LEICA MOBILEMATRIX – THE NEW DATA ACQUISITION SOFTWARE FROM LEICA GEOSYSTEMS

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ABSTRACT:

The world can be represented in GIS (Geographic Information System) and CAD (Computer Aided Design) systems, showing us the position and attributes of objects, the location of reference points and countless other kinds of spatial information. Leica MobileMatriX allows the user to add points and measurements, completed by a surveyor in the field using either a TPS (Total Station), GPS (Global Positioning System) or tape measurements, to his map, which is based on GIS or CAD systems.

Leica MobileMatriX is a software solution for the interactive processing, visualization and maintenance of survey and feature data directly in the field, based on the latest ArcGIS^{TM} technology from ESRI. MobileMatriX provides functionality for editing Geodatabases in the field and the flexibility of working remotely.

With MobileMatriX the history of the data and the data source is stored, which ensures that the quality of the data is always known. Additionally, it is also possible to write the attributes observed in the field directly into the database as objects are measured. Furthermore, since the software is graphically based, data quality and completeness can be checked immediately as data is acquired, which avoids expensive re-measurement when quality control activities in the office detect deficiencies.

MobileMatriX is specially suited for the workflow in national mapping agencies, cadastral offices and engineering companies - it provides extensive variety in the workflow, e.g. the connection to TPS and GPS sensors, and the possibility to extend the MobileMatriX framework and implement required tools to support the workflow in big agencies.

Introduction

Leica MobileMatriX performs extended survey data management for a variety of different computations.

Processing functions are available in the field and thus data acquisition and revision cycles are significantly simplified. Leica MobileMatriX provides more than data collection and feature creation, points can be easily selected and staked-out using either TPS or GPS instruments. MobileMatriX provides tools for display, query, surveying computations and mapping tasks like cartography, surveying and editing.

To ensure maximum effectiveness to the user, different working methods are supported (see Fig. 1):
- Leica MobileMatriX at the instrument.
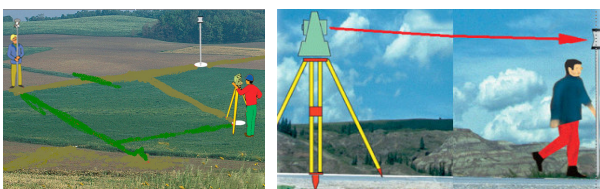- Leica MobileMatriX at the pole, and hence allows one-man surveying.

Figure 1: Different working methods are supported

A Leica MobileMatriX user is any person responsible for managing and collecting spatial information and/or making measurements either using TPS or GPS sensors or tapes in the field to create and update maps and plans, and is suitable for:

- Cadastral offices
- Engineering companies (such as Private Surveyors, Planners, Utility companies, Offshore companies, Leica's TPS and GPS customers)
- Governments and governmental agencies (such as Mapping Agencies, Military, Local and Water authorities)
- Local governments (such as Environmental and Fiscal Agencies, Asset Managers, Regional and Urban Planning Departments)
- Consultants
- Environmental analysis
- Facility Management
- Archeology and many more.

The MobileMatriX Story

Reference Points are important for surveyors as they form the basis for computing new points to locate features with their associated attributes. Features are shapes in a spatial data layer, such as point, multi-point, line or polygon that represents a geographic object. The accuracy of features depends on the source of the data and the method and equipment used for collecting the data. The accuracy of equipment used to collect data varies between a few centimeters and several meters. Often information that describes the positional quality of objects is not stored in the database. By providing quality information, ambiguity is always present.

Leica MobileMatriX allows the user to add points and measurements, completed by a surveyor in the field using either a TPS (Total Station) or GPS (Global Positioning System), to the map. The typical accuracy of this survey data is less than two centimeters. With Leica MobileMatriX you keep the history of the data and the data source is stored. This ensures that the quality of the data is always known. Additionally, it is also possible to write the attributes you see in the field directly into the database as objects are measured. This functionality extent the GIS activities from the office to the field.

