MAP PRODUCTION AND MAP REVISION WITH PHOCUS

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ABSTRACT

PHOCUS, a system for photogrammetry and cartography developed by Carl Zeiss, Oberkochen, was presented for the first time in spring 1987 and has since been used by a large number of different institutions. This paper lists some examples on the use of **PHOCUS** in map production and map revision. Some extensions featured by the latest **PHOCUS** revision are also mentioned.

1. INTRODUCTION

The value of a geographical information system (GIS) depends on the efficiency and versatility of its major components: data acquisition, management, use and revision. These components as well as the operators have to meet the most diverse demands. This is why there are not many ready-made systems that offer the optimum solution to all requirements. The responsibility for different data types is often in different hands. This is particularly true for topographical data on the one hand and thematical data on the other. Fast no-loss communication is required for good interaction in these relatively independent fields of application.

This is why Carl Zeiss decided five years ago to use its decades of exprience in photogrammetric and geodetic instrument design to develop a comprehensive software and hardware system with open flexible communication interfaces for collecting, updating and cartographically editing geometrical and geometry-related data in the most economical way. The result is the **PHOCUS** software system and the P-Series Planicomp analytical plotters /6/ as well as their periphery such as graphical digitizing and output devices. Human-engineering aspects were a major consideration in this development.

From the outset the design objective has been to expand **PHOCUS** by further geometric-thematical modules, i. e. to progress from an initially photogrammetric and cartographic system to a versatile geographical information system. In addition the fact was taken into account that there is still a considerable world-wide demand for pure map production that has to be satisfied in as short a time as possible with little training requirements and at low cost. **PHOCUS** is suited for this purpose too.

Moreover, in the field of computer-aided map production, there are specific photogrammetric tasks that can be handled very economically with analytical plotters. Examples are aerotriangulation and the measurement of digital terrain models (DTM) by means of various methods. **PHOCUS** contains suitable components also for this purpose.

The use of **PHOCUS** for these diverse applications is described in the following.

2. PHOCUS PROFICIENCY IN DIFFERENT APPLICATIONS

A software and hardware system designed for use in different fields of application should permit adaptation to differing requirements not only by the manufacturer but also by the user. Another requirement is that changing from one work environment to another should be easy and take little time to ensure that several projects can be processed by several operators with a single system.

Some of the means and user intervention capabilities **PHOCUS** offers for this purpose are listed below:

- Command menus for different devices (soft keys, digitizing tablet, cursor keys, graphics terminal, **PHOCUS** command panel) as well as macro commands
- Batch command files
- Object code tables that also allow the use of national standards
- Graphics codes (e. g. use of existing map production specifications)
- Instrument configuration and setup
- Project and operator data management
- Control point, camera and model data
- Map sheet library
- Handling aids
- Data interchange (ASCII files with different formats)
- On-line connection of other systems (direct communication)
- User programs (convenient programming interfaces on different software levels and ready-made sample programs)

The standard **PHOCUS** package already contains a large number of tools that allow **PHOCUS** to be used directly for different applications. Apart from the required application programs this applies in particular to menus, object code tables, graphics codes, instrument configuration and setup etc. All of these tools are complemented by ready-made files that can be used for training purposes /5/.

The following sections describe salient **PHOCUS** features for GIS applications, direct mapping, digital terrain models, aerotriangulation and terrestrial photogrammetry.

3. GEOGRAPHICAL INFORMATION SYSTEM

A GIS should allow the processing of geometrical data and attributes with freely selectable structures. While interactive graphical systems in the narrow sense of the term are primarily designed for direct graphical output of the stored data, map production is only one - although important - aspect within a GIS. Data interpretation according to thematical criteria is the main object of a GIS, with a graphical presentation generally being the result of this interpretation (Example: Which buildings belong to this owner?). A major requirement for such operations is a data base featuring data structures which the user can select and which - in contrast to con-ventional IGS systems - are object-oriented instead of being graphics-oriented. **PHOCUS** provides the tools required for this purpose.

