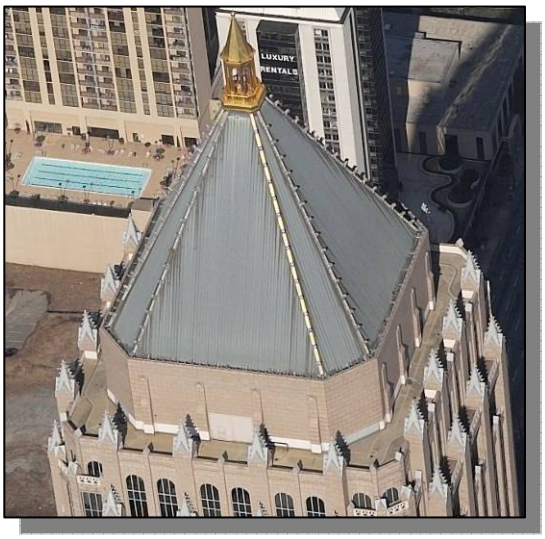
Oblique Imagery & Geo-Referenced GIS Data Pilot Project for Homeland Security



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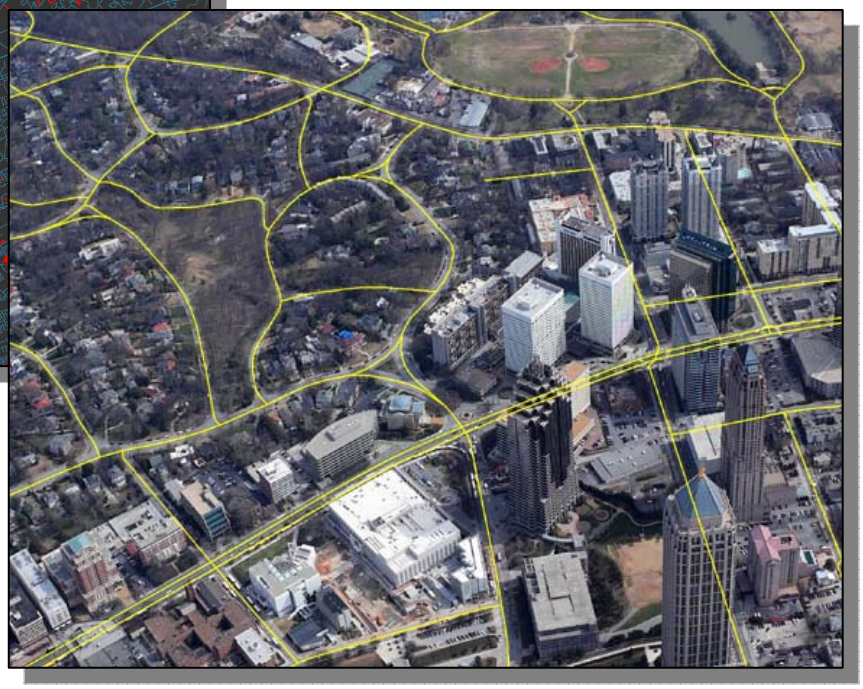

August 5, 2005

Oblique Imagery & Geo-Referenced GIS Data Pilot Project for Homeland Security

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Executive Summary

The Atlanta Region is the first major metropolitan region in the nation to enhance Homeland Security by providing updated street data married to high resolution oblique imagery for 9-1-1 Call Centers, emergency response pre-planning and emergency response execution. The 168,000 segment street data was update by ARC and has shown to be significantly better and more current than any other source of street data. ARC has been a pioneer in the use of oblique imagery libraries in small test areas of the region. The tests proved so successful that ARC received a USGS / NGA Homeland Security grant to purchase imagery for the entire 10 County Atlanta Region. The imagery capture has been completed and full region-wide implementation is in progress. The seemingly small improvement of imagery taken at an oblique angle has had a disproportionate effect on GIS use in the Region. The easy-to-use imagery is significantly increasing the number of GIS users in the Region with a corresponding increase in demand for comprehensive and up to date GIS data.

