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CURRENT STATUS OF THE PHOCUS DEVELOPMENT

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1. OBJECTIVES OF THE PHOCUS SYSTEM

PHOCUS has been designed for the acquisition, processing, storage, output, analysis and transmission of geometrical and alphanumeric data by interactive graphic working methods.

In the implementation, special attention has been given to the following aspects:

- Optimization of the system performance for the requirements of photogrammetry and cartography, with upgrading to a Geographic Information System (GIS).
- User-friendly and flexible operation due to choice between command and dialog input which can be structured extremely effectively by the use of freely definable menus.
- Support of the user by help functions and tutorials.
- Object-oriented and hierarchically structured storage of the geometric data and the alphanumeric attribute data assigned to them.
- Strict separation of geometry and graphic representation.
- Workstation concept with the environment configuration adapted to the instrument combination used, to operator habits and current project data.
- Open system with respect to workstation networking, data exchange and user programming.
- Integration of external program systems such as PROSA, BINGO, SCOP, HIFI, PAT-MR and others.

2. GENERAL FEATURES OF PHOCUS

Project and Operator Environment

PHOCUS includes a project and operator environment which can be defined before PHOCUS is started.

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The project environment comprises all information and data referring to a specific project: data base, models and all authorized operators. All relevant data becomes automatically accessible on selection of the project.

The operator environment comprises all information and data referring to a specific operator, e.g. his personal instrument configuration.

Codes protect the project and operator names against unauthorized or unintentional access to the data.

Operation Aids

PHOCUS offers a variety of aids providing optimum support for the operator:

- Help functions which list all parameters and functions available with a brief description.
- Help functions which give a detailed description of a parameter or function.
- Tutorials which give the user recommendations for a suitable working method or ips for the interpretation of results.

Convenient Input Options

Different options are available to the operator for the setting of parameters or the activation of functions:

- the dialog
  This mode is useful if the operator wishes to familiarize himself with a specific program or for setting a large number of parameters.
  The operator is guided from one query or function to the next and can return to previous queries if an error has been made.
  The dialog input can be terminated at any time.

- the command
  This mode is recommended for the experienced user and permits fast and effective processing of a job.
  Parameters can be set and functions selected directly either with an abbreviated command (usually 2 characters) or a long command (up to 10 characters). A parameter can be set by calling it up in such a way that its current value can be changed by convenient line editing.

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- the input via menu

  The menu technique considerably facilitates the calling of PHOCUS modules and the input of functions and parameters in the dialog and command modes.

  At present, PHOCUS permits menu entry on the following instruments:
  - on the terminal via a soft key menu
  - on the PHOCUS panel via a panel menu
  - on Planicomp and digitizer via overlay menus
  - on Planicomp and digitizer via key menus
  - on the graphic display terminal via a graphics menu with submenus

  The menus may have different assignments and layouts. All active menus are simultaneously open for input and can be changed at any time.

  The executable commands in a menu field may be **macros** which allow recurrent command sequences to be run after only one activation.

- the input via all active instruments

  In PHOCUS, the so-called 'event input' has been implemented, which means that all active instruments integrated into the workstation can be used for the input. If considered useful, several types of input are simultaneously available. These are:
  - text input
  - menu input
  - input of a point position
  - identification of an object, object item, line or point

  The following input media are available for this purpose:
  - terminal keyboard
  - PHOCUS panel
  - Planicomp
  - digitizer
  - graphic display terminal (VIDEOMAP, Tektronix terminal etc.)
  - ASCII file

  This technique offers maximum flexibility and efficiency in the user-computer communication.

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Convenient Output Options

PHOCUS offers a number of alternatives for data output:

- Continuous output of important status parameters
  Parameters and data that are of importance to the user are displayed on an area of the alphanumeric screen with a form layout, which can be compiled by the user himself.
- Output of result lists
  Using a constantly available command, the output of result lists, system messages and PHOCUS data can be routed to a printer.
- Graphic output
  Graphics can be output simultaneously on several graphic output instruments.

Parallel Processing of Several Tasks

If a powerful computer is available, PHOCUS permits the grouping of instruments into several workstations in order to process different tasks on one computer at the same time. The following are examples of such workstations:

- Data acquisition with Planicomp
  VIDEOMAP
  alphanumeric display terminal
- Data editing with graphic display terminal
  alphanumeric display terminal
- Graphic output on tracing table or plotter
  alphanumeric display terminal

3. THE OBJECT DATA BASE OF PHOCUS

The object data base is used for the storage, management and processing of geometrical and geometry-related data.
The hierarchic data structure is divided into

projects
areas
object classes
objects
object items
line sections
coordinates

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The assignment of object data to the levels object class, object, object item is freely selectable and is performed on the basis of an object code table (OCT).

