I. Project Title

Collaboration with City of Springfield, Greene County, MO on Local Government Remote Sensing Operations: Image-based Infrastructure Migration, Update, and Maintenance: Operationalization and Accuracy Assessment in Greene County and the City of Springfield, Missouri.

II. Lead Investigator

Primary Point of Contact:
Administration
Evelyn Honea, CPA
Director of Information Systems
Chair, Interagency GIS Policy Board
220 E. Central, P.O. Box 8368
Springfield, MO 65801-8368
Phone: 417-864-1626
Fax: 417-864-1124
Evelyn_honea@ci.springfield.mo.us

Secondary Point of Contact:
Technical
Mike Fonner
Geographic Information Systems
Department of Information Systems
840 Booneville Ave.
Springfield, MO 65802
Phone: 417-864-1942
Fax: 417-864-2059
Mike_Fonner@ci.springfield.mo.us

ICREST PARTICIPANT:
Timothy L. Haithcoat
University of Missouri - ICREST
104 Stewart Hall
Columbia, MO 65211
573-882-2324
HaithcoatT@missouri.edu

III. Research Goals / Objectives

Baseline Condition:

The goal of this effort was to implement and operationalize the use of remote sensing imagery and technologies within the GIS Enterprise (county and city governments and the municipal utilities) in conducting day-to-day operations and management.

A major stumbling block to this integration of remotely sensed data into the existing GIS database structures is the issue of the positional accuracy of the existing line-work within the vector GIS database. This inaccuracy manifests itself when overlain to more positional consistent imagery data as well as when GPS data are used. Figure 1 shows a typical situation occurring between the existing GIS data layer (parcels) and the imagery base. This is a common problem with GIS and imagery that is occurring within local governments across the nation.

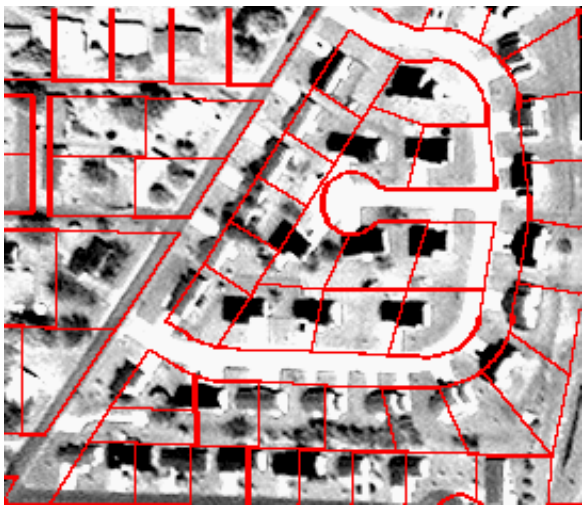

Figure 1: Typical Example of Vector Overlay on Imagery

The problems are positional accuracy and workflow issues. The positional accuracy problem is a result of limited resources when the GIS system was initially created from hand drawings. The process resulted in a seamless database, although it very accurately reproduced the inherent errors. Horizontal control for the GIS system was developed from a USGS Watershed Sinkhole Study done in the early 90's for all of Greene County, Missouri. Accuracy could be +or- 40 feet meeting the map standard that applies to the USGS 7.5 minute quadrangles. The cadastral base created from this horizontal control is currently maintained by the City of Springfield for legal tracts of record and a second version is maintained by the Greene County Assessor's Office for parcel taxation. The different editing procedures have created discrepancies between layers that should share the same geography.

The workflow problem stems from the independent nature of the organizations involved with the Enterprise. Each organization is charged with certain record keeping responsibilities that do not reflect the technology available or differing technological approaches. The use of a single base map across the Enterprise is a goal. The incorporation of GPS and the associated problems of a seamless, integrated base map with unknown positional accuracy, had caused the Enterprise to reach an impasse for the development of individual applications on a common base map. The use of high-resolution imagery with high positional accuracy (± 10 ft RMS) that can provide the common ground for migration of all files and allow for their integration and maintenance was the answer to this dilemma. The only way the Board has achieved full participation to produce and maintain this file was through the use of an imagery-based solution. Imagery can be used for more accurate assessment, planning, growth management, infrastructure assessment/reporting, and change monitoring once the GIS data are migrated to a more accurate position.

