software

The Planicomp software, which has been very comprehensive, powerful and reliable from the outset, has been improved and expanded continuously in cooperation with the users. The modular design, documented program and data interfaces and comprehensive personal consulting by Zeiss personnel have enabled many users to create their own special-purpose application programs and to modify existing programs, i. e. to tailor the Planicomp to their specific requirements.

This application programming work, which is presented mainly at regional meetings, covers such topics as

- implementation of existing background programs,
- management and manipulation of individual files,
- formatted data I/O,
- inter-computer communication,
- automatic prepositioning and checking of specified series of points,
- following and checking given lines or areas e. g. for power line planning, airport obstacle checking, or "photogrammetric" setting-out for lot consolidation.

Zeiss will also in the future devote much energy to program care and maintenance in general fields such as calibration and orientation, data collection for aerotriangulation, digital elevation models, planimetric mapping, further processing and data management. The major software innovations for the Planicomp are described in the following.

2.3.1 Calibration

Under the name B198 EXTENDED CALIBRATION, a new program package developed for Zeiss by the Institut für Photogrammetrie (Prof. Kupfer) of the University of Bonn is presented here for the first time. It enables real-time planar correction of systematic errors after the measurement of a grid comprising up to 625 points. This optional program package not only allows increasing the "normal" real-time precision of the Planicomp from about 2 micron to 1.5 micron or less but also enables reseau photography (taken with the part-metric Rolleiflex SLX-Reseau camera, for example) to be corrected for planar film distortion. The stored correction parameters derived from grid measurement afford mesh-type correction with finite elements with a bilinear algorithm /5/. This expanded real-time correction function can be activated and deactivated at option and can also be performed during coordinates storage by the corresponding transformation routines, if desired.

2.3.2 Orientation

The C007 BUNDLE ORIENTATION program, which was presented in the fall of 1983 already, provides a versatile single-step orientation option. Even though it was developed (also at the University of Bonn) especially for orienting close-range photo pairs, it can also be very useful in special cases of orienting aerial photo pairs. This program package offers the following special performance features:

- Individual weighting of the X, Y and Z control point coordinates
- Weighting of measured photo points
- Weighting (and thus retention) of the exterior orientation parameters
- Interior orientation if the observed points are distributed appropriately
- Use of control points in local coordinate systems
- Use of special control elements such as distances, coordinate differences, horizontal and vertical angles
- Introduction of the stereo camera condition
- Output of standardized corrections and of the inherent reliability for gross error detection.

2.3.3 Elevation Measurement

In many applications, profiles or grids are nowadays used for terrain elevation measurement instead of direct contour line measurement for economic reasons. Static grid measurement with analytical stereoplotters was found to be the fastest and most reliable method. This method consists in automatically prepositioning the floating mark in plan to the grid points in the model so that the operator only has to set the elevation and initiate recording. Various investigations of the attainable precision have shown that the point density and the terrain configuration have a decisive influence apart from the measuring precision. In order to be optimal also with uneven terrain, an optimum grid measurement method should allow the grid mesh to be matched automatically to the local terrain conditions with the point distance being specified by an objective criterion. In 1972 already Makarovic has proposed an interactive acquisition method under the name "Progressive Sampling" which satisfies these requirements to a large extent /6/. The Institut für Photogrammetrie und Ingenieurvermessung (Prof. Konecny) of the University of Hannover has implemented this method with an analytical plotter for the first time /7/.

With the optional B75 PROGRESSIVE SAMPLING program, a program developed by the Lehrstuhl für Photogrammetrie (Prof. Ebner) of the Technical University of Munich is now generally available which can be said to be optimum in view of the practical experience that has been integrated /8/.

Departing from an initial wide-mesh grid and further information such as break lines, approximate local terrain curvature data is computed by means of second derivatives. The curvature data is used to decide whether the initial grid should be densified locally by halving the grid point distances. This procedure is iterative, i. e. all additionally measured grid points are analyzed again during the next pass and densification occurs again, if required, until a lower threshold is reached (Fig. 2). In the Planicomp, automatic positioning of the densification points and consecutive computation of the second derivatives is so fast that the operator does not detect any delay and can concentrate on elevation measurement.