Surveyors traditionally use to work with paper maps in the field, such techniques have several disadvantages, including hard handling, updating in the office, hardly usable in bad weather conditions. With MobileMatriX surveyors continue to take maps in the field, but in digital form, as map background in MobileMatriX. This functionality provides significantly enhanced usability for surveyors to make their daily work easier.

The work of a surveyor does not end upon completing the fieldwork. The fieldwork must be documented. This documentation is often conducted by means of creating a map. The task of map creation can easily be fulfilled with the Layout functions supported in Leica MobileMatriX.

Few governments or private companies have enough money to measure a whole country or city by using GPS or TPS within a justifiable time. On the other hand, surveyors are measuring small parts of our world every day. Why not combine this data within one system? If the data could be combined, Surveyors and GIS users could conduct their daily activities in harmony. By actively using GIS databases, surveyors can continually update the GIS database to reflect the most recent situation. Leica MobileMatriX provides this technology.

Typical surveyor problems and how does MobileMatriX solve it

Problem	Solution
More and More complex mapping areas and tasks	Graphical feedback and Raster background (Orthophoto, ...)
Huge Data amount	TabletPC Power and Performance
Sensor flexibility	GPS and TPS connection, extensible with 3rd party sensors
One man field work (robotic)	Configuration of TPS through software/TPS tools such as Joystick, TPS Status/big map view for displaying the data
Attribute collection will rise	All information is stored in databases, design of UI

Surveyors are used to work with TPS and GPS – not highly familiar with Windows UI	TPS and GPS Status
Expensive re-measuring when something was measured wrong or forgotten.	Completeness and Quality control out in the field - You see what you do!
Office – Field – Office transfer will become more important	Check in/out of measured data
Survey Point could have multiple thematic meanings	Multiple feature editing
Survey work is complex – sights not always possible – e.g. finishing feature not possible at all times	Pending feature editing
Information not available in the field (Revision cycles)	All data (survey data and feature information) is out in the field – not only PointIDs and their Coord.
Different UI in field and office in the near future	Windows based UI – state of the art
Maintaining huge data amount	SQL Query based system
Mistakes in measurements (e.g. typo while entering tape measurements)	Computation Network Analyst allows to recomputed your network without deleting all existing computations.
Field crews need their special tools and workflows	MobileMatriX is customizable with Visual Basic.
Paper field books have disadvantage: updating in the office, hardly usable in bad weather conditions	TabletPC with electronic ink writing notes, doing sketches in the map and Windows Journal as application for handwriting notes.

Sources of Measurement Data

Surveyors make measurements in the field between points such as Reference Points and physical features to define their location and geometry within a given spatial reference. Surveyors are used to record their measurements in field-books and sketches.

The Field-Book functionality

A field-book is used to record the original survey measurements. Field-book functionality is inserted into Leica MobileMatriX and all measurements, setups and information is stored in the database. The field-book itself is now replaced with Leica MobileMatriX. The Survey Explorer (Fig. 2) is used to display the measurements (such as TPS and COGO) and Survey Points you have performed in the field. Additionally, the Survey Explorer is used to bring the content of the database
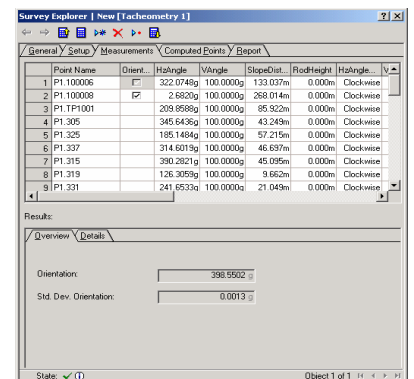

Figure 2: Displaying all measurements with the Survey Explorer

to the user level by displaying the computation and their results, to navigate between different computations, survey points and measurements. Furthermore, SQL Queries provide easy functionality to navigate through the huge data amount a surveyor needs to have in the field.

