

Thomas Wuerzer College of Design, Architecture, Art, and Planning School of Planning PO Box 210016 Cincinnati, OH 45221-0016 wuerzets@mail.uc.edu	
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CagisAIM revamped - New generation inventory asset management

Draft Manuscript

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Abstract: CagisAIM is a modular field-application platform based on state-of-the-art geographic information systems (GIS) developed by the Cincinnati Area GIS (CAGIS) for Asset Inventory Management (AIM). The modular design enables rapid application development to meet the specific needs for the inventorying and inspections of various assets. This innovative approach enables a one-time development of core GIS application services and its reuse with specific customizations for every agency's specific needs. That reflects a cost-effective development and flexible deployment for specific projects.

Introduction

This manuscript is the result of a project of the Cincinnati Area Geographic Information Systems (CAGIS) and the basis for the upcoming presentation at the ESRI International User Conference 2010, San Diego, CA.

A novel approach in asset inventory management was required when Cincinnati's Department of Transportation and Engineering (DOTE) articulated their need to collect and maintain all street poles and signs within the City of Cincinnati. This resulted in the development of a comprehensive approach to achieve the following goals:

- a) establish a platform that enables simplified adding and editing of spatially related data,
- b) reduce development costs with a common standardized platform yet flexible and adaptable for asset specific applications,
- c) consolidate expert-level GIS into user-friendly and workflow optimized processes and
- d) reduce costs for follow-up projects.

These goals also reflect the words of the initial sponsor of the project: "Why should I pay \$ 10,000 for user-unfriendly and non-practicable software which will not allow me to customize to my current needs and subsequent projects? Can you offer better alternatives?"

Geographic Information Systems (GIS) are becoming increasingly influential in the decision-making processes of local governments, due to their integration capabilities. In many municipalities, GIS appear in various forms and at different levels of integration within urban management functions: from stand-alone solutions to highly customized interdepartmental systems.

A review of literature demonstrates the transformation of GIS over time, to its current use in a variety of extended and interdisciplinary contexts. Throughout this transformation, GIS continues to address two major questions: "What is at (a location)?" and "Where is (an object)?" As a spatial information system, its primary function is to refer to objects and data in a given area, therefore enabling municipalities to share information horizontally and vertically among departments. This can allow, for example, a planning department to access and compare data with public works or the inspections department. In a 1986 evaluation of GIS use in Burnaby, British Columbia, the local municipality determined that "between 80 and 90 percent of all the information collected and used by the municipality was related to geography." Through the expansion of such roles in municipal functions, GIS is now helping local governments address very real issues of increased financial pressure on operational and capital projects.

The challenge is to determine which processes and related inventories/attributes are important to improve urban management with the help of GIS.

The Cincinnati Area GIS (CAGIS)

In the case of Cincinnati and Hamilton County, Ohio, the formation of the Cincinnati Area GIS (CAGIS) in 1993 was an essential step towards the spatial integration of data across departments and sharing of information. CAGIS is a shared services agency supporting the City of Cincinnati, Hamilton County, other municipalities and townships within Hamilton County, Duke Energy and several associated agencies. In the beginning with initial data conversion completed, CAGIS supported around 25 workstation users and shared around 50 percent of its data in a network environment. The application of data was limited to making and plotting maps and not yet close to the real potential of today's GIS.

Today with a team of 19 staff members, one doctoral fellow, and about 3-5 student interns, CAGIS develops, maintains, and supports its members with spatial services focusing on integrated permitting, licensing, code enforcement, work order, customer service request systems, and other workflow management processes. In general, CAGIS focuses on development of real-time applications for front counter, desktop, web and in the field to provide better urban management.

