

SOFTWARE FOR DATA ACQUISITION FOR LEICA PHOTOGRAMMETRIC WORKSTATIONS

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ABSTRACT :

The introduction of the SD line has enabled users to interface their analytical workstations to a selection of host computers, operating systems and applications software. The overall structure of Leica and third party software modules is explained followed by brief descriptions of Leica products for DOS, Unix and VMS hosts. The customer thus has an attractive choice of software for the capture of structured and unstructured data for triangulation, digital mapping, DTMs and GIS.

KEYWORDS : Aerotriangulation, Analytical, DTM, GIS/LIS, Mapping, Map Revision

INTRODUCTION

Starting with the introduction of the SD line in 1991 Leica offers a wider range of choice of host computers and operating systems for the photogrammetric workstations. A full range of photogrammetric software is available for MS-DOS, Unix and VMS systems.

The existing photogrammetric software for different host computers and operating systems is the product of more than 10 years experience of software development for the AC-, BC- and DSR generations of analytical instruments. As a result of the input from our users new features are added but compatibility with older systems is preserved.

THE LEICA RTP SOFTWARE

A basic concept for Leica photogrammetric workstations of the SD line is the RTP or the realtime processor (RTP). The concept of the realtimeprocessor, first introduced by Leica for DSR1, is extended for the SD line.

The RTP software of the SD line controls the realtime loop but also additional functions. A kernel or task scheduler is distributing the resources of the realtime processor between different tasks (Cogan, Hinsken, 1992). At this moment the actual tasks are the realtime loop, the control of hardware functions (zoom, illumination, measuringmarks and optical switches etc.), communications and user interface. The RTP software and its real time computer form an integral part of the SD instruments. Independently of the choice of host computer and actual photogrammetric software used the same realtime processor and RTP software is used.

APPLICATION SOFTWARE

Orientation software and other application modules are running on the host computer. Orientation parameters computed are downloaded to the RTP. With the concept of the RTP the user benefits from an open system. Any mapping, CAD or other application package can be connected to the SD hardware by means of the well defined interface of the RTP. Thus the customer has access not only to Leica software but also to a variety of third party products all using the SD line hardware and RTP software.

Existing third party solutions includes mapping software and software for DTM grid data collection and profiling. Most third party solutions requires orientation software from Leica.

LEICA SOFTWARE

Leica offers a full range of software for different applications. The list includes software for model orientation, measurements for aerial triangulation, DTM data collection, profiling and cross sectioning, measurements in momocomparator mode, mapping and plotting on a variety of flatbed and drum plotters.

Orientation software

Model set-up/DSR1B, MS-DOS, VMS

Basic software package for instrument calibration, model orientation, camera management, ground control and project management. Menu driven. Modular program design. ASCII text files.

ORI, UNIX

For orientation of pairs of stereo photographs with vertical, oblique or convergent exposures. Initialization (input of image and model parameters), measuring and computing inner and outer orientation.

The necessary functions supporting the orientation software as calibration, control point and camera management, data output and input etc. are handled by the BASIC software module.

Aerial Triangulation measurement software

AETRI, MS-DOS, VMS

Data Collection for Aerial Triangulation, with on-line check of model connections for direct elimination of gross errors with the following features:

- Automatic drive to points measured in the previous model.
- Automatic tie-point numbering facility.
- On-line check with display of residuals of model connections.
- Editing and remeasuring of points.
- Remeasuring of models
- Reorganization of the strip after remeasurement of a model.
- Preliminary Strip Adjustment for gross error detection by means of polynomials.
- Preliminary Block Adjustment for gross error detection by means of polynomials.
- Output of photo or model coordinates in simple ASCII files for transmission to off-line block adjustment packages (for example BLUH, PAT-M and PAT-B).

ATP, Unix

The Advanced Triangulation Program, ATP, provides an integrated solution for aerial triangulation measurements. It features :

- Project management
- File mangement
- File editing
- Measuring routines
- Online check of model connections
- Creation of output files for independent model or bundle block adjustment (PATM, ATM, PATB)
- Automatic numbering of orientation points
- Automatic drive to orientation points and to points measured in the previous model
- Automatic relative orientation
- Absolute orientation
- All necessary parameters for remeasurement and individual model setup are stored

DTM Data Collection Software

DTMCOL, MS-DOS, VMS

DTM and profile collection package with the following features for computer controlled measurements :

- Measurements in a grid pattern or in a profile mode.
- Operator controlled speed of the measuring mark in profile mode.
- Data can be captured in a dynamic way ("on the fly" by distance, change of slope) or in a static way.
- Project Boundaries. Measurements are taken only within these boundaries.