Depending on the terrain morphology and the desired DEM quality, progressive sampling allows the measurement time and the number of measured points to be reduced by 30 to 70 %.

2.3.4 Planimetric Mapping

In addition to "computer-supported" mapping, which has been available for the Planicomp from the outset, "digital mapping" and "interactive mapping" have now also been implemented.

D i g i t a l m a p p i n g is implemented by the PLANIMAP software package through digital storage of the measured graphical elements (points, lines, areas, buildings, slopes, texts etc.). These elements can be output with flexible optional symbol representation either on the Zeiss DZ 7 digital plotting table, HP plotters, or on graphics CRT terminals - both in real time as test plots and at any later time in the "playback" mode (Fig. 3). Off-line output is also possible after simple editing or in another location. Particularly interesting is real-time output on the new Zeiss Videomap graphics CRT unit screen for superimposition on the Planicomp viewing optics image /9/.

I n t e r a c t i v e m a p p i n g is implemented by connecting the Planicomp with an Intergraph IGDS stereodigitizer workstation through a powerful real-time interface (Fig. 4). A versatile communications protocol allows data acquisition to be controlled at the Planicomp panel. The graphic design files are created and processed by the Intergraph workstation. Superimposition of the display of an Intergraph graphics CRT terminal with the Planicomp viewer image has been shown for the first time in the world in 1983 /10/.

2.3.5 Further Processing

The Planicomp background programs also have been and will be improved continuously according to requirements. The improvements of the aerotriangulation block adjustment programs (PATM and PATB of the University of Stuttgart and BLUH of the University of Hannover) focus on the handling of gross errors. The HIFI program package of the Technical University of Munich has been improved considerably specifically in handling and in graphical elevation representation.

2.3.6 Data Management

The GEFIO program package was created for managing data measured or computed with the Planicomp, Orthocomp or with computer-supported analog instruments. GEFIO comprises the newly expanded GEFIL program for editing and - with A series computers - creating general files, and the GREAD and GWRIT programs for reading and writing magnetic tape data in ASCII or EBCDIC with optional blocking factors. An internal ASCII file is always created which can be processed with the HP editor. The advantages provided by this program package are high reading and writing rates and simplified data interchange with other computers.

3. System Configurations

Users today place the most varied demands on analytical plotters. Not only the wide variety of applications but also the different user categories (e. g. small private companies and large state organizations) dictate that the Planicomp be available in different configurations.

This is why Zeiss has introduced the family concept. From the spectrum of components such as different viewers and computer models and the modular software and software options, several Planicomp systems have been assembled which are described in the following.

3.1 C130 Planicomp

The C130 Planicomp analytical stereoplotter is the cheapest member of the Planicomp family. As a standalone application-oriented workstation for computer-supported data acquisition and mapping, it is t h e workhorse in particular for model and bundle block measurement, digital terrain model measurement (e. g. for orthoprojection), and for computer-supported digital or interactive mapping.

It consists of

- a standard viewer without zoom lens, i. e. with 8x magnification or with 16x magnification if the optional 16x eyepieces are used.
- the HP 1000 Micro 26, i. e. the A600+ processor with a memory capacity of 512 KB and an optional integrated 10 MB Winchester disc with 3 1/2" microfloppy disc drive, or a 16 MB Winchester disc with integrated cartridge tape backup unit.
- Zeiss control electronics housed together with the computer in a cabinet below the viewer.
- HP 2621B terminal with integrated thermal printer.
- basic Planicomp software for orientation and measurement.
- optional software for mapping (PLANIMAP or Intergraph communication), bundle orientation (C007), progressive sampling (B075), strip triangulation (STRIM), data I/O, off-line (GEFIO) and on-line (computer interconnection), and user programming.