The Sketch

A sketch is often used as part of the field book to record information not recorded in the field-book. COGO information does not always have a physical source but may sometimes come from the implied knowledge of the user. For example street edges may often be accepted in the field as having parallel edges. Leica MobileMatriX offers tools (available if working with TabletPCs), which allows writing field notes and sketches directly in MobileMatriX (see Fig. 3).
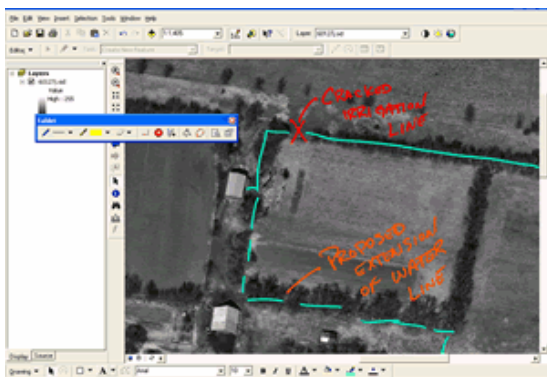

Figure 3: Working with the TabletPC tools

Attribute collection in the field

While out in the field and observing features, the survey crew or other specialist can directly connect the feature attributes and store them directly in the database together with the feature (see Fig. 4).

Further more pictures or documents can be attached to each feature.

Figure 4: Attribute collection

Synchronization with ESRI Databases

Leica MobileMatriX provides tools for synchronizing the office database with the field database and vice versa. More and more mobile users, such as a field survey crew, require similar functionality. They need to work independent from an organization's infrastructure and database connection, often for a longer period of time. When preparing for a particular work order or project, the relevant data would be transferred to a portable device, such as a TabletPC. This device would then be disconnected from the network, enabling the user to operate independently.

Mobile users may then continue to work with and modify the data in the field even though they are disconnected from the office network. When a connection to the network is re-established, any changes made to the data will be transferred to, and integrated with, data maintained in the central database.

Survey Features

Survey Feature - the fundamental MobileMatriX object used when surveying. When surveying, a Survey Feature should be created for each real-world object that is about to be surveyed. Leica MobileMatriX makes it possible to fill the gap between surveying and GIS by using survey points to define the vertices of features. This allows the user to link the existing feature data with the measured points in the field. Instead of deleting valuable thematic information and creating a feature completely new, the existing feature can be transformed to the accurate position measured in the field or new features can be surveyed while the thematic feature information is linked to the survey point.

By linking features to survey points it is possible to associate feature geometry with the accuracy defined for the survey points (see Fig. 5). This gives the user additional knowledge about the quality of features, whether they come from an old map that has been digitized or from a highly accurate GPS device. With Leica MobileMatriX, it is always possible to have information on feature source and quality. Survey points are associated with measurements and computations and can be linked to features in the Geodatabase. These features are called survey features. Survey features should not be thought of as different to any other features. They are simply features that have become survey-aware and are created while you perform a survey task
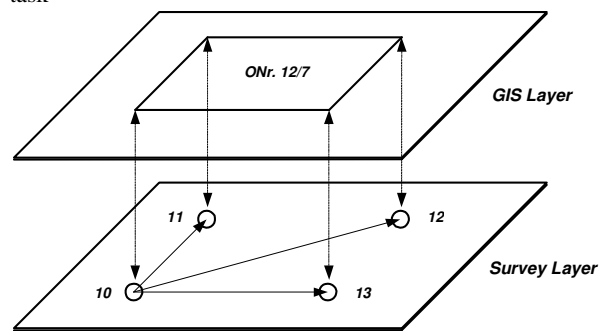

Figure 5: The link between survey and GIS data

The end result of an update is that each survey feature geometry is altered to coincide with the geometry of the link *survey points*.

An easy example for that functionality, illustrated in Fig.6: You simple sketch the feature you want to survey, then you simple survey, maybe using a TPS or GPS, the vertices of the building

and the sketched feature changes from a simple sketch to a proper surveyed feature with accurate location information.
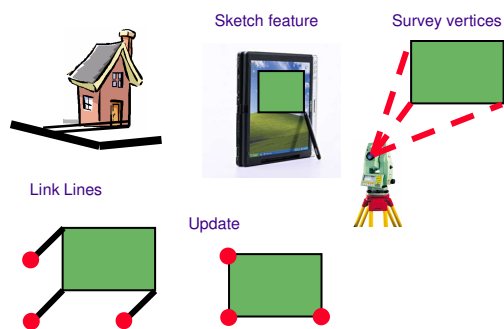

Figure 6: Measure a sketched feature

Multiple Feature Editing

Creating more than one feature with just one side-shot measurement is also possible in MobileMatriX. Such technology ensures economic field practices whereby one point is measured to extend/create multiple features. The Surveying window (see Fig. 7) contains a list of multiple Survey Features. By simply checking the required features, the user can easily define which feature he wants to measure with the next side-shot or COGO measurement.