The geometry of the object data is stored irrespective of their cartographic representation and can therefore be adapted very easily to different scales or specific map requirements by the use of different graphic codes.

Geometrical elements may belong to several objects or object items (topological connection), e.g. if a line is the edge of a building and part of a boundary line at the same time, or if a point indicates the position of a boundary point and is at the same time the starting point of several parcel limits.

Each object or object item can be assigned alphanumeric data which allow the storage of a great variety of attributes (e.g. description of a road by class, surface, condition etc.). The geometrical data and attribute data can be accessed with complex search words.

All objects or object items in the data base are identified by so-called 'timing marks', permitting selection of smaller work data bases from a large central data base and retransmission to the central data base after processing in such a way that double storage is avoided.

Data security is ensured by the following measures:

- The data base and other data files can be protected against unauthorized access by the PHOCUS project management and by measures at the operating system level.
- Inadvertent changes can be cancelled by resetting the data base to a previous status.
- If the data base is in an uncontrolled condition after a system breakdown, e.g. due to power failure, usability is restored with a recovery function.

4. DESCRIPTION OF THE MAJOR PHOCUS MODULES

Project and System Management

The project and system management can be divided into the following areas:

- Creation, changing and management of the projects
  Any number of projects can be created and subsequently changed, if necessary.

- Creation, changing and management of the operator names
- Setting of the system parameters
  These include the default directories, the user coordinate system (left-handed, right-handed), the sequence of the coordinate axes, the distance units (km,m,cm,mm,miles,ft,in,usft,usin), the designation of the coordinate axes, the output format of the user coordinate system, the units of angle (rad,grd,deg) etc.
- Definition of the workstation configuration
  An instrument table defining the workstation environment is assigned to each operator.
  This ensures that the operator always finds his predefined environment. Here, it should be mentioned again that up to three workstations can be set up at the same time.
- File survey
  PHOCUS offers the possibility of calling up information separately according to system level, project level, operator level and freely accessible level via the files currently in use.

P-Software

The P-software supports the analytical plotters of the P-series. It comprises the following modules:

Modules for Data Management

- Camera data management
  This module permits the input of all data of a camera calibration and is not tied to any specific camera type. In addition, camera data determined by BINGO bundle adjustment can be entered.
- Control point management
  All control points of one or several projects can be managed together in a control point file. Management is designed in such a way as to ensure very fast access to the individual control points.
- Model management
  Any number of models can be stored.
  An ASCII file input and output are provided for the exchange of model parameters with other systems. This interface is clearly defined and freely accessible.

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It is also possible to read in model data directly from the ORIENT files of the C100 Planicomp or data from PAT-M/MR and BINGO.

Modules for Model Orientation

- Interior orientation
  Up to 16 fiducials can be measured for interior orientation.
  The module also permits grid measurement.
- Relative orientation
- Absolute orientation
  The adjustment algorithm automatically recognizes the special features of terrestrial models and is able to determine any model orientation without prespecified data.
  If the control point file contains more than the minimum number of control points required for orientation, further planimetric control points will automatically be prepositioned and offered for measurement.
- Setting of a personal model elevation
  If several operators are working on the same model, each operator can set his specific model elevation without having to perform a new absolute orientation.
- Orientation of a map on P1/P3
  The tablet of the P1 or P3 Planicomp can be used as a digitizer. This permits, for example, the addition of photogrammetric data of those areas which are not visible in the aerial photograph. Switching from the Planicomp mode to the digitizer mode is possible at any time.
- Orientation of SPOT models
  PHOCUS enables the plotting of SPOT models using orientations computed with BINGO.

Further Modules

- Camera calibration
- Definition of the plane of movement
  This function is particularly useful for terrestrical models, in order to adjust the plane of movement to the inclination of a specific reference surface.
- Orientation of a contact print or map to the model
  This module permits the orientation of a map or the contact print of an aerial photo with respect to a model. After setting a position on the piece

of material and pressure of a Move Absolute key, the Planicomp can be moved very rapidly to the approximate position.

- Orientation of up to 4 menus on the P1 or P3 tablet
- Modification of the Planicomp system parameters
  This module permits changing the direction of movement and speed of the P-cursor, handwheels and foot disks and the modes of viewing and movement.

D-Software

The D-software enables the integration of digitizers into the PHOCUS system. It comprises:

- Orientation of material by plane transformation
- Affine correction of material shrinkage
- Transformation into the higher-order coordinate system
- Management of orientation and control point data files
- Input of area-, line- or point-related elevations to complete the planimetric information by the third dimension.