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Background

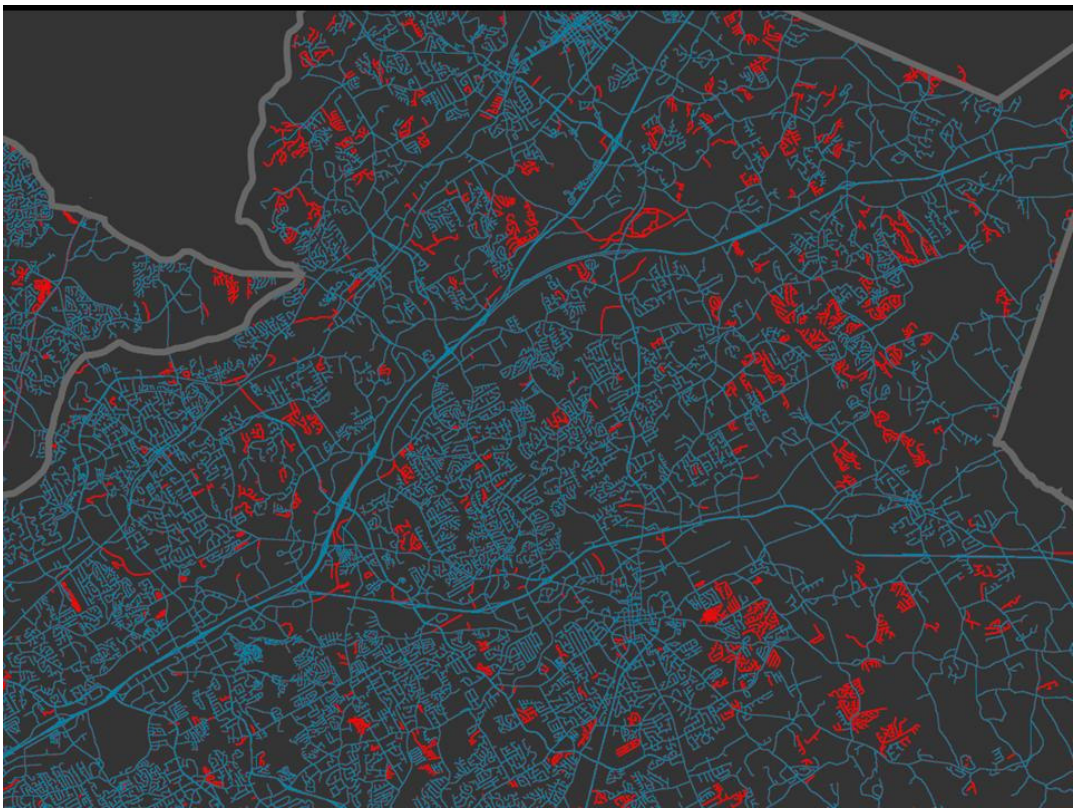
As the Metropolitan Planning Organization (MPO) for the Atlanta Region, ARC must develop population & employment estimates and forecasts more frequently than the decennial Census using approved computer models. ARC uses the DRAM / EMPAL population model to calculate the estimates and forecasts. A required input to the model is accurate and up-to-date street centerline data with address ranges to permit geo-coding of new employment and new building permit data. As the actual street base grew, ARC modelers were finding it increasingly difficult to find and geo-code locations using available street data such TIGER or one of several commercial data sources.

Since the street base data was becoming increasingly out-of-date, it became necessary to update the street data in-house to satisfy the stringent requirements of our modelers. At the same time ARC learned about new high resolution oblique imagery that could aid in identifying new streets and geo-coding new facilities. Most important, it became readily apparent that a synergistic benefit could be achieved for planners, emergency responders and 9-1-1 Call Centers in the Region by using the updated GIS street data overlaid on new technology geo-referenced oblique imagery.

Six inch pixel oblique image overlaid with GIS street data, house numbers and fire hydrant locations.

After a year of work the updated ARC street data was completed and proved to be superior to any other source. The ARC street data contained approximately 7% more

new streets than the latest version of TIGER and 4%-6% more than commercial data sets such as GDT/TeleAtlas and others. As a result, field trips to verify employment and building permit data were significantly reduced.



Part of the Atlanta Region displaying old streets in blue and new additional streets in red.

The synergy between the easy-to-use oblique imagery and software overlaid with GIS data opened the GIS and imagery world to many more users. No one anticipated the impact this small improvement would have on the region's GIS community. It has created legions of new users and champions of GIS. Now that the novelty of this imagery has become routine in some counties, we are seeing that oblique imagery is becoming a regular tool and part of the business process just as GIS and ortho imagery were in the past. No county that has fully integrated oblique imagery into the county business operations has been willing to now do without it. Several counties are in fact planning annual updates of the imagery rather than the normal 2 year cycle updates.