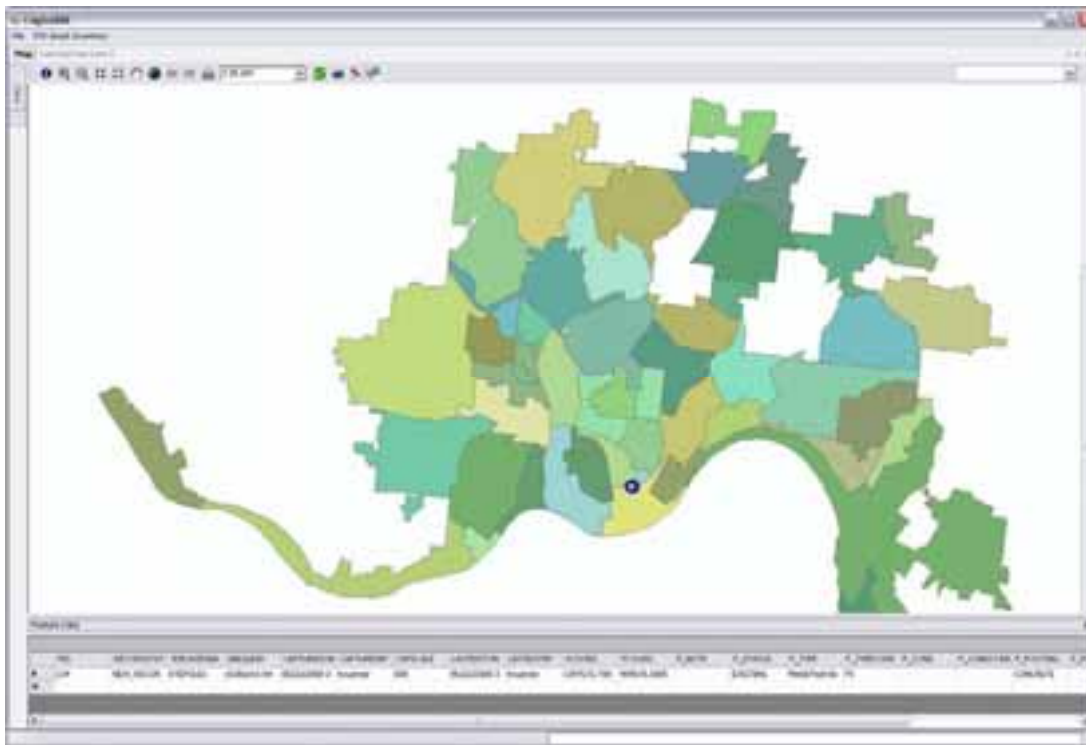
These services enable agencies to communicate and share information and make it possible for them to coordinate their activities and services. In general, the initiatives allow client agencies to work more efficiently by integrating processes with the geography to view as-built data as well as to display all municipal related activities in a specific area.

What is CagisAIM?

CagisAIM was designed, developed, and continues to be enhanced, to support field applications for asset inventory. The need to maintain inventory, such as poles, signs, culverts, corner cans, newsstands, street lights, streets striping, picnic tables in your park close-by, or storm water drainage systems demands a platform which is simple use and flexible in its application.

The need for AIM

As part of the CAGIS consortium and a department of the City of Cincinnati, DOTE articulated its needs for a mobile asset inventory application that would integrate with the existing CAGIS data framework. The primary goal was to develop a guided and simplified user interface. The application would need to download existing data, manipulate existing elements, add new features, and then upload the changes back to the enterprise wide server environments with minimal training of users who would be primarily student interns. GIS can support almost any spatial operation but the challenge of this application development was to reduce the complexity and increase the accuracy of the field collection that would match the varying skills of the users.



CagisAIM provides a modular framework that integrates asset specific inventory requirements with core shared mapping interface. This provides an easy to use interface with a common look and feel across a broad range of uses for field personnel.

In short, CagisAIM establishes the ability to integrate complex operations into an easy-to-understand-and-to-do-process.

It is essential to understand the basic concept of CagisAIM: disconnected field applications. Literally, the user takes an AIM enabled laptop out in the field and does inspections, inventory, or other needed assessments without any internet connection or access to the City's network. The main backbone is the support of high-resolution imagery (1/2 ft ortho images) as background imagery and the use of current CAGIS framework data. As a result, we have mobile in-field software in our hands that is built on ESRI software on a minimal license level.

