The Next Generation GIS/LIS – A Surveys Information System Integrated within a GIS

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Key words: Linking, Snapping, GIS, Measurements, Measurement Data, GIS Features, Spatial Quality.

SUMMARY

GIS technology has evolved to the point where GIS systems can finally take advantage of accurately surveyed locations (the data surveyors provide). The ability to store survey measurements in a GIS database, perform survey computations and adjustments on the measurements within the GIS, the ability to represent the surveyed locations as a new layer integrated into the same map drawing environment, the ability to link existing GIS features to the coordinate locations determined from the resolved survey measurements and computations, the ability to then link, snap and move the GIS features to their surveyed location, the ability to digitize new features from surveyed locations, and finally the ability to evaluate the accuracy of existing GIS features from the computed survey data results in an integrated GIS/LIS.

Within a unified application environment survey measurement data is loaded into, stored, computed and adjusted within the GIS. This new technology represents the next generation GIS/LIS where Survey Data are stored as projects within the GIS's RDBMS and viewed as another layer within the GIS mapping environment. Finally, there is an opportunity for the surveyor and engineer to build a "Surveys Information System" within the GIS.

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1. INTRODUCTION

The need to integrate survey data into a GIS while allowing for the improvement of GIS spatial quality has been a long standing need. Digitizing, scanning, and even using Coordinate Geomerty (COGO) to create GIS map features usually results in GIS spatial layers less accurate than the source material. If our goal were to improve the spatial quality (accuracy) of GIS layers, we would need to start with the source data and improve the method of data integration into GIS. In this case the source data is survey data, referred to as measurements.

The result of building such a system, a hybrid system of Survey and GIS integration, would be a new "Information System" – a Surveys Information System in a GIS. To build this system we would need to engineer a system that included: 1) current GIS technology using advanced operations on spatial data stored in modern Relational Database Management Systems (RDBMS) for data management, editing, analysis and database driven cartography, and 2) tools for the management and integration of survey information such as, survey points, measurements, computations and coordinates in the same RDBMS.

This system requires a level of integration that takes advantage of the data processing tools available in a RDBMS based GIS system while supporting the integration of survey measurements in a seamless environment. This seamless environment supports survey data management along with GIS analysis and mapping within the GIS framework, figure 1.