Two system design problems and one institutional problem were encountered. Two key design issues were initially encountered. First, the imagery is provided from multiple directions and two resolutions with a single 1.5 foot pixel ortho image and oblique images from 2 or 4 directions with a 66% overlap. The same views are also repeated at a 6 inch pixel resolution from 4 directions plus an ortho. As a result, massive disk space was needed for the large imagery files. This was solved by adding 3 terabytes of storage to ARC's central system and purchasing several 500 GB portable hard drives for file

transfer and field operations. Second, although the oblique image viewing software imported, re-projected, geo-referenced and overlaid ESRI Shapefiles on the oblique imagery, there was no direct connectivity with ESRI GIS software. This was solved with an ArcGIS extension that sends X-Y coordinates from ArcView to the oblique image viewing software so that the correct images are displayed.

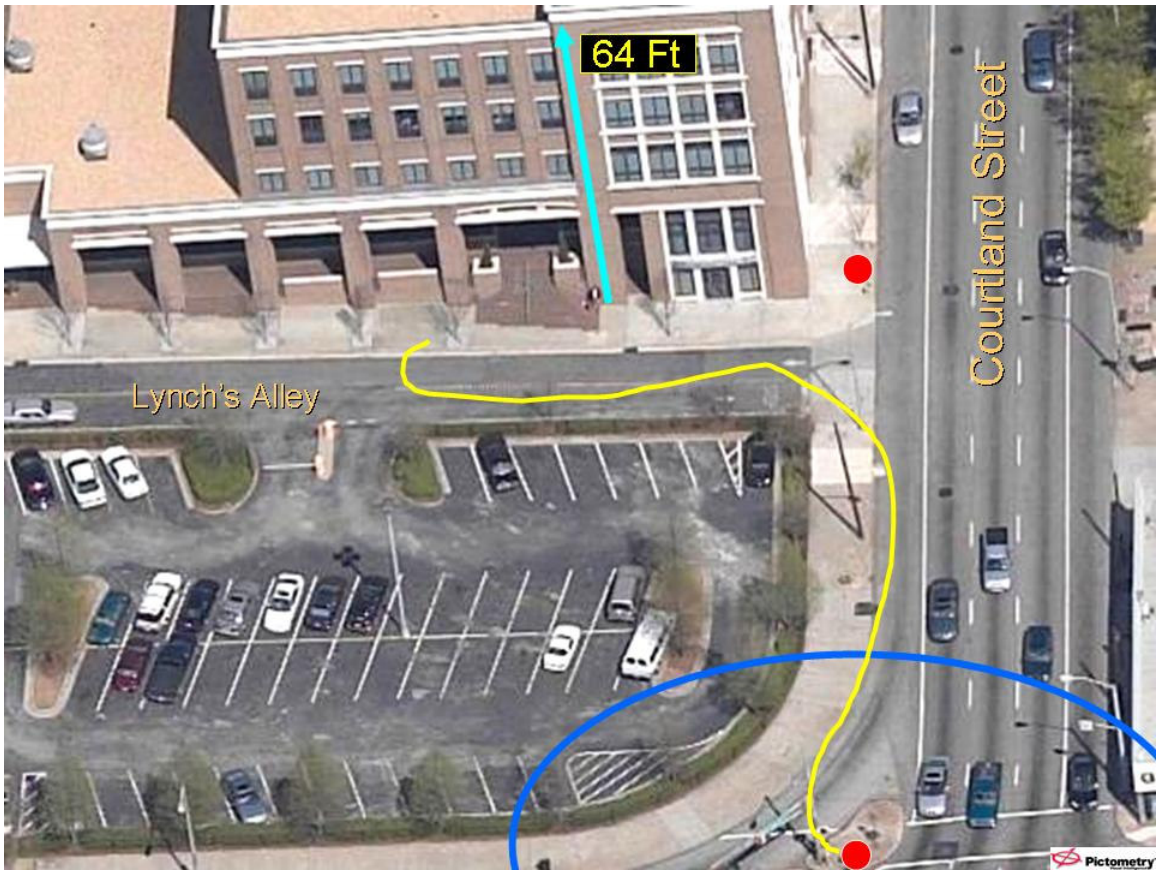
A serious institutional problem was also encountered when some GIS professionals seemed threatened by this easy-to-use imagery and GIS viewing software. There seemed to be a reluctant opinion from some that this new imagery and software made GIS "too easy." That it was not ESRI-centric nor was it as accurate as ground control rectified ortho imagery. There was a misunderstanding that this new capability was intended as a replacement of the existing GIS and ortho-imagery rather than the new additional tool and resource that it was. By their nature oblique images are not as positionally accurate across the entire image as otho imagery but they are more than accurate enough for the new intended uses. They serve completely different and complimentary functions. This initial reluctance from some GIS professionals has been changing rapidly as more users adopt and have experience with the new technology.