3.2 C120 Planicomp

The C120 Planicomp analytical plotting unit (Fig. 1) is a flexible workstation offering further processing options. It features increased computer power and more flexible peripheral equipment and software configurations than the C130. The C120 consists of

- a viewer with two independently adjustable zoom lenses for a magnification range of 7.5x to 30x,
- an HP 1000 Micro 27, i. e. the A700 processor with floating-point hardware and a memory capacity of, for example, 512 KB, and a 16 MB Winchester disc with tape backup unit or user-selected periphery,
- the Zeiss control electronics housed together with the computer in a separate rack cabinet,

- an HP 2621 B terminal as for the C130 or one or several other terminals such as the HP 2623 A graphics terminal,

- more basic Planicomp software than for the C130,

- optional software in addition to the C130 software, e. g. background programs for further data processing, for block triangulation (PATM, PATB, BLUH), and for computing digital elevation models (HIFI).

3.3 C100 Planicomp

The C100 Planicomp universal analytical plotting system is a photogrammetric processing center which, because of its high computer power, is particularly suited for organizations in which further plotters (analog instruments, comparators, off-line plotters etc.) have to be supported in parallel with Planicomp operation and further terminal workstations or long-term data management are required.

The C100 consists of

- a zoom viewer as in the C120,

- an HP 1000 computer (either the Model 45 with F processor and RTE 4B operating system or the Model 29 with A900 processor and RTE A operating system) and optional equipment, e. g. disc drives for up to 120 or 132 MB,

- a Zeiss control electronics housed together with the computer in one or two rack cabinets,

- an HP graphics terminal with separate, powerful printer,

- optional software as for the C120 plus support of analog instruments (PLANI-AS), monocomparators (PK-AS) or stereocomparators (STCMP).

4. Conclusions

With the described spectrum of components and configurations, the Planicomp family is a mature system that enables powerful and cost-effective solutions for all photogrammetric users.

The Planicomp users are in addition supported by Zeiss through comprehensive system support, regular information and upgrade services, documentation and accessibility of program and data interfaces, and individual programming advice or program modification. Thanks to the world-wide dissemination of the Planicomp, this is complemented by regional experience interchange in User Clubs, Workshops, and through direct cooperation. These factors have made the Planicomp system the leading analytical plotter in photogrammetric production. Thus all requirements are met to ensure that (e. g. close-range) photogrammetry will increasingly be accepted and used as a powerful measuring method also in related disciplines.

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Fig. 1: C120 Planicomp with Zoom Viewer and HP 1000 A700 Computer

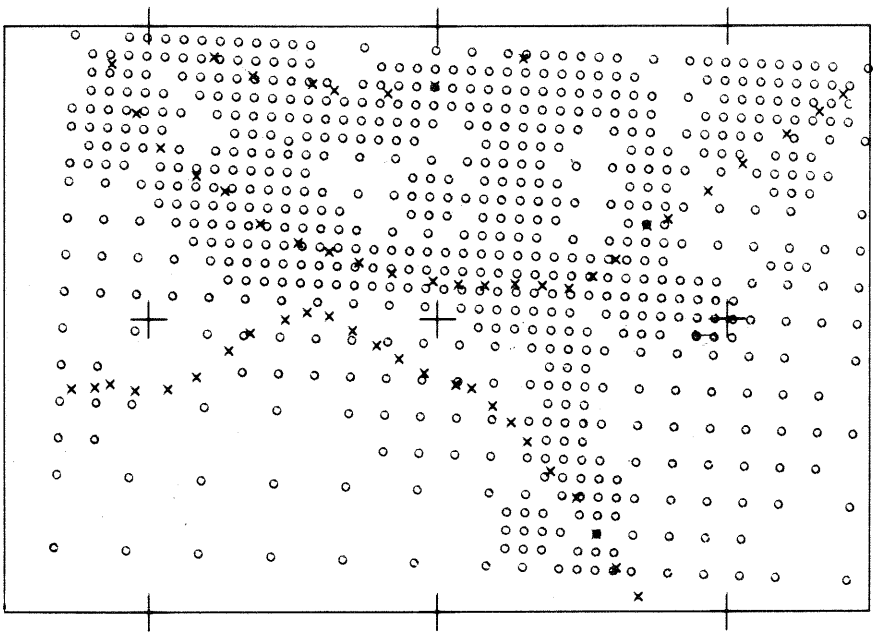

Fig. 2: Point Densification in the Planicomp by the Progressive Sampling Method allowing for Break Lines