In brief, CagisAIM's backbone is a plug in-based application with a standardized reusable core module built on the ESRI ArcEngine environment, which links to configurable agency specific project plug-ins for tailored solutions. This reduces development costs not only for the base application but also across multiple projects for various departments and municipalities. As an example, a base tool such as the intersection distance measurement is developed for the Hamilton County Engineers. As a result, all users of CagisAIM will have the ability to utilize this tool in their applications. This cross-department tool sharing is a large benefit because of the plug in-based-application structure of AIM and -the plug in based project module concept. Perhaps the most powerful feature can be summarized is its adaptable customization within a shared common module framework

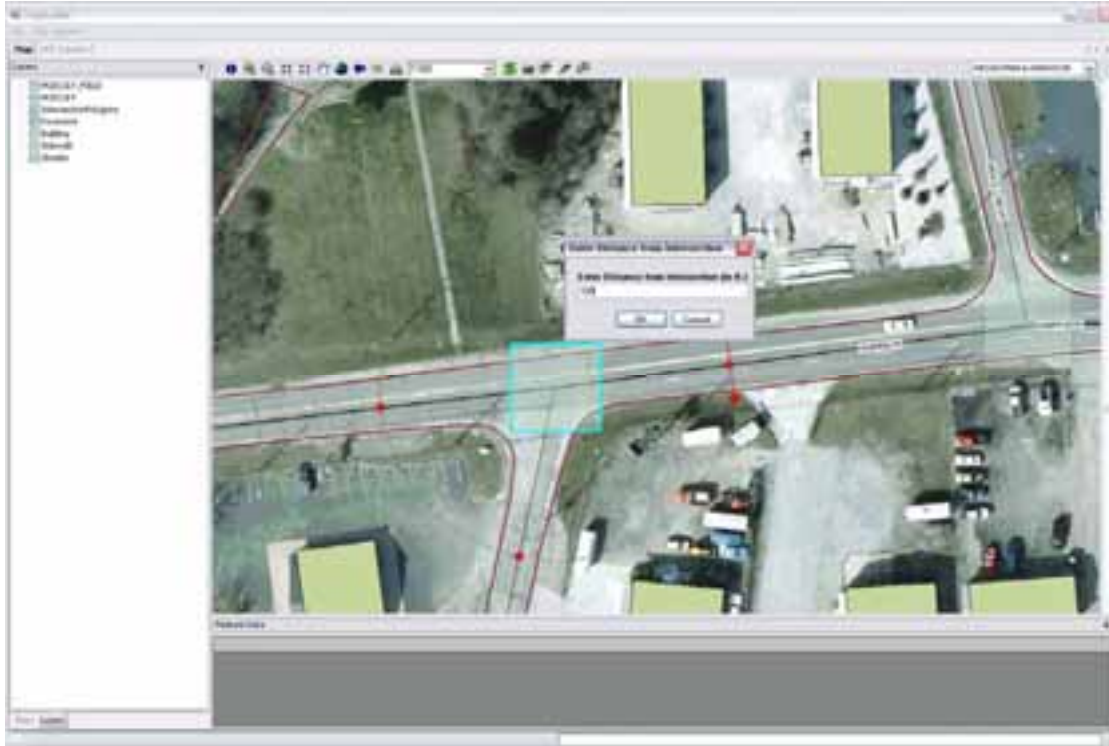
Inside AIM – a modular approach

The power of CagisAIM lays in its modular approach of software architecture as a stand-alone application developed on Visual Basic .NET. Utilizing classes and modules, AIM is broken



High-resolution ortho photos and CAGIS GIS data support detailed display of the location of interest. Here, CagisAIM is used to review an existing fire hydrant. The review form is integrated in the mapping interface to create a user-friendly platform in the field.

into independent sections such as data communication, event classes and interfaces, mapping, configuration settings via xml-files and a global .mxd file. This enables programming on a specific plug-in without interfering with other -applications. The project plug-ins handle geometry-free business logic which enables interfacing and communication without i.e. ESRI ArcObjects dependency (essential to maintain data interoperability to other systems). Based on the configuration file and command line, CagisAIM loads a specific plug-in and follows its command structure.



The modular approach in CagisAIM allows multiple tools to be combined providing a focused application for specific asset types. The Intersection Tool provides measurement from intersections along the centerline and radial distance to locate culverts. The distance measure is displayed on the screen and AIM guides the user in the creation of a new asset feature.