- Model Window Definition. A window must be defined by either digitizing or by manual input of ground coordinates in order to avoid measurement overlap.
- Grid Measurements. The grid spacing is user defined.
- Parallel profiles. The user defines the direction and the step-over distance of a profile.
- User defined profiles. The user may define start and end points for particular profiles.

DTM, Unix

DTM and profile collection package with the following features for computer controlled measurements :

- Single profiles
- Parallel profiles
- Parallel profiles for orthophoto production
- Operator controlled speed in profiling
- Regular grids
- Arbitrary profiles and grids allows measurement of predefined data sets for registering time dependent changes
- Cross sections
- Single point (static) recording or automatic (dynamic) by time, distance or slope

Plot programs

PLOTR, VMS, MS DOS

PLOTR is an off-line plot program using data collected with MAPS200 or PC PRO400. Output is possible on Leica GP1 and TA10 precision flatbed plotters or on less expensive drumplotters. All parameters like scale and sheet size can be specified. The complete data file or selected features can be plotted.

PLOTF, MS DOS

PLOTF is a plot program with format conversion for Leica GP1 and TA10 precision flatbed plotters. The program reads data generated in HPGL format and plots this data after conversion for GP1 or TA10. The HPGL plot file can be generated with MicroStation, AutoCAD or other sources.

PLOT, UNIX

PLOT is an off-line plot program for Leica TA precision flat bed plotters or HPGL compatible plotters. It features:

Map sheet preparation, plotting of ground control, plotting of atlas and mpfiles (generated with MAP) and profiles and cross sections (generated with DTM). Plotting is possible in all planes parallel to the coordinate planes (XY, YZ, XZ) but also in any plane defined by three points.

Monocomparator software

MCP, UNIX

On the Unix based systems a program for measurements in monocomparator mode, MCP, is available. MCP includes modules for measurements, data editing, data output for adjustment (PATB) and printer output. If there are control points enough in the image its orientation can be computed.

Close-Range Photogrammetry

ORIZB, UNIX

For the SD line instruments ORIZB exists as an add-on module to the standard orientation software ORI. ORIZB supports orientation of terrestrial stereo models, taking into account additional mathematical conditions.

MAAS-CR, MS DOS

MAAS-CR is a new package specially designed for close-range applications (Hinsken, Cogan, Kotowski, 1992). The package is directly connected to the Leica RTP and integrates measuring process, bundle adjustment and analysis in one package. The program handles additional observation in object space like distances, angles, height differences, planes etc. It provides free net adjustment and deformation analysis as well as up to 21 parameters for on the job calibration of multiple cameras. After bundle adjustment models are formed from the orientation parameters obtained. The models are downloaded to the SD RTP. The program also features handling of multiple models on the stages.

Mapping software

PC PRO 600, MS-DOS

PC PRO600 is a program built around MicroStation 4.0, running under MS-DOS on 386 and 486 PC's. MicroStation is a popular and powerful CAD package, from Intergraph Corp. and Bentley Systems. It allows highly customised applications to be built around it, which allows the powerful features of PC PRO600 to be seamlessly intergrated into MicroStation.

PC PRO600 makes full use of the graphical user interface of MicroStation. This interface is exactly the same on every version of MicroStation, thus reducing learning times for moving between computers. Full use can be made of mouse, tablet, stereoplotter, windows, menus, icon palettes, menus etc., to provide an interface efficient for data collection, management, interactive editing, and starting batch editing.

3D photogrammetric data capture is possible with the Leica SD line, Kern DSR line and encoded analogue instruments. Full use is made of the analytical stereoplotter: Driving the instrument during snap operations, driving to mouse posi-

tion, in collection of gridded DTMs and profiles. PC PRO600 is fully integrated with the new Leica Coloriss image superimposition for the SD line photogrammetric workstations.

As a complement to 3D photogrammetric data capture 2D digitizing with a wide range of digitizing tablets is supported. By performing an orientation it is possible to digitize directly in ground coordinates.