The Enterprise had invested approximately $15 million dollars and 194 person years in the development of 175 additional GIS data layers that reference the base map. The Enterprise had, in collaboration with the University of Missouri – ICREST, access to the needed tools and techniques for the development of the high resolution, high accuracy image base map and the accurate migration and maintenance of the large number of vector data layers to the image base. These issues were resolved through this project in order to build remote sensing operations into local government.

IV. Summary of Research Activities

A process was developed by the University of Missouri – ICREST (funding from NASA) that uses tie-points from imagery sources as well as ties derived from within the GIS parcel map layer to create a gridded continuum of linearized adjustments. The parcel linework (or any other data layer built on that parcel framework) is then degenerated into points and topological relationships and the individual positional locations altered based on the adjustment surface. Once adjusted, the linework is reassembled and topology reestablished on the adjusted layer. This tool has assisted the Enterprise in migrating their vector data to the image base while maintaining the integrity and the **relative**-positional accuracy of the vector data. The application has documented the **absolute** positional accuracy of the vector data layers as well as created

a new vector database with known, higher positional accuracies. The application has systematically and in a common fashion corrected the discrepancies across GIS layers.

This is critical work as it is this migration and spatial referencing capacity that has allowed the legacy systems and databases to be integrated with the remote sensing data available today. The technologies, tool kits and interfaces to allow for this conversion process were transferred from the University of Missouri – ICREST to the Enterprise. Training and education in the use and utility of these tools was provided to ensure proper implementation and integration within our local government applications.

Vector Migration Training

Our main objective is transferring the technology developed in-house to external clients who will then have the ability to modify or continue with the operation. The key to moving the base of operations is relaying the technology in its entirety and keeping open the lines of communication. Dead ends and other problem areas are given the same level of importance as the successes. This is done to ensure that time and money is spent improving the operation rather than reinventing the same broken wheel. Ongoing information sharing provides an opportunity for the client to receive technological support, and produces feedback for the parent organization to improve the product prior to future implementation. Following these parameters ensures a smooth and efficient transition whereby the client is independently operating the technology and all parties have benefited from the partnership.

It was decided that the algorithm's complexities should first be tested prior to training and delivery. Smaller pilot areas had been used during algorithm development, but applying the algorithm to a large multi-zoned area containing both rural and urban sites would present challenges not found in the pilot studies. The application of the algorithm to the 28 non-edge-matched parcel zones of Boone County, Missouri provided the trainer with the experience necessary to understand the complex process, as well as the way it behaves under irregular conditions. The successful migration of Boone County's parcel vectors supplied confidence in the product, and in our capacity to transfer knowledge of the product.

Delivery of the vector migration algorithm to Springfield and Green County was coincident with a two-hour training session beginning with a step-by-step presentation of the algorithm as applied to sample data obtained from Springfield, and ending with a question and answer session that was interactive with the data. The trainees were provided a cookbook of the algorithm, which was also the outline of the presentation. The algorithm was applied to data that the trainees would be working to adjust after the session for the sake of clarity and familiarity. While displaying the process on a projection screen at the front of the room, the algorithm was demonstrated from beginning to end. All information, appropriate usage as well as mistakes, gained from previous experiences was provided for the audience to increase efficiency by avoiding the duplication of errors. Every trainee was familiar with Arc software, making the presentation portion of the training effortless.

Questions raised during the question and answer session were primarily in reference to irregularities similar to those encountered during the migration of Boone County's parcels, which were accurately fielded by the presenter. Other questions centered on the inclusion of control points previously collected by the trainees. This option was not previously tested, but the possibility of inclusion was discussed at length

and found to be favorable. The best methods for doing so, along with conceivable problems, were also presented.

The session ended with an exchange of phone numbers and email addresses, and with the agreement of a follow-up visit. These actions best exemplify that movement of operations from in-house to an external entity should not terminate with the delivery of products and knowledge. Communication should be maintained with the client in order to offer technical support and establish a feedback loop for the parent organization.