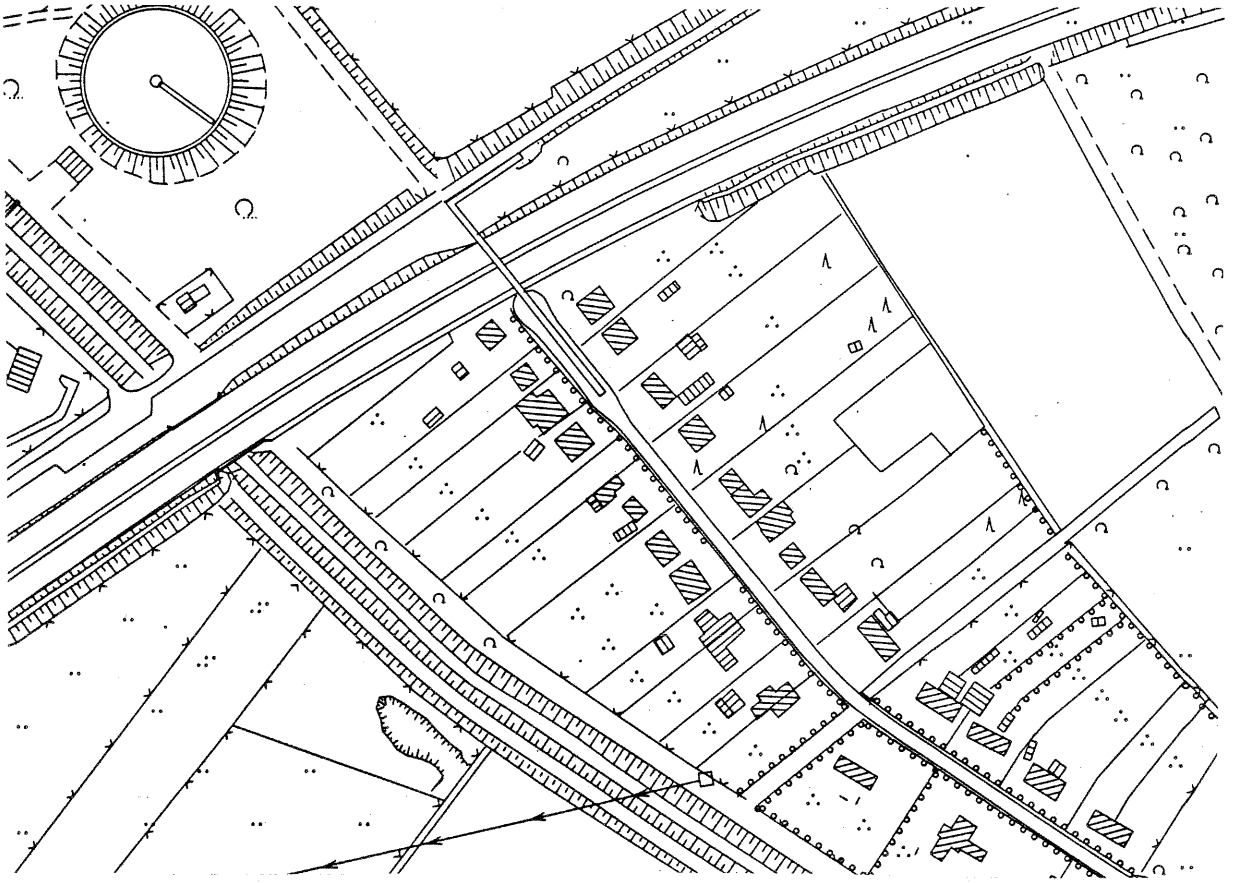

Fig. 3: Sample Digital Map produced with the Zeiss PLANIMAP and the Planicomp

Fig. 4: Interactive Mapping with the Zeiss Planicomp and the Intergraph Stereodigitizer Workstation

Zusammenfassung:

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

- C130 Analytisches Auswertegerät als preisgünstiger Einzel-Arbeitsplatz (Workhorse) für numerische Messungen und Kartierung,

- C120 Flexible analytische Auswertestation mit vielseitiger Meßdatenverarbeitung,

- C100 universelles analytisches Auswertezentrum mit Meßdatenverarbeitung und Rechnerunterstützung für weitere Arbeitsplätze.