Data Communication and Event-Interfaces

As a disconnected application, AIM depends on the ability to download the most current data from the server environment maintained by CAGIS or a particular department such as the Greater Cincinnati Water Works (GCWW). It also supports the ability to track changes in the field for existing sets, log criteria for departmental quality control (i.e. QAQCheck), and upload filed changes and additions to the server environment when back in the office in a easy seamless fashion using a cost-effective licensing model.

Internally, AIM has an extensive event and interfacing structure, which enables any module, base tools, or specific plug-in (project) to react on others interactions. This enables functions like an automated query of street names of close-by streets or the measurement of current elevation using a digital elevation model (DEM) to be implemented as an AIM base service in a progressive manner.

The following basic communication functions are implemented in AIM and they give an overview how the interoperability of AIM is structured.

- **SDE/SDO-connect** to enable **download** of feature classes from server environments. Currently, download of server data is executed through SDE middleware and related functions. However, a call-push-model via web services is envisioned to simplify a large data download. This means that AIM will request an update from the server and a special web based service will process, package, and submit the requested data to its AIM-client.
- **Oracle-connect**
In addition to web services, AIM still holds the ability for ODBC connects to Oracle based databases and platforms. This enables a direct connect to Oracle environment and geometry free attributes updates.
- **Shape-files (.shp)**
In its earlier version (AIM v1), AIM was solely based on the usage of ESRI's universal shape-files. On the local (client) side, the download would create a local .shp-file and store all relevant data in it. Once changes or new inspections were made, AIM would reproduce such .shp and keep it for feature upload, and (after successful upload) delete the changes. In addition to the shp file, AIM defines symbology, labeling, and other render settings through .lyr files. In the current version, the configuration manager checks whether the xml-file based configuration exists and loads .lyr files or a preset-plugin.mxd.
- **MS Access (.mdb)**
in AIM v1 was used as a local data store for field-asset additions and changes to avoid SDE licensing costs. Ms Access database was also used to store lookup tables for customizable forms and item-lists in the user interfaces and forms. In the current version v2, the MS Access database is replaced with ESRI's file based geodatabase.
- **File based Geodatabase**
Shortly after the introduction of ArcGIS 9.2., the AIM architecture was adapted to AIM v2 and v3 (multiple project plug-ins and new data structure; will be focus of the presentation). Both versions contain the ability to utilize file-based geodatabases. Local data for field-inspection is loaded from internal database tables and eliminates the shp-file-approach.. AIM reads all relevant lookup tables as well as domain values from the file geodatabase. Data required for integrated shared services such as address lookups or DEM elevation queries are supported in this manner as well.

Map Interface and Control

Even the most powerful application succeeds or fails due to its user interface and controls. CagisAIM is able to adjust to its users interfaces with built-in and customizable toolbars. Beyond this setup, each project has its own configuration and settings. AIM is developed on the ESRI ArcEngine license level of map-control and corresponding ArcObjects-libraries. This means that it can use the ArcEngine standard navigation toolbar and tools. Further, it takes advantages of predefined .lyr-files defined in an xml-configuration and loads them into the mapping interface.

One aspect of AIM being a CAGIS application is the fact that all CAGIS shared services and components are developed to be used in an interchangeable manner in any application, be

it web based, ArcMap or custom .Net desktop. This means that the geolocator service to geocode and locate any addresses within Hamilton County is easily accessible through CagisAIM. A search combo-box, storing past searches, provides a powerful address search and zooms automatically to any location.

The heart of AIM – Plug-in Controls

The essential core of AIM is the parent module and its extension, the project specific plug-in. This plug-in handles all business operations relevant to the management and access of any feature or tools in CagisAIM. Based on the wired event structure it is responsible for all operations involving the workflow in the project; and the control of user interfaces and forms. The business logic is responsible for controlling the internal structure to facilitate object-oriented classes such as the standard AIM features (logging and quality control functions), specific attributes, or with the integration of AIM v.3 the ability of multiple sub-plugins. These multiple AIM (MAIM) plug-ins enable the base project to switch 'on the fly' between multiple plug-ins (no restart needed) and is providing up to 18 different categories of asset inventories feature types to be managed. The important part of the main core is the fact that it is geometry free. This means, all operations are handled based on pure business logic code without the integration of ArcObjects.