The Atlanta Region is the first implementation of a consistent region-wide street database coupled with region-wide oblique imagery. One example, most 9-1-1 Call Centers use paper maps, CAD drawings or GIS mapping with little or no adjacent county planning data. Most do not use imagery and no region-wide system uses street data with geo-referenced oblique imagery. The ARC region-wide system provides a valuable multi-county mutual aid resource for planning and response to Homeland Security and disaster preparedness events many of which do not conform to county boundaries. It fosters a regional approach which is strongly stressed and encouraged by the Federal Department of Homeland Security as a way to leverage valuable resources and capabilities during emergencies.

IMPLEMENTATION

Phase 1: 2002 ARC started the update of Region-wide GIS street data. This took approximately one year requiring approximately 2 man years of labor.

Phase 2: 2003 ARC purchased oblique imagery and viewing software for a pilot area from an oblique imagery vendor, Pictometry International Corp. The early version of the oblique image viewing software, called EFS, to access the imagery was a stand-alone software product. The software was able to import and geo-reference ESRI GIS data but it had no geo-coding capability against an address range street base.



This oblique image displays the capability to overlay GIS data on the image to identify streets and other features. It also shows the capability to accurately measure horizontally and vertically shown in blue. The user tools also permit the operator to quickly layout to scale, items such as a fire hose shown in yellow.

Phase 3: 2004 An upgrade to the EFS software created a link tool extension from ArcView to EFS. This permitted us to geo-code or locate any feature in ArcView and then send the coordinates to EFS so the correct imagery could be displayed. This was not an elegant solution but it did create a needed capability.

Phase 4: 2004 Four ARC Counties purchase high resolution oblique imagery and begin implementation. Several other Counties in Georgia also purchase and use the imagery, most notably security pre-plan, monitoring and emergency response during the G-8 Summit in Savannah.

Phase 5: 2005 An upgrade to the software created a link tool extension from ArcGIS to EFS. This permitted us to geo-code or locate any feature in ArcGIS and then send the coordinates to EFS so the correct imagery could be displayed. This linkage worked much better than the ArcView link.

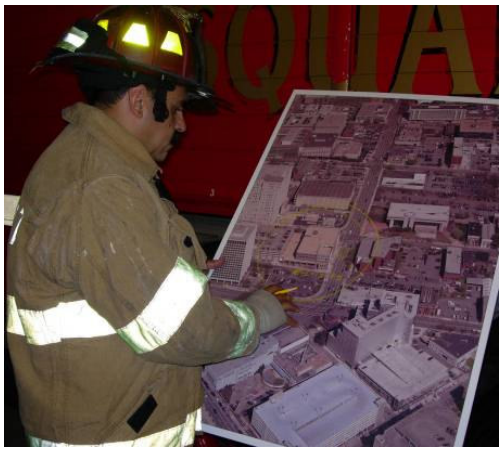
Phase 6: 2005 ARC GIS personnel became qualified and set up a training center to conduct training for all ARC and county employees needing training. The

ARC GIS training lab is equipped to train up to 15 students at a time in the use of ESRI GIS software and oblique imagery.

Phase 7: 2005 ARC applied for and received a grant from USGS / NGA to purchase 1.5 foot ortho and oblique imagery for the entire 10 County Region. This imagery coupled with the ARC street data and software now makes it possible for any County in the Region to benefit from the oblique imagery and GIS data at no additional cost to the County.

2005 Understanding the broad utility of the oblique imagery with GIS data and remembering the lessons learned from New York City during 9/11, ARC's GIS Division built a mobile emergency GIS capability capable of setting up a field GIS operation anywhere in the Region on 1.5 hours notice. The field package consisting of two laptops with GIS data and ArcGIS software, oblique imagery and software, four portable 500 GB external drives, router, LCD projector, screen, "E" size plotter and a "E" size lamination machine that permits mounting and lamination of the plots on waterproof foam core.