Figure 7: The Multiple Feature Editing window

The list of Survey Features may be sorted by name, class or type by clicking on that column header.

Pending Features

Pending features technology allows the user to maintain already existing data easily in the field. There is no need to delete an existing feature when modifying it. Simply use the Insertion Lines to edit an already existing object.

Working With Leica MobileMatri*X*

Leica MobileMatriX supports all phases of data collection, refinement and representation. It easily imports for post-processing purposes various types of geometric data, such as field survey results, digitized data captured from maps, manually entered coordinates and third party data. MobileMatriX captures all the phases of surveys. Processing functions are available in the field and thus data acquisition and revision cycles are significantly simplified.

MobileMatriX viewing capabilities allow simultaneous representation of survey data, measured features and underlying survey point quality. These features can be comfortably edited using graphical editing tools and integrated with new thematic information, or additional survey data, at any time. With the addition of a known quality-level on data, an iterative enhancement of its quality over time is assured.

The Data Manager (see Fig. 8) replaces the ArcCatalog known from ESRI. With the Data Manager the user can create new databases, feature datasets, feature classes, survey dataset, survey projects, conversion to other data formats and many other tasks.
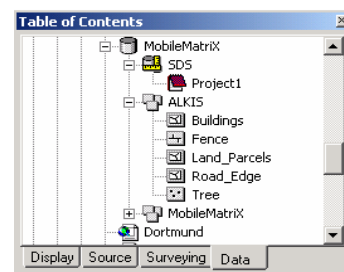

Figure 8: Data Manager as replacement of ESRI's ArcCatalog

Reporting
Reporting in MobileMatriX is based on XML scripts. Reports can directly be stored in html format. This offers the user an easy way of sharing the results through the Internet.

Data Exchange
For data collected in the field by a surveyor it is normally a long and complex chain into a GIS. After data collection, the data is imported to an office-software to execute the computations for the points. The resultant points are then exported to a CAD system where additional constructions are performed and finally the data is imported into the GIS. If the user detects a problem in his results, by checking the position of the created features in the GIS, he/she has to rerun the whole chain. All survey data measured in the field is automatically stored into the ESRI Geodatabase format, eliminating the need for data conversion when moving data between Leica MobileMatriX and ESRI's ArcGIS applications. Just transfer the data into the office and open it with any ESRI® application. To update the office database, simply use the synchronization mechanism to transfer the data from office to field and vice versa.

To ensure maximum compatibility with all systems, Leica MobileMatriX allows the user to interact with data from different sources, like CAD systems, Shapefiles and Raster Data. Additionally, Leica MobileMatriX provides interfaces from and to the most common TPS formats such as GSI (Geo Serial Interface), ASCII, SDR, TDS and Geodimeter. Such functionality provides the ability to process most data and use the powerful tools for data editing also in mobile offices. Custom converters may be created in any COM programming language. The powerful ArcGIS scripting language, Microsoft Visual Basic®, offers a very convenient environment for this purpose.