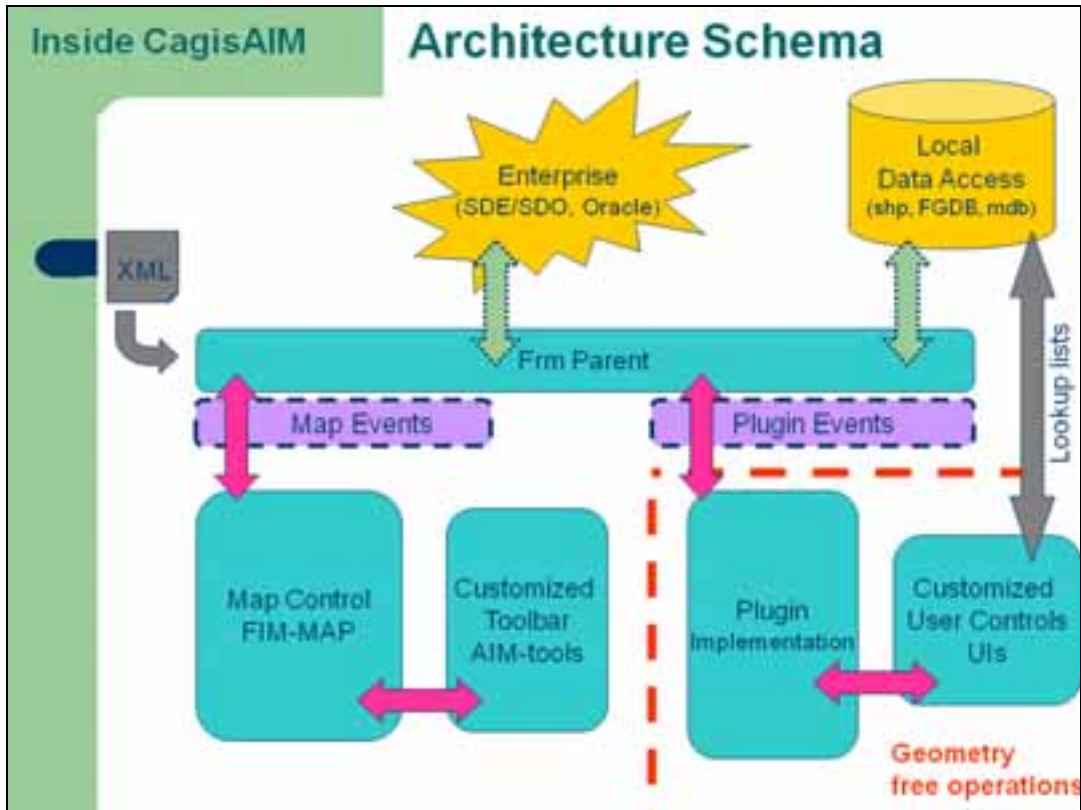
Based on the plug-ins configuration, CagisAIM loads look-up tables and user forms specific to its field assessment tasks. Whether it is the sign and poles inventory, storm water drainage system, or culverts managements unit, CagisAIM will satisfy the user with optimal workflow and graphical support (i.e. image-based database for sign look-ups).

Configuration

As mentioned earlier, CagisAIM's configuration for each plug-in is controlled through an xml-parsed class to define tool bars, settings, and locations of specific project data. The config file contains setting parameters for general database connections and a list of layers (.lyrs) to be loaded into AIM. In addition, the config-file controls the placement and activation of own tools and functions within CagisAIM, i.e. it is possible to control whether the google streetview adaption (for desktop use in AIM) is placed as an icon on the top or left toolbar. The config-file also determines which database connection CagisAIM should use. This option is particular valuable if a department has not yet upgraded to the latest server version or circumstances require a primary data-access-bypass into temporary tables for QAQC purposes.

Architecture Schema

The principal architecture of AIM is simple: A base module (frm parent) loads a specific xml file as configuration and establishes connects to databases, and initializes the load of project specific tools, functions, and classes. The flexibility and adaptability is illustrated by the fact that with just an uncomplicated change in command line parameters, Cagis AIM will load different project plug-ins (HCE Culverts inventory instead of CWW fire hydrants inspection project).