Fast graphic update keeps the graphic image online with the stereoplotter: dynamic panning, zoom in/out, set view scale, fit the view. The actual scale is displayed.

MicroStation supports a wide range of graphics cards, from low resolution 640*480 pixels 16 colour VGA to high resolution 1280*1024 256 colour coprocessor based cards. MicroStation can drive two graphics monitors at one time, with the MicroStation windowing system running on both. One monitor could be used as a graphics overview, one as a detail plot etc. MicroStation provides a robust, industry standard data format that can be used on many different computers and with many different third party packages.

All coordinates in the graphic database are stored as true 3D ground coordinates. MicroStation allows the following geometric elements (amongst others) to be stored in its graphic database: Point, line, text, parallel lines and shapes.

MicroStation graphic files (design files or .dgn files) can be freely transferred to a wide range of different implementations of MicroStation

MicroStation includes DXF Release 10 and Release 11 translators, for both import and export.

PC PRO600 includes import and export of KernCAM files from MAPS200 or PC PRO 400.

PC PRO600 provides project management tools for grouping graphic files into projects, creating files, renaming and deleting files, and the use of standard seed files which contain constants useful for mapping.

Tools for reference file management: fast attachment in read only mode, for model surrounds, project coverage etc. Reference files can be used for snap operations, but the data cannot be modified in any way.

A Library program is used to create a table of feature code descriptions. Each library entry can be a symbol, a linetype, a text annotation or a closed-shape.

Symbols are cells (MicroStation graphic representation), colour, weight, line style, level, scale and a possible associated annotation (lines of X, Y or Z coordinates, or text strings). Line types are MicroStation symbologies, possible online patterning, level. Shapes are MicroStation shapes with possible area or hatching descriptions.

All data collected with PC PRO600 is tagged with the library defined feature codes. Further, each element can hold five tags at once if the element defines multiple features. Tools are provided to display the tags associated an element, to change the tags etc. Coding can be made either by the operator during initial data collection, or afterwards during editing phases of the project.

Effective digitizing procedures: type in (or use the Polytell Keypoint) to call up a feature code number. The library definition is used to set up MicroStation ready for symbol, linetype or shape placement.

Various commands are used to digitize, including features such as continous collection modes, stream mode, undo/redo last point, undo/redo last feature, snap and drive, undo contour, drive the instrument in Z

Instant changeover between mouse and stereoplotter: when one is moved it takes over the cursor. Useful with drive instrument to mouse location, partial delete (of for example contours)

Various manuscript preparation tools: plot ground control points, gridding program (lines, symbols, annotations). Included are powerful facilities for management of models for map sheet preparation, including reference files.

Contour annotation, annotation across multiple contours, slope hachuring, cleaning interior boundaries (cleaning contours from houses).

MAPS 200, VMS

VAX MAPS 200 for GP1, TA10, DMP, CALCOMP 1040, HP pen plotters or softcopy display inside VWS. Digital and/or Graphical Data Collection in combination with the above specified graphics output device, offering the following features:

- Extensive Feature Code Library
- Manuscript Preparation with any type of grid, various types of grid annotation and plotting of ground control points
- On-line Compilation with simultaneous recording of data and graphical output.
- Large screen display of X, Y, Z coordinates and P (distance) in ground units.
- Display on the screen of the plot mode, feature code number with related feature description, pen and scale factor currently in use.
- Eight digitizing/plotting modes: Straight, Curve, Continuous Straight, Continuous Curve, Object (Symbol), Spotheight, Network, Arc
- Automatic spot height annotation with free placing of the annotation
- Variable annotation of symbols with alphanumeric characters

- Model connection to extract from files of neighbouring models the end points of lines which lie in the current model. The floating mark can be driven to these points and the lines can be continued
- Parallel line facility with determination of the width either by digitizing or keyboard entry, different line types can be specified for either side
- Simultaneous closing, squaring, clipping and aligning of features, e.g. buildings and roads and fences etc. (up to 500 vectors), with or without open areas
- Different groups of features are aligned to their respective azimuths also
- Multiple coding: up to 10 feature codes can be assigned to the same feature

PC PRO400, MS DOS

PC PRO400 is a mapping package based on MAPS200 for MS DOS host computers. It features on-line output on GP1, TA and HPGL compatible plotters. A softcopy version will be available. This is an entry level mapping package for SD line instruments with a MS DOS host computer.