The Key Features

Connection to TPS Sensors

All of the powerful tools associated with the TPS instrument and the use of them (see Fig. 9) are also available in Leica MobileMatriX; such tools include Controlling and Setting up the TPS with MobileMatriX, ATR and Power Search support, steering the TPS instrument using a virtual joystick, tracking a direction in the map, measuring eccentrics and much more.
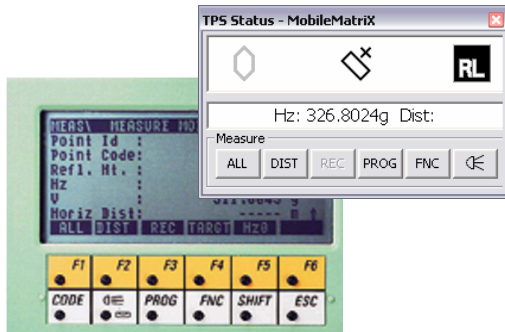

Figure 9: Leica TPS Product Familiarity

Connection to GPS Sensors

When using GPS a window displays status information from the GPS sensor (see Fig. 10). The current location of the GPS can be optionally displayed on the Map, and hence provides real-time location information relative to mapped features, displaying the status information coming from the sensor, setting up the GPS device within MobileMatriX. Additional information like Float or Fixed solution is stored with the computed coordinates and many other tools exist.
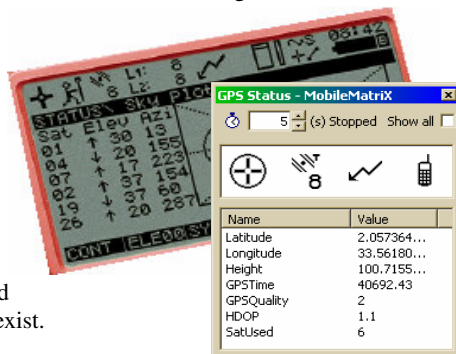

Figure 10: Leica GPS Product Familiarity

TPS Computations in Leica MobileMatriX

All measurements taken in the field are automatically displayed in the Survey Explorer and immediately represented in the map. A number of different computation methods for processing the measurements are available:

- Tacheometry
- Resection
- Free Station
- Surveying Traverse (such as open and closed Traverse)
- Least Squares Adjustment

Leica MobileMatriX also provides COGO computations

With a number of COGO computations, CAD functionality is available in the field:

- *Basic computations*, these need one survey point as an input: XY-Point, Delta XY, Direction/Distance and Deflection Angle.
- *Curve computations*, these two computations are used to create circles with different parameters as input: Fillet Curve and Circular Curve.
- *Intersection computations*, all combinations of intersections between directions and distances are available; they all need two points as input
- *Station and Offset computation*, including XML reporting: The station and offset computation defines a series of points using a sequence of distances and orthogonal offsets from a line between two points or along a circular curve segment.
- *COGO Traverse* (Bearing or Angle Right traverse), which includes an adjustment and XML reporting: a COGO traverse allows a sequence of Direction distance, and circular curve computations. It can also define a sequence of deflection-angle COGO computations.

Stakeout

Use the Stakeout to transfer the design into reality. Leica MobileMatriX also includes an easy-to-use, interactive stakeout with visual feedback. Different ways of performing the Stakeout task are available in Leica MobileMatriX. The UI provides dynamic circles, which always gets adapted to the according situation. Stakeout supports both GPS and TPS instruments and creates a Report to document the work conducted in the field.

Survey Data Management — More Than One Coordinate

The accuracy of a coordinate can vary from a few millimeters to meters depending on the quality of measurements, the standard deviations of reference points and the accuracy of surveying instruments used to collect data. Leica MobileMatriX stores all computed and imported coordinates with their quality information and history in the Geodatabase and allows the user to decide which coordinate to use. This eliminates losing old information and permits continued navigation through old computations.
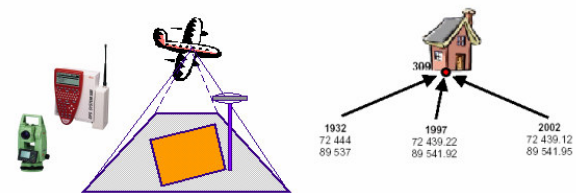

Figure 11: More than one coordinate

Computation Network Analyst

A key advantage of Leica MobileMatriX is the dependency it creates and stores between computations, points and measurements (see Fig. 12), which allows the user to easily trace the computation network. For example, imagine you realized that the coordinates typed in for datum point A are incorrect? Without Leica MobileMatriX you must delete and re-create all the computations, which are related to point A. While using Leica MobileMatriX this work can be performed automatically and all Survey Points will move to their new