The user can define the data structure required for a project in an object code table (OCT). The following structural levels are available:

Level	**Examples**
Project	Land register of country ABC
Area	Locality
Object class	Building
Object	Public building
Object item	Passage
Geometry item	Lines of passage
Coordinate data	Point of passage

The relationships between the object data on the project, area, object class, object and object item levels can be defined freely so that hierarchical relationships can be stored (Example: Roof ridge is part of a building.). Topographical relationships can be constructed on the geometry item and coordinate data levels during data acquisition and revision that may also have the character of networks (Example: Nodes in a pipe system).

The OCT contains data on the

- object class code
- object code
- object item code

and their interrelationships. The geometrical type can be specified for every object item code, i. e. point, line, area or text. Explanatory text can be added to each code.

The object code table also serves to check the user's responses to ensure data consistency already during collection and collection-related editing. The OCT is so designed that the diverse code catalogs that already exist in many institutions and countries can be used easily.

The current **PHOCUS** package already contains a series of tools for simple attribute data. Examples: Information on the origin of the data (digitized 1:5000 map, 1:12000 aerial photographs, terrestrial measurement etc.) or on the data status (final or provisional entry, updating requirements), technical object data (materiel and diameter of pipes) and many others. These data elements can be used for complex retrieval operations (Example: List all pipes with a given diameter) and are directly available to the user. Further options are being developed, with the aim being flexible structuring and coding of attribute data by means of an attribute code table (ACT). A typical example might be an "owner" attribute with name, address, date of birth etc. that might be logically related to the "Lot" and "Building" objects defined in the OCT.

4. DIGITAL MAPPING

Quite a number of photogrammetric instruments are being used with plotters or tracing tables for direct mapping during measurement. This work method is appropriate if a given map has to be produced as quickly as possible and at low cost, and if the data is not required for other uses. It is even more valuable if the data is also stored digitally for later off-line graphical output (digital mapping e.g. with PLANIMAP). **PHOCUS** and the P-Series Planicomp can be used very efficiently for this purpose.

PHOCUS does not require any specific preparations for direct mapping and digital mapping. Neither data constructs need be defined not graphics codes. The operator can use the conventional cartographic signatures during measurement, i.e. with the touch of a key he can enter commands like "brown line, 0.2 mm" instead of "object code 10 m contour" or "black line, 0.3 mm, dashed" instead of "Path". Ready-made menus and symbol li-braries are available for this purpose. The menus show the different sym-bols in the various grid fields or on the keys. Logical relationships that are being used intensively in GIS need not be defined. Functions like "Snap Point" or "Snap Line" and optical superimposition of the air photo on the map with VIDEOMAP, which are very valuable for high-precision map production, are available in these modes just as much as interactive gra-phical editing. Sifting lines, inserting pointa or changing the thickness or color of a line are typical editing examples.

5. DIGITAL TERRAIN MODELS

The measurement of digital terrain models (DTM) differs from general topographical data acquisition in that special measurement strategies and a relatively simple data structure are being used. The latter essentially comprises "normal" points that are often arranged in a grid, special points (synclinal points, peak points, anticlinal points), break and skeleton lines and cut-out area boundaries. Because of the large number of points that have to be measured, special measurement strategies have been evolved to ensure fast and complete area measurement. Some of these strategies directly produce a DTM that can be used for further processing (contouring, volume or profile computation) without a regular-grid DTM or a triangular mesh, for example, having to be computed (depending on the requirements imposed by the processing programs). The DTM software packages SCOP and HIFI make **PHOCUS** a powerful tool for this field of application.

The MDTM module enables measurement of grid-shaped, parallel-profile, cross-section and random-profile DTMs. Either the static or the dynamic method can be used for measurement. Static measurement is disadvantageous in that many points are measured in relatively flat terrain, which can be avoided with dynamic measurement (e.g. every 20 m in plan plus every 5 m in elevation).

The problem mentioned last can also be solved convincingly withe the progressive sampling method. This method uses a regular large-mesh grid for terrain measurement and automatically superimposes finer grids to suit the terrain curvature. The progressive sampling factor can be specified in accordance with the precision requirements. Break and skeleton lines can be measured in addition. This method is becoming ever more popular since the PROSA program was introduced at the University of Munich /1/. PROSA has now been integrated in **PHOCUS** and the P-Series Planicomp and developed further. A salient new feature is real-time superimposition of contour lines with VIDEOMAP for immediately checking the measurements made in a subarea and, specifically, for assessing whether uneven terrain has been measured with sufficient precision. If not, additional points can be measured as required.