MAP, UNIX

MAP, the map data acquisition and editing software unifies the hardware generations of the AC1, BC1, BC3 and SD 2000.

The most powerful mapping software is not accepted by practitioners if its logical concept, the interrelations of basic data files (basic parameters) with graphic libraries, the editing functions and the human interface (between software and operator) have not proved its quality under day by day practical working conditions. MAP fullfils these requirements.

- The concept is user friendly and production oriented but without complex and sophisticated database features.
- The database is structured in object classes (levels), object groups, segments (lines) and points.
- Input, management, editing and retrieval of data in the database structure is possible.
- A true XYZ database is provided, normally in state plane coordinates, with 14 digits of precision per axis.
- Data can be read in from a 2D screen cursor position, by 3D typed in coordinate values or in 3D on line mode from an analytical restitution instrument. Each of the modes is immediately accessible by use of function keys or "hot keys".
- Library files are available for graphic definition of line, symbol and pattern representation in either a general application or project specific adaptation.
- Four character alpha-numeric attribute can be given to each data item for selective post-processing of data.
- Feature coding is available with a six character code for object class number or alphanumeric description of object class.

Apart from the usual point and segment editing functions there are automatic routines for linking pairs of lines, clipping overshoots and hanging under-shoots, deleting all data within a given polygon, and for combining segments into groups for subsequent global editing.

- Delete inside/outside polygon
- Pick to line, snap to any existing feature
- Reinsert previously deleted feature, or part of a feature
- Adjust line connections (hang and clip)
- Rectangularise objects or groups of objects (building squaring)
- Close, square or hatch a polygon
- Connect to reference file (edge matching)
- Change attributes (feature code, line type, pen etc.)
- Change scale representation
- Delete, place or change text or symbols
- Semi-automatic contour line densification and annotation
- Fit feature group to local field data
- Zoom and pan a selected window
- Graphics management: group/ungroup object classes, select filter object classes, select segments, select points, select projections in X, XY, ZY and Z planes.

The new Leica Coloriss Image superimposition will be available for MAP on SD line photogrammetric workstations. In addition versions of MAP with 2D digitizer input (MAPDE) or with the plotting table on-line (MAPOP) exists for the SD line instruments

Mapping/LIS/GIS

INFOCAM/MAPIT

This is the Leica LIS/GIS with the capability of on-line data collection on the SD line photogrammetric workstations. At present seven different modules have been implemented in the build up process of the database system. The existing modules are:

IMAGE: "Interactive Manipulation of Geo-Elements"

The spatially related data stored in the INFOCAM data base is processed with the IMAGE module. Over 150 functions are available in user defined menus. The geometrical and themetical aspects of the spatially related objects are processed by groups of functions:

- Data capture and construction functions
- Editing
- COGO functions
- Spatially related and/or thematic query and display
- Computation of geometric conditions according to the least squares method
- Polygon overlay
- Management of attributes
- Dimensioning and display of attributes

INCOME: "Infocam Compilation Of Map Elements"

INCOME is a module for data capture and updating of 2D or 3D data with digitizer or photogrammetric input. On-line and off-line digitizing are supported. On-line connection with Leica SD line photogrammetric workstations and Coloriss system allows image superimposition of available data from the INFOCAM database merged with the newly captured data.

INCA: "Infocam Cadastral Application"

INCA has been specially designed for the use in surveying for land registration. Using the mutation concept, INCA guarantees that the highest priority is given to the legal validity of data compliance and to fulfilling local laws and regulations.

IMPRESS: "Infocam Map PREsentation System"

Pans and maps remains important carriers of graphical information in order to guarantee access to spatially related data. In addition to setting out plots there still is a demand for high quality maps and plans. With a collection of layout functions IMPRESS offers the same possibilities as a "desktop publishing system". Creating and placing titles, headings, gates, grid north arrow, diagrams, map rotation, zoom etc., is handled by an interactive process.

INUSE: "Infocam Utility Service"

INUSE is a module for utility mapping and network documentation. Various types of dimensioning, display of attributes as well as calculation and display of longitudinal profiles can be carried out.