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location. With the Computation Network Analyst, networks can be easily kept up-to-date and hence saves a lot of time!
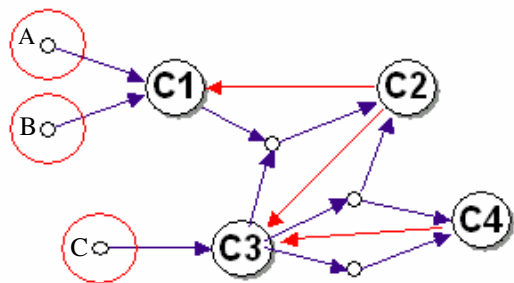

Figure 12: Computation Network Analyst

You see what you do

With Leica MobileMatriX you can always directly check the results of your fieldwork. Either it's the graphical representation of your measurements, survey point or the survey features with their attributes.

With the labeling functionality you can display various things, such as the area of the surveyed feature or the values of the COGO measurements.

Extensibility

The innovative software architecture of ArcGIS is based on the Component Object Model (COM) standard and is delivered as a completely open solution for developers. Leica MobileMatriX has been engineered to these standards and is therefore fully customizable by end-users and developers. Any COM compliant programming language can be used to extend Leica MobileMatriX without limit. Users and developers can further extend the data model to create custom measurements and computations.

Conclusion

Leica MobileMatriX provides a technology that meets what surveyors expect from both GIS and field software. The system offers the capabilities expected from any good surveying software with the addition of quality information to enhance the decision making process.

Few governments or private companies have enough resources to measure a whole country or city by using GPS or TPS within a justifiable time. On the other hand, surveyors are measuring small parts of our world every day. Why not combine this data within one system? If the data could be combined, surveyors and GIS users could conduct their daily activities in harmony. By actively using GIS databases, surveyors can continually update the GIS database to reflect the most recent situation. Leica MobileMatriX provides this technology. Furthermore, MobileMatriX always provides same functionalities either working with COGO, GPS or TPS sensors:

- On-the-fly (O-T-F) feature creation
- Pending feature editing
- Multiple feature editing
- Attribute editing
- Stakeout functionality (TPS and GPS)

- Sensor configuration (TPS and GPS)

Why Leica MobileMatriX?

Leica Geosystems has years of experience in the surveying market and as a worldwide successful surveying company can provide their customers a solution for extending the customers relevant office systems into the field including GIS and CAD. With any COM language, MobileMatriX can be customized to meet the specific need of the client both in architecture and functionality. Leica Geosystems developed a field software that allows companies to improve their efficiency out in the field. This saves time and money by improving the quality of data directly in the field, improving customer service and workflow and by increasing the field crew's productivity and efficiency. Leica MobileMatriX addresses all the needs for a professional field workflow: Controlling sensors, Editing, Collecting, Visualization and Mapping tasks.

Leica MobileMatriX provides:

- Familiarity leads to efficiency – use similar user interface on sensor and in MobileMatriX
- Pending features (O-T-F feature creation)
- Multiple Feature Editing (O-T-F feature creation)
- Powerful GPS and TPS configuration functionality
- You see what you do – Quality (including displaying of error ellipses) and Completeness control
- What you see is what you get
- Raster and Vector data in the background of MobileMatriX
- Seamless Dataflow from field into office and vice versa
- Computation Network Analyst
- Survey Data Management – keep your history
- Advanced Layout functionality - Easy way to generate maps
- Interfaces to a big variety of different office solutions (GIS and CAD)
- GIS functionality – add attributes to the surveyed feature
- Replacement of the classic field-book
- Robotic solution – 1 man work for TPS provided.
- Attribute collection and editing directly in the field
- Rotation of the map – supports easy field orientation methods
- Linking feature – updating sketches by simply measuring their vertices with TPS/GPS
- SQL Queries to maintain and navigate through huge data amount
- State-of-the-art UI compared to other field systems
- Extensible with any COM language and extensible architecture
- High-quality cartography
- Internet-enabled
- On-the-fly coordinate and datum projection