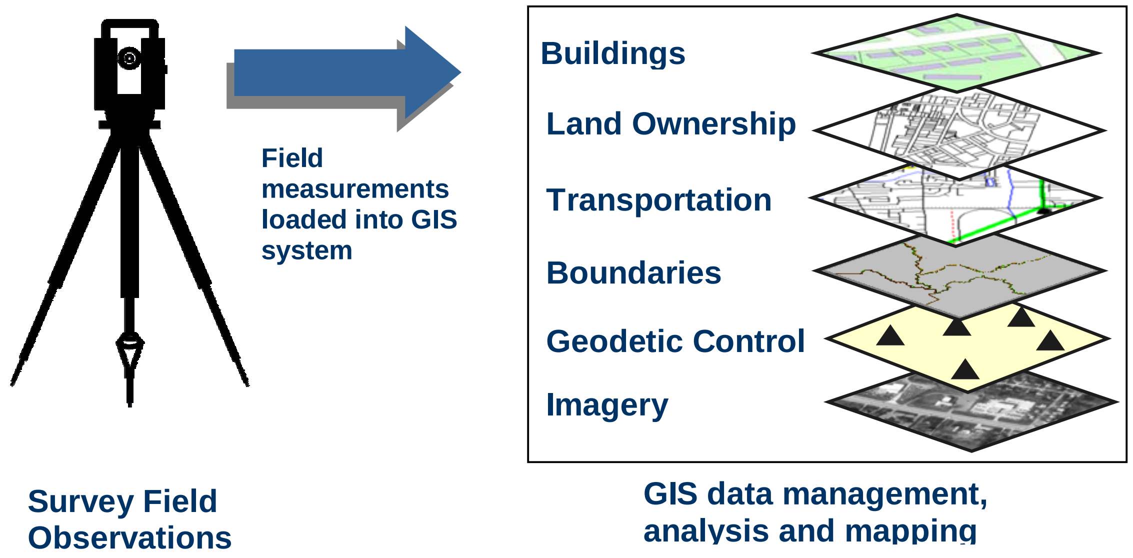

Figure 1

2. IMPROVED WORKFLOW WITH BETTER INTEGRATION

2.1 Current Workflow (figure 2)

Currently, surveying systems exist to conduct field observations and to compute and adjust surveys from measurements into a survey, such as a field traverse. The results of this process (the surveyed information) are then entered into another system for mapping and design work – often times using COGO procedures. The resulting maps and data from this process are then exported to a format for use in a GIS system. Many current GIS systems can import the resulting CAD data from this process directly into the GIS for mapping and analysis.

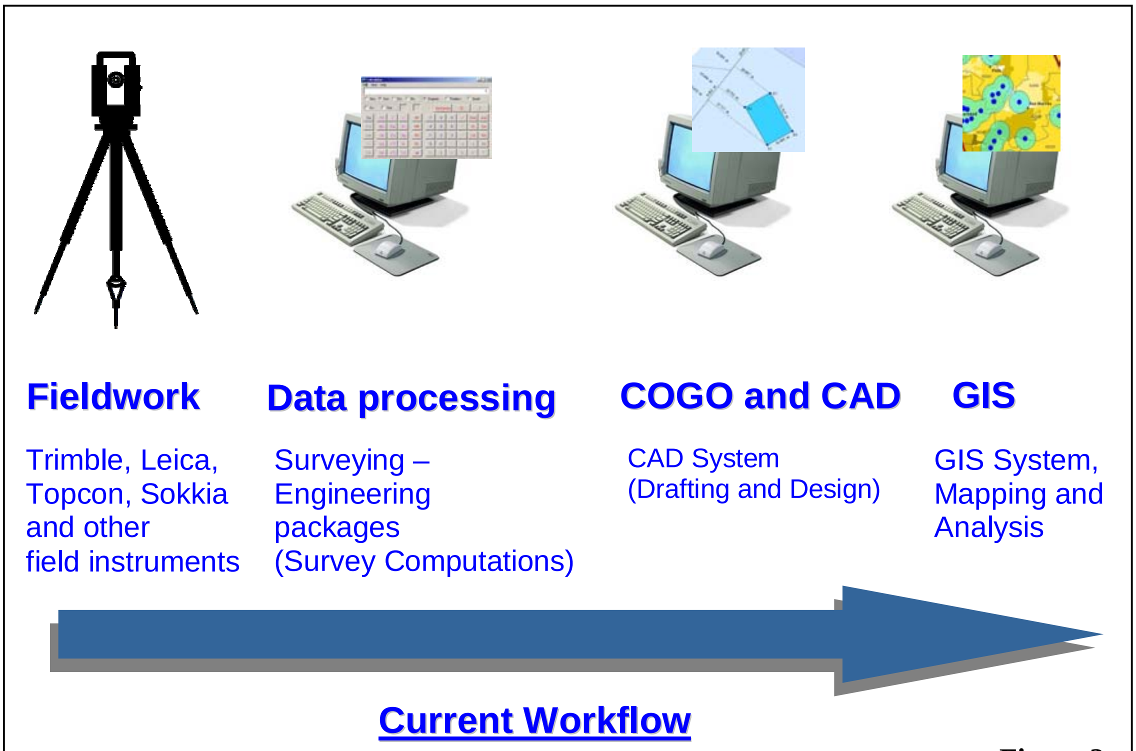

Figure 2

Deficiencies in the above system or workflow is that there are no links between the first step (field measurements) and the final GIS or cartographic map product. This becomes problematic if a new survey is conducted or a new value is determined for some of the contributing survey points to a GIS map layer. This current methodology requires the entire process above be repeated to update GIS or map features.