The following digitizers are currently supported:
ARISTO digitizer, **ALTEK** digitizer, **NUMONICS** digitizer, **MICROGRID II** digitizer

Processing of Object and Graphic Tables

This includes

- Setting up and processing of the object code table
  The object code table (OCT) describes the project-specific data structure and contains information on the object classes, object codes, object item codes and their relative allocations.
- Setting up and processing of the graphic code table
  The data structure of the PHOCUS data base is strictly object-oriented. The relationship between the object data and graphics is established by graphic code tables (GCT) which assign the symbol construction and symbol execution to each object or object item. This offers the advantage that only the graphic code table needs to be changed for adaptation of the data to different types of map sheets.
- Setting up and processing of the symbol construction table
  The symbol construction table (SCT) contains the unscaled representation of point, line, multiple line, area and slope symbols and of text. The symbols thus created can be output in a clear graphic form.

- Setting up and processing of the symbol execution table
  The symbol execution table (SET) contains execution parameters such as symbol size, tracing pen, text layout etc.

All the above-mentioned tables can be exchanged with other operating systems via a defined ASCII file interface.

Preparation of Graphics

The preparation of graphics comprises the following procedures:

- Input and processing of instrument-dependent parameters
  The parameters which differ for each instrument, e.g. background colour, colour table, plotting speed, plotting tools, are defined here.
- Map sheet preparation
  A powerful program module permits the definition of an indefinite number of parameter sets for the compilation of a complete map sheet.

Data Acquisition and Editing

Data acquisition in PHOCUS can be classified according to the following aspects:

- Object-structured acquisition
  One of the most important applications of PHOCUS is the acquisition of object-structured topographic data using analytical plotters or a digitizer. PHOCUS offers the complete range of functions required for map revision or the acquisition of new data.

  The measuring and editing functions work directly together with the PHOCUS data base and permit not only the interactive graphic editing of geometrical data elements and their attributes, but also the direct correction of acquisition errors. Special mention should be made here of VIDEOMAP which enables a direct comparison of the stored data with the aerial photo and whose intelligence offers all possibilities of data editing.

  The measuring functions provided cover such an extensive range that they can only be briefly listed here:

  - The type of line connection (vector, spline, arc of circle, circle) can be freely selected and combined.

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- Objects can be stored as points, lines, areas, slopes or with text annotations.

The supporting elements include

- Function for setting a point symbol with automatic annotation (point number and/or the terrain elevation).
- Function for measuring parallel lines.
- Function for making line sections invisible (e.g. for subways).
- Snap point function for positioning to a previously measured point and for filing it as a nodal point in the data base (no multiple storage of identical points).
- Snap line function for positioning to the nearest line which is automatically divided, and a point inserted.
- Transfer line function for transferring previously measured line sections to another object or object item. The line sections are only stored once in the data base. A new feature is that lines passing through a nodal point can now also be transferred.
- Transfer area function which automatically forms an area by combining the surrounding line sections into an area (no multiple storage).
- Squared polygon function for adjusting the measured polygons in such a way that approximate right angles are transformed into exact right angles. Invisible corner points are computed automatically. The adjustment makes allowance for control points.
- Function for the computation of slope lines.
- Text function for the complete adaptation of a text to any environment by rotation, curving, stretching or compression.
- Construction function for the incorporation of data measured in the field (e.g. points obtained by orthogonal or polar measurement)
- Function for the correction of measuring errors such as deletion of the last point, object item or object, opening of a measured object, etc.

With the above-mentioned measuring functions, the editing functions available to the user include the following:

- Deletion of points, lines, areas, texts
- Shifting and rotation
- Insertion of points in line sections
- Parallel displacement of line sections (e.g. to eliminate roof projections)

- Adjustment of polygons.
- Combination or separation of objects or object items.
- Intersection of two lines.
- Elimination of line projections
- Changing the line type
- Changing the code of objects or object items.
- Setting or changing attributive data.
- Computation of distances and areas.

- Data acquisition for a digital elevation model
  Two modules (MDTM and PROSA) are provided in PHOCUS for this purpose:

  The MDTM module which enables the measurement of a regular grid or of longitudinal and transverse profiles with fixed, specified distances or positions. In addition, break lines and single points can be measured.

  The position data for the longitudinal and transverse profiles can be read from an ASCII file. The measurement results are stored in an ASCII file in such a way that they can be read directly by DTM computation programs such as SCOP and HIFI. It is also possible to perform old/new comparisons by the prepositioning of points.

  The PROSA module is an intelligent DTM data acquisition program developed by the Department of Photogrammetry at the Technical University of Munich: depending on the type of terrain involved, the number of points to be measured is reduced by automatic control of the optimum point density. After completion of a patch, preliminary contour lines are computed and plotted, permitting direct checking of data acquisition.