The follow-up visit allowed us to view our creation taking on new life. The Springfield group contoured the algorithm to meet their needs in a way that could not have been foreseen. Their more experienced knowledge of the native datasets permitted them to improve upon our basic methodology. Seeing the improvements in the algorithm to accommodate local parameters will benefit us by demonstrating a new alternative for future implementation, and coincidentally offers a source of pride and satisfaction that we have successfully transferred knowledge that is helping a partner.

The most notable accomplishment from the project is the successful transfer of knowledge from the developing entity to the end user. Adding to this accomplishment is the mutation of the knowledge, proving that the operation is now external, and ironically the end user has become a developer. We have succeeded in our goal of accomplishing a technology transfer whereby the knowledge has completely changed hands and all parties have benefited.

V. Conclusions

Supporting Mandated Responsibilities/Decision Making:

The Enterprise participants have responsibilities mandated from the City Charter, City Council ordinances, County Commission, Board of Public Utilities and State Legislature. These mandates relate to record keeping in many forms, map/drawing productions, maintenance, economic development, and ultimately public safety. Greene County, City of Springfield, and City Utilities of Springfield are in constant need of accurate geospatial information.

The project has increased the positional file accuracy and resolved the discrepancy between the two base maps that are the foundation of the GIS user applications. It developed a shared responsibility workflow enabling the Enterprise to eliminate redundancy and encourage an integrated and cooperative effort to more efficiently meet the mandates for record keeping that each respective organization is charged with. *The application has provided future decision-makers, and the public, with a much needed level of confidence in the information they are using.* The project allows county, city, and private sector users to maximize the use of spatially integrated remote sensing and GIS vector data.

The benefits realized from this application are both tangible and intangible. They include but are not limited to:

Community Growth & Resource Management:

- Utilizing imagery with referenced base layers (parcels, roads, etc.) for change detection
- Planning and zoning, land use, land cover, population estimates/projections
- Emergency vehicle route mapping, automated vehicle locating

- Evaulation of sinkholes and flood plains

Decision Making – Public & Private:

- Promote the perception for the necessity of imagery to monitor growth management and planning
- Promote a consensus for the first comprehensive base map to be created within the Enterprise
- Permit public access to the information upon which the Enterprise bases their decisions, providing a forum for better understanding of the decisions

Increased Productivity:

- Increased speed of access to information
- Procedures in place for use of future imagery data sets
- Personnel time savings in daily work flow
- Create an environment for data sharing and leveraging resources
- Provide a foundation for spatial database conversion and development

The Enterprise participants are constantly in need of information to include geographic, survey, and distributed facility data (utilities, property, and infrastructure). These organizations use or provide maps and drawings for almost every project (new or for ongoing maintenance) they become involved with for planning studies, geographic or demographic analysis, property mapping, ownership studies, utility system mapping, engineering and construction planning and drawing efforts to support permitting, application, and public hearing requirements. The Enterprise participants are constantly striving to recover lost productivity to maximize savings and other intangible benefits. Use of timely and cost effective remote sensing products will help the Enterprise accomplish the previously mentioned goals.

The program was developed and implemented according to a plan currently under development within the Interagency GIS Policy Board. The partners each set aside resources in terms of staff, machines, and time to accomplish this goal. The key players include the information technology departments, the planning departments, and surveying departments. The full operational plan impacts most government departments, as the base map is the foundational element necessary to achieve success with the mapping and decision support programs.

The completion of this project and its operationalization within the Enterprise was viewed to be the single springboard to broader use and adoption of remotely sensed imagery. When the parcels line up, then assessment for land in agricultural production or assessment for stormwater drainage (via impervious surfaces) can be calculated resulting in assessment equity. The application of run-off models and flooding models including the areas impacted and risk assessments performed, will have greater meaning and accuracy. The programmatic goals of the planning office with regard to growth management and the urban–rural interface can be tracked, assessed, and pro-actively managed. All of these are very important functions (many of which are revenue generators and items of citizen interest) which are now enabled for adoption.

VI. Presentations / Publications

There were no publications neither was there any presentations made in regards to this activity other than training.

VII. Students Supported

Derek Smith, MA, Geography
Wenbo Song, MA, Geography

VIII. Subject Inventions

No inventions or other intellectual property was developed with support from this grant in regards to the activities outlined above.