We have learned that sometimes a low-tech embodiment of a high tech system is more effective than high tech tools. This is why we provide the capability to print and laminate the GIS data and imagery for rough field use permitting mark up with grease pencils in wet locations. The same laminated images can be used to very quickly construct a physical 3D model of a building or neighborhood for hostage SWAT team planning.



The imagery can also be overlaid with Shapefile footprints generated by the Cameo/Aloha EPA toxic chemical plume generation software to identify evacuation areas.

ORGANIZATIONAL IMPACT

ARC is using the imagery overlaid with GIS data for public meetings including large laminated displays. The oblique images and GIS data are used in paper electronic publications and presentations since it is such an effective visualization and communications tool. It is especially useful to covey complex projects to the public.

Currently 4 of 10 ARC counties are subscribers to the high resolution oblique imagery for their respective counties and are at various stages of implementation. The most mature installation is in Gwinnett County initiated by the fire department. Since that initial installation the use of the imagery and GIS has spread from 5 users to over 450 users County-wide. Some examples of use by Counties include:

9-1-1 Call Centers - Aids in fast communication, visualization and evaluation of the

emergency situation. XY coordinates are then sent to responding unit so they can bring up the corresponding image.

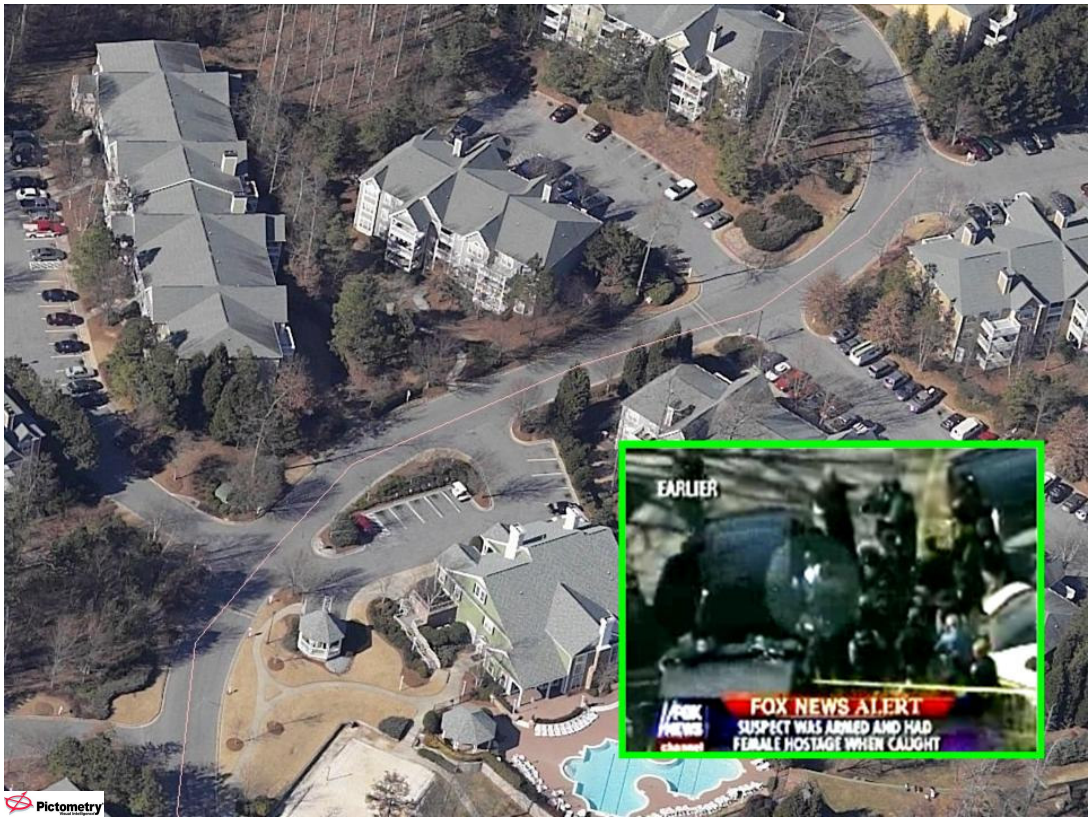
All Gwinnett County fire trucks have laptops with oblique imagery installed

Fire Department - Has aided greatly in pre-planning action on the way to the fire with a reduction in the amount of time needed to start action to correct the problem.