- Data acquisition for aerotriangulation
  This module is used for the acquisition and storage of photo and model coordinates for transfer to adjustment programs such as BINGO, PAT-M, PAT-MR etc.

Graphic output

As mentioned before, the purely object-oriented data structure in PHOCUS allows very easy and rapid adaptation of the cartographic representation to specific map types by changing the graphic code.

Different, freely combinable criteria can be applied in the selection of the object data.
The selection may be based on elements of the object data structure (object class, object or object item code, attributes) but also on purely cartographic elements, such as drawing materials or pens.

For graphics, either a very extensive symbol system can be created for fair drawings or a simplified symbol system for the production of outline drawings.

The following graphic instruments are currently supported:

- Graphic display terminals (Tektronix 420x, 4111, 4211, 422x, DEC VAXstation, VIDEOMAP)
- HP plotters (74xx, 757x, 758x, 759x), Benson plotters (16xx and 18xx with HP 758x emulation)
- Tracing tables (T102/110 PLANITAB, DZ 7, TA30).

Ouput is also possible on a plot file with HP-GL commands.

Data Base Interfaces

PHOCUS offers a variety of possibilities for data exchange with other systems.

- ASCII Exchange Format PHODAT
  PHODAT comprises a series of data sets in ASCII coding with a simple sequential structure.
  When reading a PHODAT file into the data base, the topological connections can be established even if the file does not contain any direct topological information. All common points and lines are automatically searched for and entered in the data base with the appropriate reference.
  With the aid of this exchange format, the following data interfaces have been created to date, either by Carl Zeiss or by others:

  PHOCUS —▷ ISIF (Intergraph)
  PHOCUS —▷ DXF (AutoCAD from Autodesk)
  PHOCUS —▷ SICAD (Siemens)
  PHOCUS —▷ DIGSY (Siemens)
  PHOCUS —▷ ARC/INFO (ESRI)
  PHOCUS —▷ MOSS (McDonnell Douglas)

PHOCUS —▷ EDBS (standard data base interface in the Federal Republic of Germany

PHOCUS —▷ ISOK (Swedish exchange format)

Direct Access to the PHOCUS Data Base

Carl Zeiss offers a PHOCUS programming course which enables the user, for example, to make direct access to the PHOCUS data base. This direct access is used at present for the data exchange with PLANIMAP.

Macro File

This is an ASCII file which may contain any PHOCUS commands, e.g. coordinates and their assignment to objects or object items. This is a very simple way of opening up a variety of possibilities to the user for creating his own procedures.

Geodetic Data Input

This module permits the transformation of data obtained in geodetic surveys for storage in a PHOCUS data file. Point coordinates (x, y, z) and the appropriate point numbers can be entered.
With the aid of a conversion table and the point numbers, the point coordinates can be assigned to objects or object items.
In addition, this table can be used for the entry of attribute data.

5. COMPUTER CONFIGURATIONS AND THEIR OPERATING SYSTEMS

The workstation computer used for PHOCUS may be any of the microcomputers of the HP 1000 series with the RTE-A/VC+ operating system from HEWLETT PACKARD or the VAXstations with the operating system VMS 5.0-2 or later from DIGITAL EQUIPMENT CORPORATION.

The operation of PHOCUS is virtually identical in both computer families. Several systems of this type can be interconnected via ETHERNET or a cluster system.

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6. OUTLOOK

PHOCUS is a photogrammetric-cartographic system in which the longstanding experience of Carl Zeiss as the leading manufacturer of photogrammetric systems has been systematically incorporated.

In the near future, Carl Zeiss will be upgrading PHOCUS as quickly as possible to form a geographic information system (GIS) by incorporating a relational data base. Regardless of this aim, however, PHOCUS will continue to be developed further in the photogrammetric and cartographic field.

Further information on this subject is provided in /6/

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ABSTRACT

PHOCUS is a universal photogrammetric-cartographic system developed by Carl Zeiss and presented for the first time in 1987.
This paper gives a rundown on the major components of PHOCUS and deals with the latest further developments of the P-software, D-software, processing of object and graphics tables, graphics preparation and output, data acquisition, editing and the data base interfaces.

GEGENWÄRTIGER STAND DER PHOCUS ENTWICKLUNG

ZUSAMMENFASSUNG

PHOCUS ist ein universelles photogrammetrisches System, das von Carl Zeiss entwickelt und 1987 erstmals vorgestellt wurde.
Der Beitrag gibt einen Überblick über die wesentlichen Komponenten von PHOCUS. Es werden Hinweise über die neuesten Weiterentwicklungen der P-Software, der D-Software, der Bearbeitung von Objekt- und Graphiktabellen, der Graphik-Vorbereitung und -Ausgabe, der Datenerfassung, der Editierung und der Datenbank-Schnittstellen gegeben.

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