2.2 Next Generation GIS/LIS Workflow (figure 3)

The Next Generation GIS/LIS integrates the survey process and the mapping/GIS process in the same operational environment – facilitating improvements to workflow while supporting updates to the survey data as well as the GIS data layers.

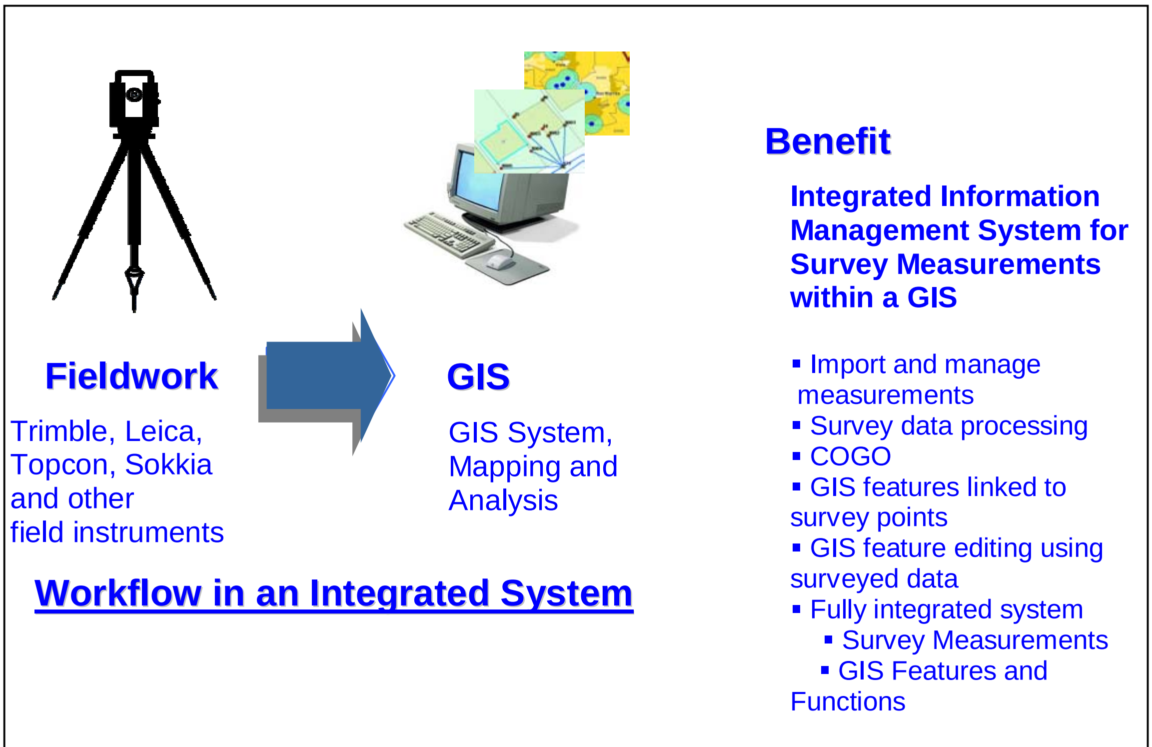

Figure 3

3. SYSTEM COMPONENTS

3.1 Data Model – Measurements and GIS Features

3.1.1 <u>The survey data model consists of four data types</u>

These include points, measurements, computations and coordinates. Modern surveying systems allow for the capture of measurements and the reduction of measurements into a survey. Once a survey has been computed and adjusted, final coordinates are determined for the surveyed points. In most cases a survey results in the accurate location of manmade or natural features. These surveyed features often represent features contained within a GIS layer.

The survey data model also includes a survey network – a network such as a traverse. Survey networks are modeled by their associated computations. A series of traverse stations with instrument setups and measurements constitute the fieldwork part of a field traverse. The computation and adjustment along with the measurements constitute the entire survey network.