Both modules, i.e. MDTM and PROSA, exhibit the convenient and flexible handling that is so typical for PHOCUS /3/, viz. useful details like "Delete last point" and "Abort profile". The measured data can be stored not only in an ASCII file but also in the **PHOCUS** object data base. MDTM measurements can be used directly for orthophoto production with the Z 2 Orthocomp. The new HIFI-88 package is even capable of computing contour lines directly from the PROSA data structure /4/.

6. FURTHER APPLICATIONS

Photogrammetric aerotriangulation is a major field of application for analytical plotters that has proven its worth for years. Even so the P-Series Planicomp and **PHOCUS** offer further improvements in this field. Apart from the linkage of BINGO, PAT-MR and other programs for bundle and model block adjustment, a new PHOCUS module called MECO affords particularly convenient measurement of photo and model coordinates. Special features are the measurement of approximate coordinates with a digitizer and the automatic setting of points that are known precisely or approximately.

Terrestrial photogrammetry deals with objects whose surfaces are randomly arranged in space and which often represent closed bodies (e. g. architectural objects). Such data can be stored in the **PHOCUS** object data base without the data having to be assigned to several files as in other systems. All object items can automatically be assigned an attribute during measurement that classifies them as elements of a specific façade, for example (attributes like "North façade", "West façade" etc.). Object selection for representing different planes is facilitated considerably by these attributes. The floating mark can be guided in the steremodel with the P-Cursor or the handwheels and foot disk of the P-Series Planicomp in any spatial plane. A P-Cursor movement on the tablet can, for example, result in a model movement on a sloped roof plane.

The measurement of satellite photograms involves specific corrections made necessary by the small photo scale and, in some instances, special taking geometries. Program modules for these purposes are also available in **PHOCUS**. Following contour lines in SPOT models, for example, is now also possible /2/.

These examples illustrate the wide range of functions of the described products. To complement them, users have developed special **PHOCUS** modules e.g. for environmental protection, land consolidation, and linkage with other systems within one year of its introduction already. The intensive development work by Carl Zeiss and our customers ensures a steady flow of further application-oriented software modules.

7. COMPATIBILITY

PHOCUS is highly compatible with other methods and systems.

Small companies in particular must rely on their system being capable of step-by-step transition to modern methods, e.g. from digital mapping to using structured object data.

The owners of Zeiss C-Series Planicomp and PLANIMAP can continue to use their equipment and change over to the new system (e. g. by purchasing a new Planicomp P-Processor and HP 1000 A computer memory extensions) by installing **PHOCUS**. An efficient data interchange link also allows **PHOCUS** and PLANIMAP to be used in parallel.

A number of data converters afford data interchange with other systems (e.g. ISIF, DLG, EDBS, AUTOCAD). A communication program for connecting a Planicomp to other systems and using the photogrammetric **PHOCUS** software (P-Software) with these systems is also available.

Their versatility, openness and compatibility make **PHOCUS** and the P-Series Planicomp a rewarding investment also in the future.

LITERATURE

/1/ Ebner, H. and Reinhardt, W.: Verification of DTM Data acquisition and Digital Contours by Means of Optical Superimposition. Technical Papers of the ASPRS-ACSM Annual Convention, Vol. 5, Baltimore 1987

/2/ Kruck, E.: Photogrammetric Mapping of SPOT Images with BINGO in the **PHOCUS** System. Presented Paper 16th ISPRS Congress, Commission III, Kyoto 1988.

/3/ Leidel, W.: The Principles of **PHOCUS** Software. Oberkochen 1987

/4/ Reinhardt, W.: Digital Terrain Models - New Developments and Possibilities Presented Paper 16th ISPRS Congress, Commission IV, Kyoto 1988

/5/ Rosengarten, H.: Tuition Concept and Learning Aids in Modern Application Software, Using **PHOCUS** as an Example. Presented Paper 16th ISPRS Congress, Commission IV, Kyoto 1988.

/6/ Saile, J.: The Special Features and Versatile Interfaces of the P-Series Planicomp. Presented Paper 16th ISPRS Congress, Commission II, Kyoto 1988.