Services provided in AIM

CagisAIM utilizes general services that are available in the CAGIS application framework. Sophisticated geolocating services that are used to locate addresses within Hamilton County (the same service is used by emergency services or Cincinnati's police) enables AIM to find any location based on street addresses. Automatic 'fetching' of current elevation from DEMs, the closest road name, nearest address with a user's choice or the calculation of feature's length (i.e. culverts) are integrated services. In addition, tools such as the Distance Measure with display of radial and along street-distances enables proper measurement in the field based on accurate spatial data. A 'triangulation'-tool (for multiple radial distances) empowers CagisAIM to measure locations on inaccessible terrain and situations. In comparison, special operations such as adding and editing of features appear as simple seamless operations attached to these individual tools.

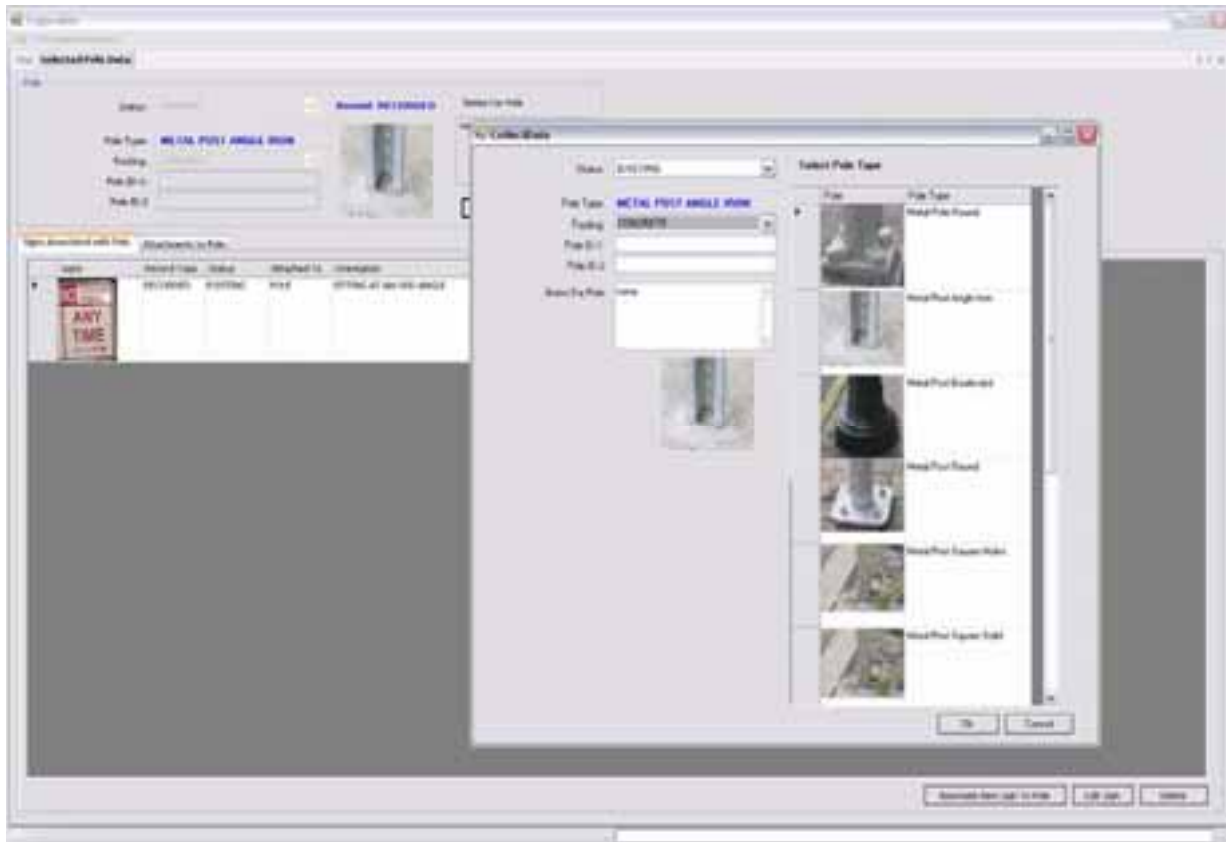
CagisAIM in Action

A review of success

As part of quality and satisfaction review, CAGIS asks its members and interacting departments repeatedly for feedback on development and projects. The following statements from various departments within the City of Cincinnati and Hamilton County that use CagisAIM provides an overview of the diversity of use and the success of this program:

Cincinnati Department of Transportation and Engineering

Revell Sherrer — *“The Department of Transportation and Engineering is using the CagisAIM software and have been for a few years now. Our main use of CagisAIM is for collecting an inventory and initial inspection of each pole and sign. Now all new installations of signs and poles are placed into the system using the same interface in the office as was used in the field. The ability to call other near features as hydrants, driveways and orthophotography has made the latest version quick and simple. Earlier versions used GPS as a locating source. Using the digital orthophotos has made the application much more useful and realistic (faster). **Using pull down menus and inventory pictures, the user quickly navigates the screens and fields with nothing more than a wand. It is that easy.**”*



The Pole and Signs Module was designed to simplify data entry through images and pull down menus. This reduces data entry errors and maximizes fast capturing of asset information in a standardized environment.

*“We also have used the CAGIS AIM software for one-time data collecting efforts. The software was adjusted to collect the location of newspaper racks, along with a picture and owner of each rack. **With its pictures, pull down menus, and easy to read forms, one user can quickly walk the area of interest by locating and collecting all the features and needed data.** The software was also adjusted to capture light attachments to poles and all the needed data on attachments. Cinergy and DOTE collaborated on its design and inventory initiative.”*

Greater Cincinnati Water Works

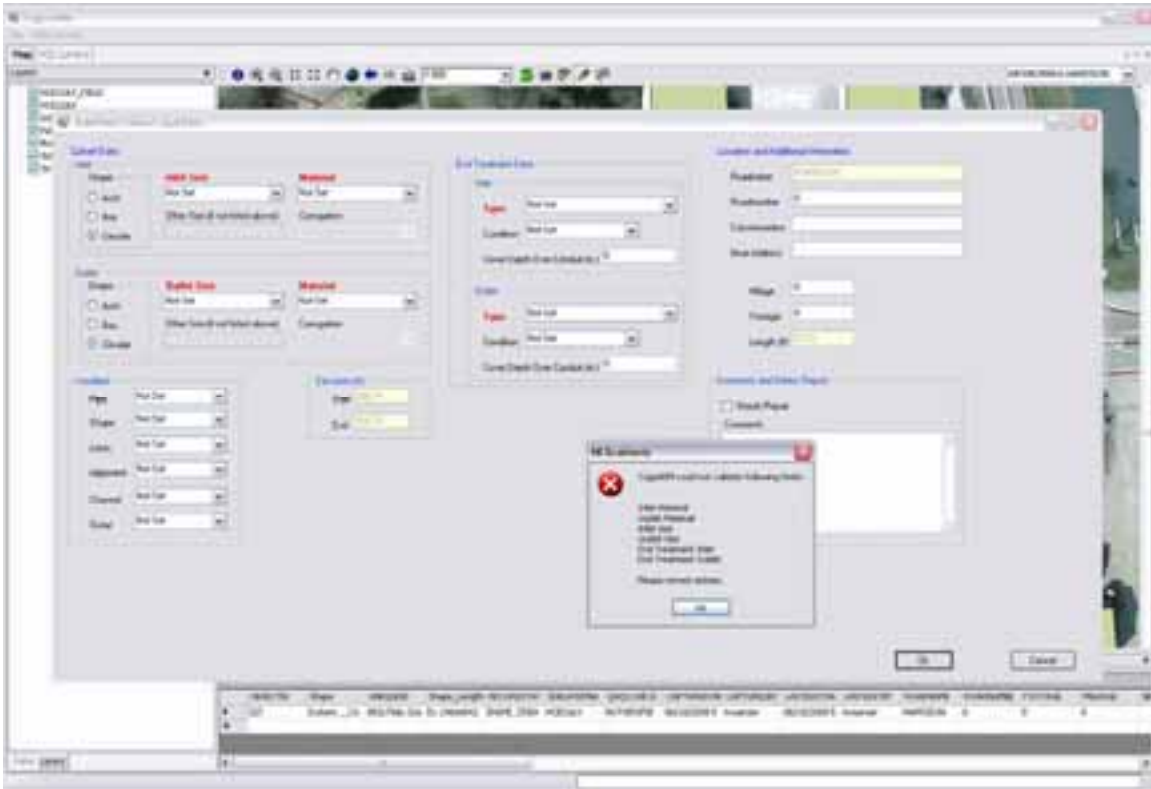
David Raffenberg — “GCWW performs Fire Hydrant inspections on an annual basis. The inspection work is captured in our work order system as a single task for a specific location. For example, Task: Inspect all fire hydrants in Mason. This is done since it is impractical to create a thousand tasks in the work order system to inspect each and every hydrant.