Any change in the network (measurements or coordinates of know points) results in the requirement to re-compute the survey with the new information. The new computation often times results in new coordinates for traverse stations. This can often result in changes to other survey networks downstream from the newly adjusted points. Any new surveys information system must model computation networks.

3.1.2 New GIS Data Models Result in Intelligent Data Stored within a Modern RDBMS.

GIS features are stored in layers within an RDBMS system such as: ORACLE, INFORMIX, DB2, SQL Server or Microsoft Access. GIS software provides the tools to edit GIS data and to perform mapping and analysis functions on data stored within the RDBMS.

GIS data are stored in separate thematic layers such as roads, parcels, water, sewer, and municipal boundaries. Thematic layers are usually created, edited and operated on separately using GIS software. GIS systems allow users to conduct very powerful models, such as site-selection and suitability models and perform analysis such as demographic and crime mapping. Modern GIS systems are ideally suited as mapping platforms with production quality mapping capability.

3.2 Data Management – RDBMS

The RDBMS is the container to hold and manage GIS data and survey data in an integrated environment, figure 4. GIS software provides tools to operate on data stored within the RDBMS.

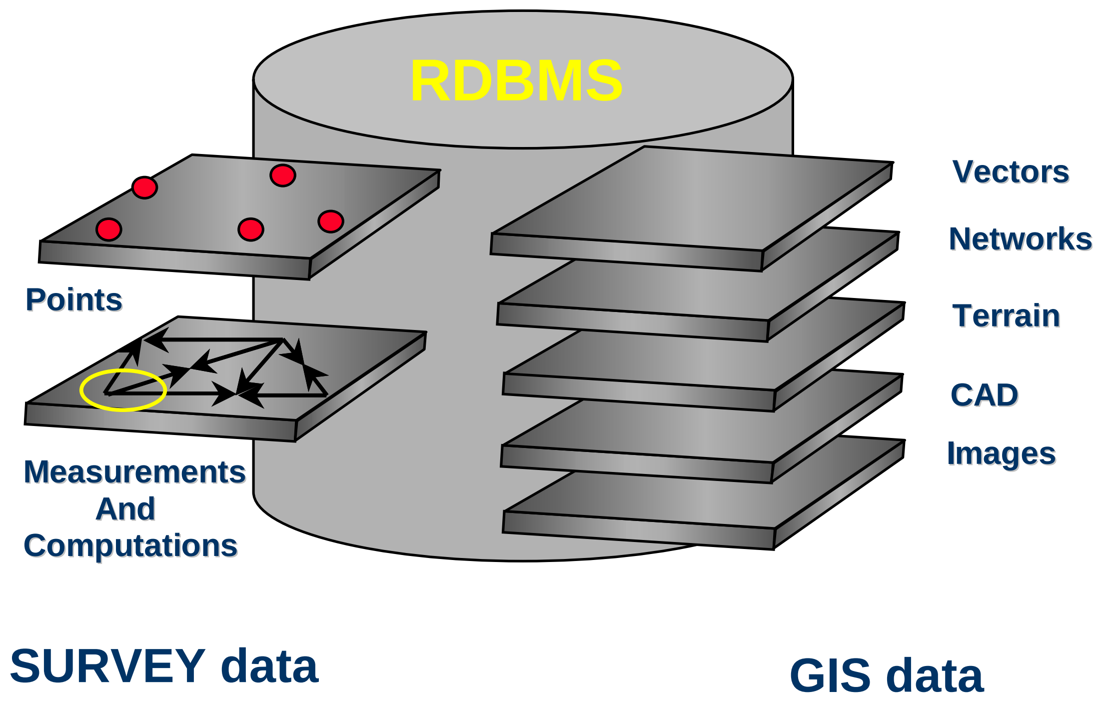

Figure 4

3.2.1 Working with Survey Data

The GIS system provides tools to load raw survey data into the database. This data can be in the form of digital files from Total Positioning Systems such as Leica-Geosystems, Trimble, Sokkia Topcon and others. Other data formats include ASCII and COGO computations (data from maps and plats).