Fire chief viewing pre-plan GIS data and oblique imagery on a laptop on the way to the fire.

One county used the imagery to locate and close off an open retention pond that was not holding back toxic chemicals pouring from an industrial fire. Unchecked the chemicals would have caused a major river contamination.

Police Department - Used to pre-plan actions. One example was the SWAT team preparation for the apprehension of fugitive Brian Nichols.



Oblique view of apartment complex. Note street centerline GIS data overlaid on the image. The SWAT team pre-plan was so thorough it even included facing SWAT team vehicles in a way to maximize protection offered by vehicle engine blocks from potential gunfire originating from fugitive's location.

Justice Department - Used for serving warrants by Sheriff's deputies. Most warrants are served at night. Deputies said that by viewing the parcel data and imagery of the residence they could stage agents at logical escape routes and the suspects "literally run into our arms." Additionally, the district attorney uses the oblique imagery in courtroom trial presentations instead of hiring a helicopter to take aerial pictures of a crime scene.

Finance Department - Uses the GIS overlaid data and imagery for GASB 34 inventory work and review. Has significantly reduced field trips.

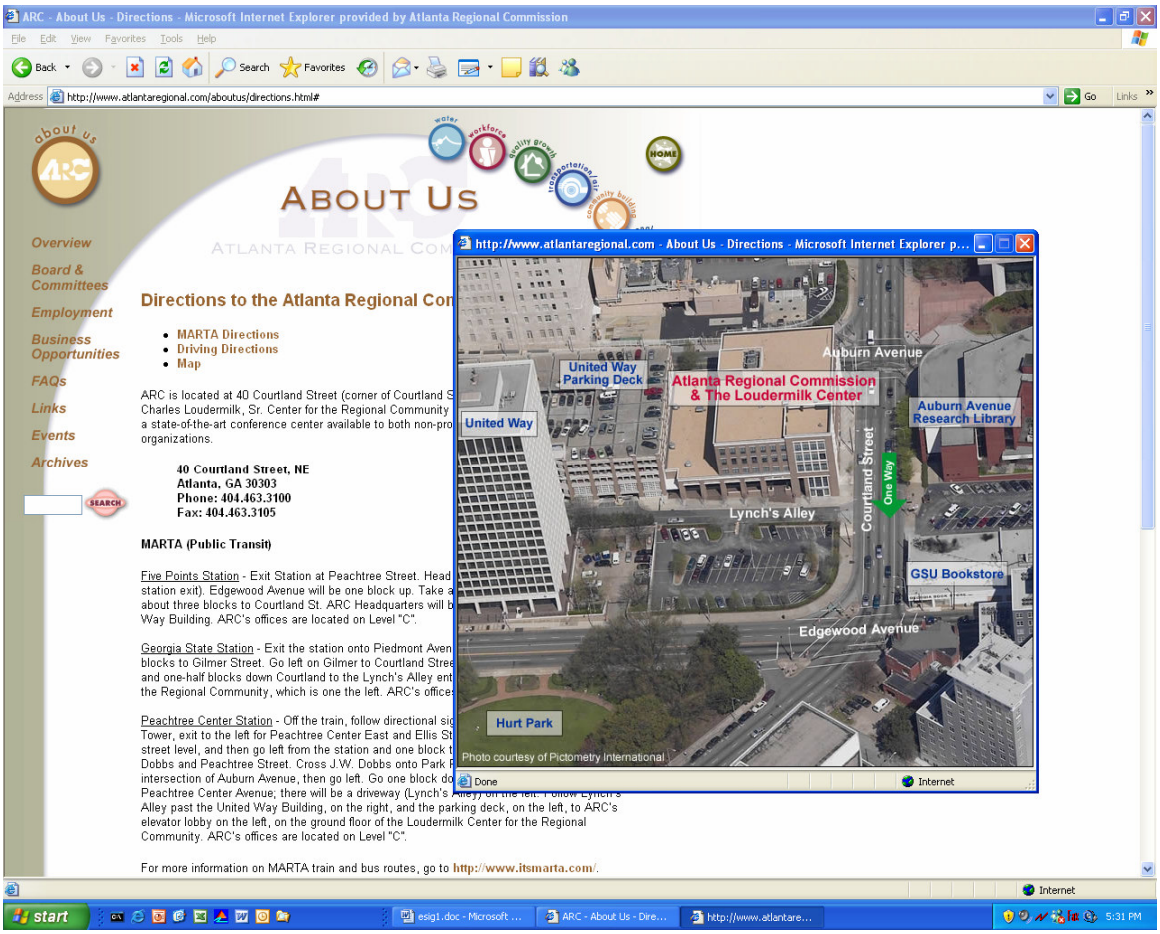
Public Works - Uses GIS data with imagery for project tracking and cost estimation of paving, roofing and lawn maintenance. See sample images below. (Note that the images with overlaid GIS street data have been extracted, compressed and placed into a PDF format for publication. As a result, the images are not as crisp and clear as the original imagery viewed on-screen or printed on high-resolution plotters.)