“In the work-order system, supervisors can monitor the status of the task to make sure the work is in progress or completed. **However, using only the work order system, GCWW can neither determine at the asset level which fire hydrant was inspected nor how many there are left to inspect.** After seeing a demonstration on the CagisAIM project for street sign capture, GCWW inquired into leveraging this technology to perform fire hydrant inspections. The application was rapidly modified to allow GCWW to capture inspection data on individual fire hydrant assets, while at the same time maintaining the status of the task for the work order system.

“The application is easy to use and very intuitive. The map in the field allows the inspector to follow a logical path for completing the task, which reduces time spent in the field. **It also, allows the inspector to review the location of the hydrants in relation to major streets or intersections. This allows them to adjust their schedule to patterns in traffic flow, thus providing a safer work environment.**

“A great feature of the CagisAIM application is the use of pictures to identify the fire hydrants. The inspector can easily verify the make and manufacturer of the hydrant from the picture thus improving the quality of the data.

“This year CAGIS and GCWW are piloting using a wireless Citrix environment for capturing the data. Using the Citrix environment allows the manager to monitor the progress in near real time. In addition, the data is backed-up on a frequent basis since it resides on a server at CAGIS instead of on the laptop in the field.”



For the HCE Culverts project AIM uses internal validation of integral fields in the data entry form and warns about invalid data entries. This reduces errors and data mismatches and creates high quality asset information base for the department.

Hamilton County Engineer's Office

Todd Long — *“Upon viewing CagisAIM in use by the City of Cincinnati for signage and by the GCWW for hydrant inventory, it became obvious that this tool could be adapted for inventory of the County road assets. The first item we have envisioned being able to inventory with the CagisAIM program architecture is culverts.*

“In a very reasonable timeframe CAGIS staff was able to work with the Engineer's Office to develop a method that would assist the collection of the assets for which we had previously been keeping paper records, by developing a tool that allows the user to enter a distance from any given intersection to assist in the location of the physical asset in the field. This feature was needed because of the past recordkeeping methods on linear projects. Additional programming was added to allow for the graphical selection of point and an offset distance to be depicted, thus allowing for triangulation of the asset to be inventoried. These features make the CagisAIM Culvert Module very flexible for the field staff entering the assets. The Engineer's Office is hopeful that this program architecture will allow for the future development of other modules for additional fixed assets such as guardrail, signage, striping, signals and potentially other assets that our office maintains.

“The ability to add pictures to the culvert asset inventory will allow another method of standardization and quality assurance and allow the Engineer's Office to efficiently collect data for the entire county road system.”

Outlook:

CagisAIM through continual evolution is in its third wave of development. With the latest updates to ArcGIS 9.3 and beyond, the author and CAGIS' development team look forward to present the newest version in a presentation ("CagisAIM revamped: A new generation of multitasked inventory asset management") at the ESRI User Conference 2010.

Remarks:

The author would like to thank Raj Chundur and Jay Erndt of CAGIS for ideas, valuable input and help in developing CagisAIM to its current version level and their support as supervisors to advance AIM to be a powerhouse in field assessment software in the Hamilton County region. A warm thanks to Dan Young of CAGIS, for testing the user interfaces of AIM. Additionally, I express thanks to Revell Sherrer (DOTE) and Todd Long (HCE) for their commitment as users to make CagisAIM a state-of-the-application. A general thanks all CAGIS staff who made working on the development of CagisAIM a pleasant and rewarding experience.