DTM: "Digital Terrain Model"

INFOCAM uses the program SCOP from the university of Vienna as DTM module. SCOP allows interactive processing of digital terrain models and supports gridded data, irregularly distributed points, profiles, contours and break lines as input data. SCOP offers interpolation and display of contour lines, calculation and display of profiles and cross sections, volume calculations and calculation and display of perspective views.

TASCAL: "Tacheometric Surveying Calculations"

In this module all functions for recording and processing tacheometric data are collected. The site coordinates and elevation of points are calculated either from manually or automatically registered measurements

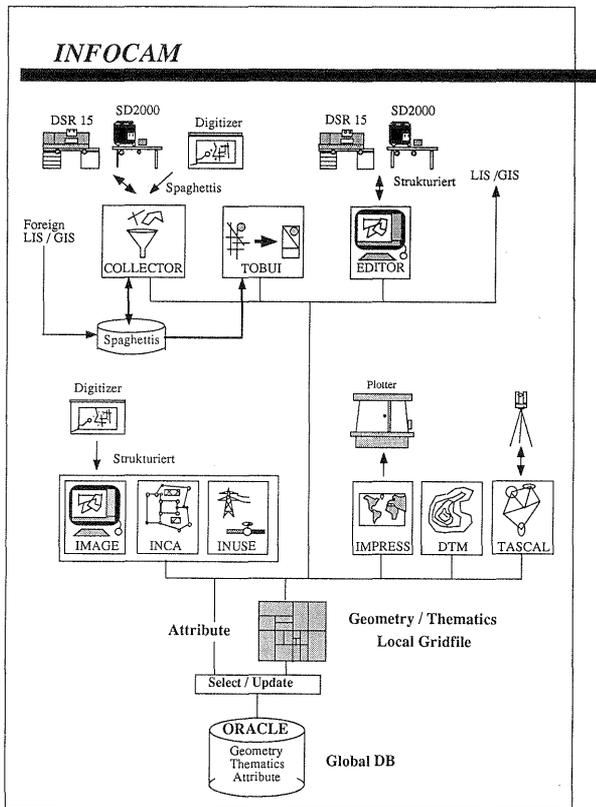


Figure 1. INFOCAM software modules

Photogrammetric datacapture with INCOME

The capture and updating of data forms a very important and powerful function of INFOCAM/MAPIT. It is carried out with the aid of the INCOME module linked to the SD line photogrammetric workstation. This function must be simple and reliable in order to be cost effective.

Data selected from the data base and newly captured data can be merged into the Coloriss image superimposition system on the SD line workstation. Thus the operator can compare the existing digital data from the data base with the photogrammetric model. With Coloriss as an additional tool he can easily and safely carry out the necessary changes in the INFOCAM data base.

If a huge amount of data must be collected or processed, one would like to capture the individual lines and symbols quickly without paying too much attention to structures. However, for small projects or updating of data bases it is of an advantage to capture the geometric elements as such. INFOCAM/MAPIT offers both solutions.

Recording in "free" mode is suited for new projects but can also be used for updating. The operator digitizes "spagetti". One (or several) thematic codes can be assigned to the spaghetti and the operator is freed from structuring and description work. He can digitize large amounts of data quickly and efficiently. The data is prepared for entry into the data base in a second step.

"Spagettis" are automatically structured by a topology builder. In this second step the geometric and thematic consistencies are checked. When updating, the newly captured Spagetti data is combined with the existing structured data. Objects consisting of regions and lines are made up by comparing the thematic codes. Irregularities are recognized by the system and can be cleaned with support from the program. Once the geometry is correctly stored, the attribute data is entered to make the data base information complete.

The "structured" mode is important for updating and revisioning. If an extract from the existing data base is superimposed it is easy for the operator to carry out the necessary changes. Consistency checks are carried out on-line. Thus with a relatively small amount of data to update the process is faster than the two step procedure outlined in the previous section.

Development Tools: P2 Libraries

For programmers wanting to interface their applications with the SD 2000 we provide a complete set of MS-DOS libraries in C, C++ and Pascal.

CONCLUSIONS

With the introduction of the SD line photogrammetric workstations Leica offers a wide range of application software on hosts with different operating systems. The customer can easily integrate the photogrammetric workstation in his existing computer environment. At the same time compatibility with former systems of Kern and Wild origin is preserved.

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