1.5 foot pixel oblique image and GIS data

1.0 foot pixel ortho image and GIS data

6 inch pixel oblique image

6 inch pixel oblique image zoomed in



ARC website showing directions page with annotated pop up image

ARC Uses - Used to help Website users visualize directions to ARC, public meetings to discuss/evaluate LCI projects, PowerPoint presentations, imagery plots with GIS data overlay, ARC's emergency mobile GIS planning, site visualization and special use such as Aloha/Cameo plume footprint generation and overlay to identify homes for evacuation in the event of toxic chemical spills.

Qualitative benefits have been legion. Fast visualization of 9-1-1 calls, more effective fire and police actions, safer serving of warrants, reduced field work by county employees, etc. See list in section E-6. Qualitative data gathering is in progress by GIS students and Department Head Dr. Mark Patterson of Kennesaw State University. Dr. Patterson and ARC will publish a joint White Paper documenting the ARC Pilot Project and cost vs. benefits of the oblique imagery for county use after data is gathered.

The most significant monetary impact has been tax assessor work. I our pilot project County, Gwinnett County was preparing to sign a contract to take single digital photographs of each building in the county. The price would have been $850,000. The Tax Assessor saw the high resolution oblique imagery and realized that instead of a single photo of the front of each building the oblique imagery would provide aerial photos of the front, sides and back yard of each piece of property for less than half the price with GIS parcel data overlaid on the imagery. The Gwinnett County Tax Assessor then contracted for four way high resolution imagery of every square foot of the County.

The Tax Assessor has stated that he has found numerous cases of tax under reporting with significantly less field work. He feels that the GIS tools and imagery were so beneficial that he is increasing the frequency of photography from a two year cycle to annual cycle. He also indicated that the cost of the imagery has been recouped by way of increased tax revenue generated by finding unreported improvements, other taxable events and reduced tax personnel field inspection trips. This has been especially gratifying since funding of GIS data creation and imagery is no longer an issue for other departments since the Tax Assessor is now providing the primary funding.

The most important effect on productivity has been 9-1-1 Call Centers and emergency responders. Shaving 20-60 seconds off response and emergency action all responders agree will save lives and property by taking effective action rapidly. A more effective team also has the effect of leveraging resources by nipping problems at an early stage rather than when the problem grows and becomes more severe. Other examples include reduced field work by ARC data collection personnel or tax assessor, financial or public works personnel at counties.

Since the oblique imagery is so visually compelling and intuitive to non-technical users, such as police, fire or politicians, they embrace it quickly. After the initial excitement of the oblique imagery the discussion naturally leads to logical follow-on questions about the image such as "What street is this? or What house number is this?" at which time we show the overlaid GIS data. That is the "Ah hah!" moment that then leads to the ultimate understanding as to why one needs a GIS, GIS data and an ongoing GIS data maintenance effort. The image alone is not as valuable as the image with GIS data. As a result we have seen more converts to supporting GIS than any other single product or event.

This kind of group enlightenment has led one of our counties, Clayton County, to completely revamp county operations, tearing down "stovepipes" and mining valuable unpublished data that is being shared with other departments and the public via an enterprise GIS and GIS web applications. Although the process now involves far more than just oblique imagery, the oblique imagery was the catalyst to get the process started. We see the same potential starting in several other late adopter counties in ARC and the rest of the State now that all ARC Counties have some imagery and GIS data provided by ARC.