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

- Zoom-Betrachtung für den optisch-mechanischen Viewer

- Graphische Superimposition

- Grauwert-Digitalisierungszusatz

- Verwendung der neuen abgestuften Mikrocomputer-Modelle der HP 1000 A-Serie

- Möglichkeit einer erweiterten, flächenhaften Echtzeit-Korrektur von Bild- und Gerätefehlern

- Programm zur einstufigen Bündelorientierung insbesondere für die Nahbereichs- bzw. Industrie-Photogrammetrie mit flexiblen Möglichkeiten

- Programm zur DHM-Messung nach der Methode des Progressive Sampling

- Digitale Kartierung mit ZEISS-Planimap und ZEISS-Videomap

- Interaktive Kartierung durch Echtzeit-Anschluß an INTERGRAPH mit zusätzlicher Superimposition

- Daten I/O mittels geblockter Magnetbänder oder Rechnernetzwerken.

Zusammen mit der umfassenden Systemunterstützung durch ZEISS und den weltweiten Kundenerfahrungen bietet das Planicomp-System Lösungen für alle praktischen Aufgabenstellungen.

Abstract

The Zeiss Planicomp analytical plotting system has been expanded into a complete system family. Typical configurations are the:

- C 130 analytical stereoplotter, a low-cost single workstation for numerical measurement and mapping,

- C120 flexible analytical plotting unit for versatile measured data processing,

- C100 universal analytical plotting system for measured data processing and computer support of additional workstations.

Major innovations in the different configurations are:

- Zoom lenses for the opto-mechanical viewer
- Graphical display superimposition
- Digital Image Processing attachment
- Use of the new HP 1000 A series of microcomputers
- Optional real-time planar correction of photo and instrument errors
- Flexible program for single-step bundle orientation in particular for close-range and industrial photogrammetry
- DEM measuring program using the progressive sampling method
- Digital mapping with Zeiss PLANIMAP and Zeiss Videomap
- Interactive mapping through real-time connection with Intergraph system and optical superimposition
- Data I/O with blocked magnetic tape or in computer networks.

Thanks to the comprehensive Zeiss system support and world-wide customer experience interchange, the Planicomp system provides solutions to all practical requirements.

Résumé

Le système de restitution analytique ZEISS Planicomp a été élargi et comprend dorénavant toute une série d'équipements dont les exemples types sont

- l'appareil de restitution analytique C 130 d'un prix avantageux destiné à un opérateur (workhorse) et servant aux mesures et à l'établissement de cartes par voie numérique,
- la station de restitution analytique C 120 offrant une grande souplesse d'utilisation quant au traitement des valeurs de mesure et
- le centre universel de restitution analytique C 100 assurant le traitement des valeurs de mesure et offrant une assistance par ordinateur utilisable par d'autres opérateurs.

Les principales innovations comprennent:

- Appareil de base opto-mécanique (viewer) doté d'un dispositif d'observation à zoom
- Superposition d'informations graphiques
- Convertisseur numérique des valeurs de gris
- Emploi de la nouvelle série échelonnée de micro-ordinateurs HP 1000 A
- Recours à un modèle perfectionné pour la correction en temps réel des erreurs au niveau de l'image ou de l'instrument
- Programme autorisant une compensation par gerbes perspectives en un seul pas, destiné en particulier à la photogrammétrie terrestre et offrant une grande souplesse d'emploi
- Programme de mesure de modèles altimétriques numériques selon la méthode dite "progressive sampling"
- Etablissement de cartes par voie numérique à l'aide du programme Planimap et du système de visualisation Videomap de Zeiss
- Etablissement de cartes interactif par connexion en temps réel à des équipements INTERGRAPH offrant une superposition supplémentaire
- Entrée et sortie de données à l'aide de bandes magnétiques établies par blocs ou de réseaux informatiques.

Profitant de l'assistance technique complète offerte par Zeiss et de l'expérience acquise par les utilisateurs de par le monde, le système Planicomp se prête à la solution de tous les problèmes pratiques.