The data are loaded into a Survey Dataset within the database. Survey datasets are further divided into projects to accommodate workflow, figure 5.

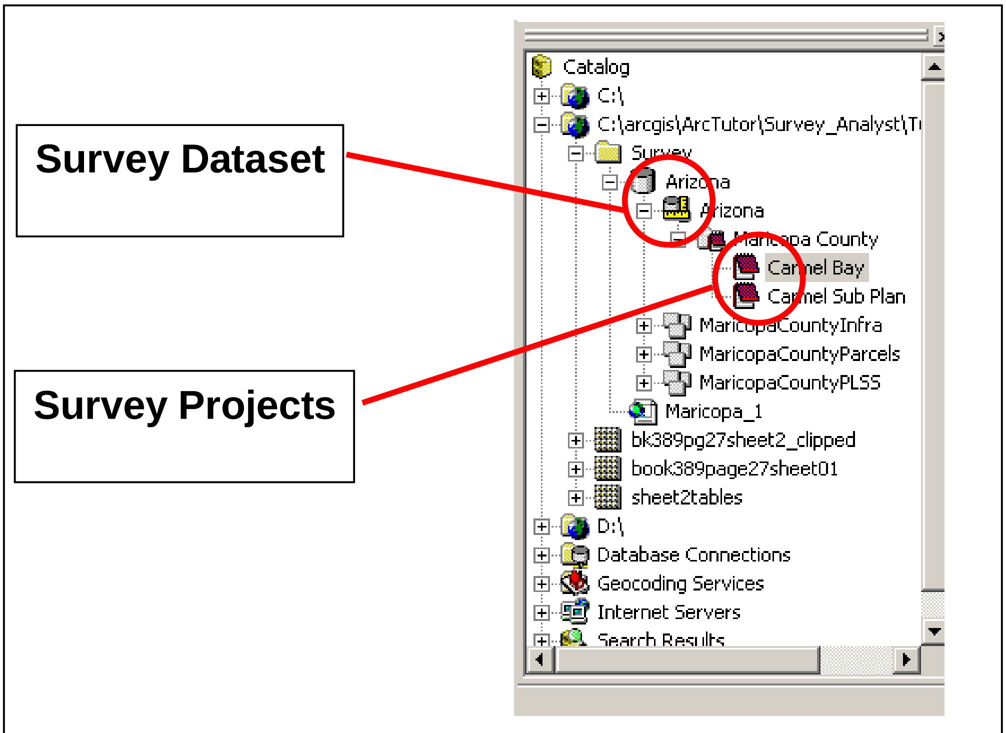

Figure 5

Survey computations are performed on data within survey projects to resolve the survey computation network and compute coordinates for the surveyed points. The results can be displayed in the GIS systems map space for GIS editing, figure 6.

3.2.2 Working with GIS Data

GIS layers are displayed within the GIS mapping environment. An edit session is started to edit features contained within GIS layers using survey data. Operations such as updating existing features and creating new features from survey points occur within the GIS edit environment.

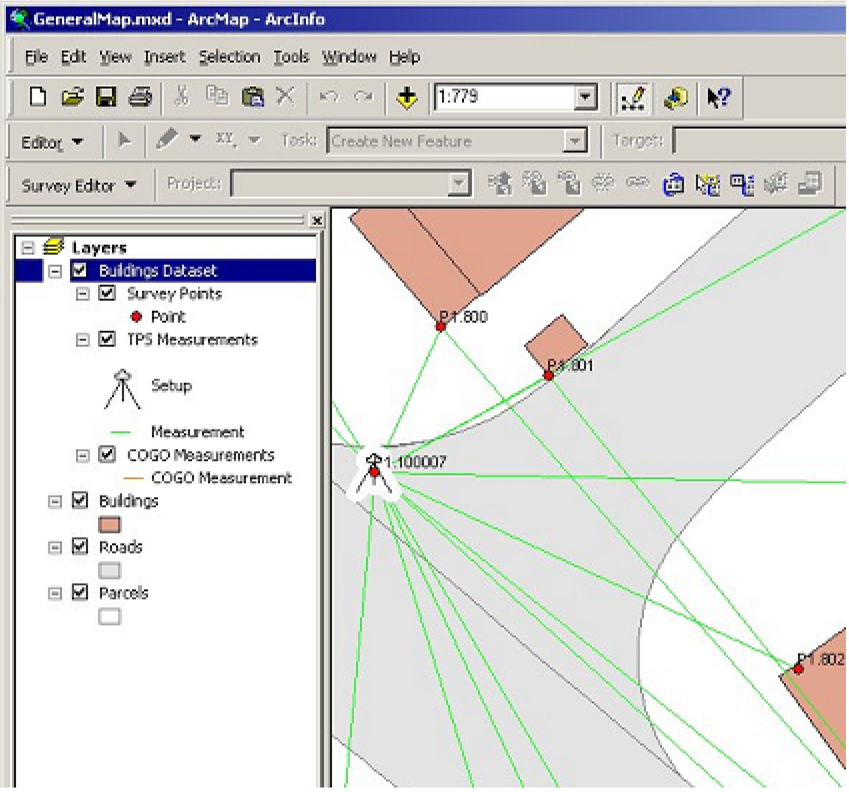

Figure 6

3.2.2.1 <u>GIS Feature Linking</u>

GIS features are linked to survey points within the edit environment. Links are established between GIS features and the survey point that represents the same feature on the ground. These links are stored with the GIS feature geometry pointing to the survey point contained in the survey layer, figure 7.

3.2.2.2 <u>GIS Feature Snapping</u>

Once a feature has been linked to a survey point it can be moved in coordinate space to the survey point, figure 8. This represents an improvement in the feature geometry – improving the spatial quality. Moving the GIS feature to the survey point will allow the GIS to determine the spatial quality of the feature based on the information from the survey point. The Standard Deviation in Position of the survey point will apply to the GIS feature.

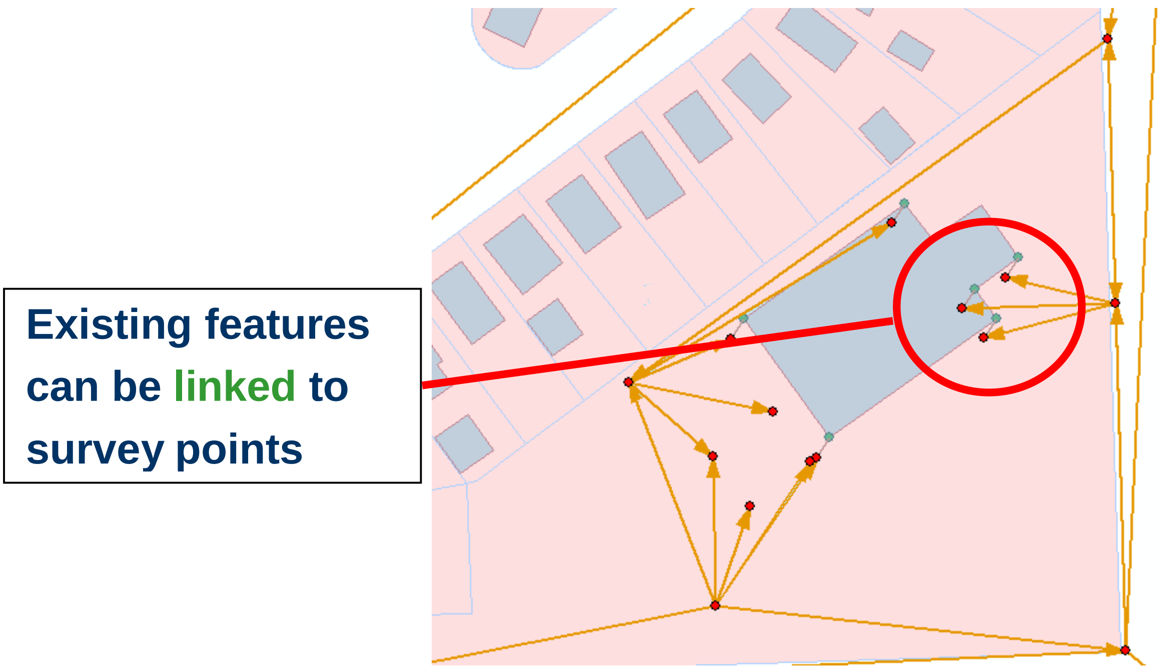

Figure 7

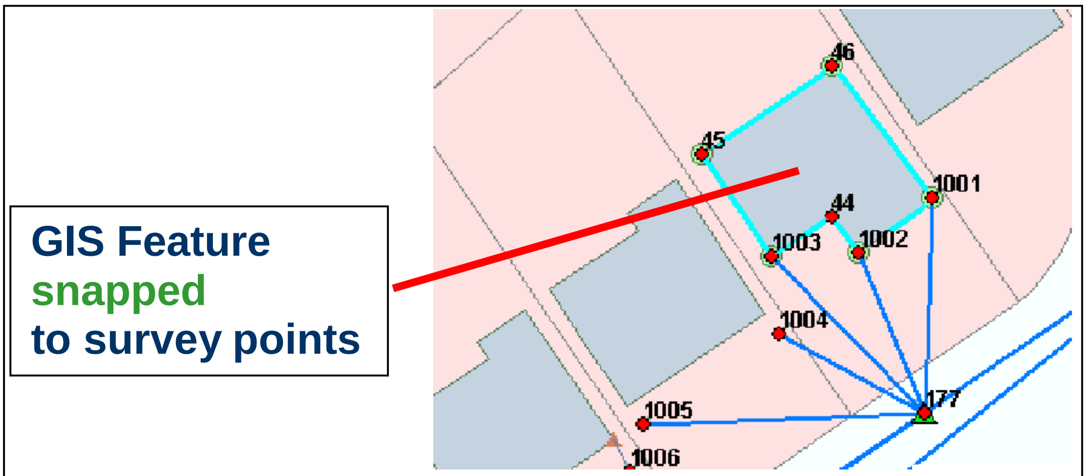

Figure 8

3.2.2.3 <u>Displaying Error Ellipse Information</u>

Standard deviation in position computed for survey points can be displayed as error ellipse information, figure 9. Error information for GIS features is the same as the value for survey points if the GIS feature has been snapped in to the survey point.

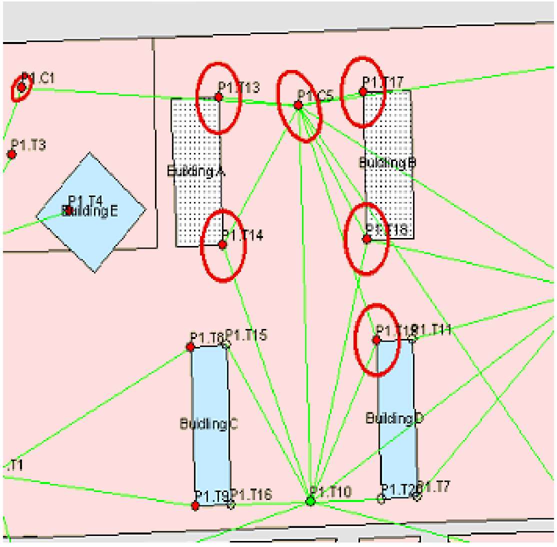

Figure 9

3.2.2.4 <u>GIS Feature Digitizing</u>

Displaying survey points within the GIS editing environment will allow new GIS features to be captured by digitizing directly from the survey points, figure 9. This represents a substantial improvement in data capture.

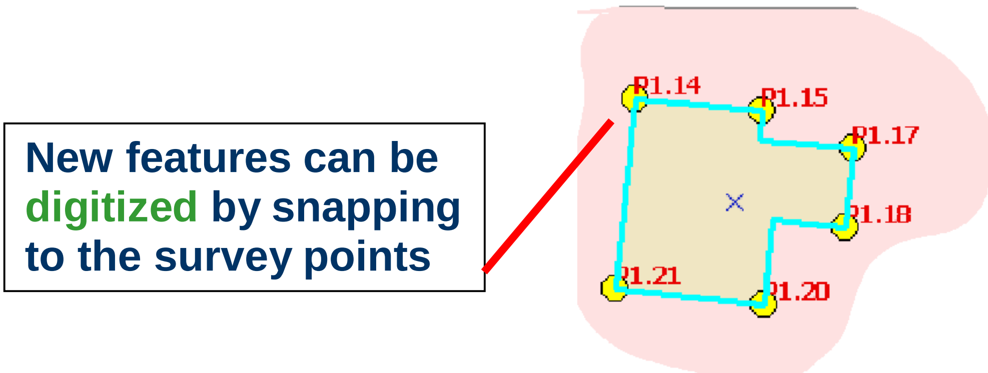

Figure 10

3.3 Integrated Survey Computation and COGO Environment

Survey operations are performed within the GIS framework. Survey computations include standard survey computations and survey adjustments required to resolve and compute surveys. Computations include:

Basic COGO computations: XY-point, Delta XY, Dir-Dist, Defl-Ang

COGO Intersections: Dir-Dir-Inter, Dir-Dist-Inter, Dist-Dist-Inter

COGO Curves: Circular Curve, Fillet Curve

COGO Advanced Computations: Traverse, Station and Offset

TPS Computations: Tacheometry, Traverse, Adjustment, Resection, Free Station

3.4 Mapping and GIS Functions

Mapping and GIS functions are supported within this framework. A survey layer becomes foundational data – represented as a survey information within the GIS environment. This provides a continuous framework of measurements utilized to improve the quality of GIS layers. In this environment data updates are captured in the field, loaded into a GIS database, computed using state-of-the-art survey methods and computations, linked to GIS features for editing and updates to base map layers.

This system is ideally suited for:

- A Surveys Information System
- Multi-purpose Cadastre
- Cartography and Map Production
- GIS analysis
- Records of Survey
- Engineering Design

3.5 The Benefits for Surveyors Include the Ability to:

- Manage survey data in an RDBMS within a GIS
- Build a surveys information system
- Organize survey data as projects
- Compute GIS coordinates from survey measurements
- Become more engaged in the GIS arena

3.6 The Benefits for GIS Professionals Include the Ability to:

- Improve the spatial quality of GIS layers

- Link GIS features to surveyed points
- Snap GIS features to surveyed points
- Digitize new features from surveyed points
- Evaluate the accuracy of updated features based on error ellipse information from the survey points

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BIOGRAPHICAL NOTES

Mike Weir has worked in the fields of surveying and mapping for over 30 years as a surveyor and GIS professional.

His surveying experience includes geodetic control surveys, astronomic observations, construction layout surveys, boundary location and topographic surveys where he has served as instrument operator and in positions of responsible charge as party chief, chief of field parties, and chief of survey operations. As a GIS professional Mike has served as a GIS consultant, GIS manager, application developer, and master instructor with considerable international experience in both surveying and GIS (including international teaching and conference presentations). Mike has worked at ESRI for over 12 years and now serves as the Surveying Industry Manager.

Mike graduated with Honors from National-Louis University with a Bachelor of Arts in Management. Mike also graduated with honors from the Advanced Geodetic Surveying Course, the Mapping Charting and Geodesy Officer Course, and the Warrant Officer Terrain Analysis Course.

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