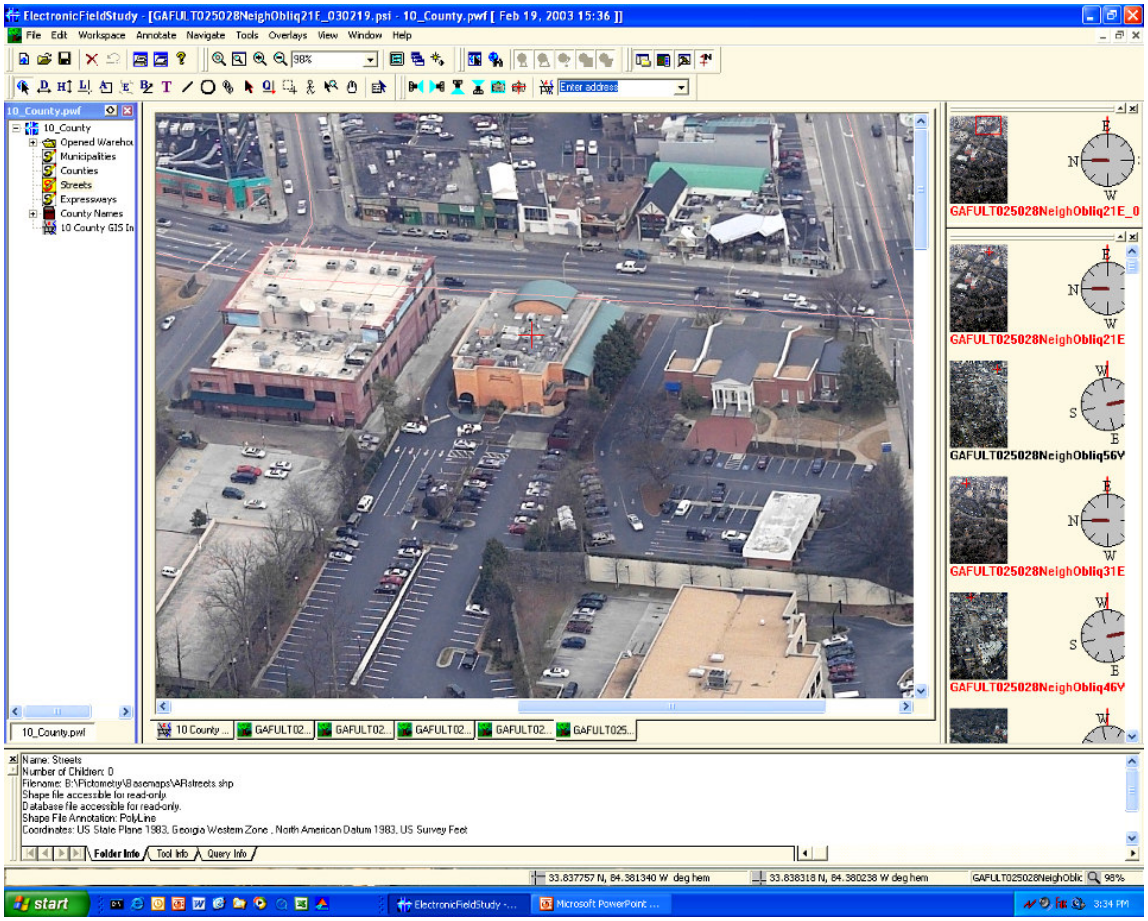
The following are some examples of how the business of ARC and local governments has changed as a result of this new imagery. We are still surprised at the new unanticipated uses that evolve regularly.

OLD WAY	NEW WAY
ARC	
Public meetings used GIS maps and ortho-imagery	Public meeting now include oblique images overlaid with GIS data and proposed projects for even better visualization.
Regional data development consisted of extensive field work and many man-hours of research.	Oblique imagery is now used to reduce field work in data gathering projects such population, housing, employment, sidewalk inventory work, streets and road characteristic data collection.
Our web site contained only written directions to ARC and a vector map showing our location.	Our web site now contains a GIS annotated oblique image for better visualization of the ARC offices and parking (See image in section E-2)
Land Use data development was done through photo interpretation of ortho-imagery and phone/field research.	Land Use data development is now supplemented with oblique imagery to help in the identification of certain land ownership by reading signs on buildings to identify public of private facilities.
ARC publications used maps, ground photos and occasional ortho images to tell a story.	ARC now has a library of aerial oblique images from at least two directions covering every square foot of the Region overlaid with GIS data so visually compelling images can be used to tell the story more clearly to the public.
Grant applications were mostly text, maps and charts.	We now submit some grant applications that include oblique imagery that reinforces and builds on the application narrative.
No mobile emergency GIS capability	ARC now has a portable emergency GIS that can be set up in any part of the Region within 1.5 hours. ARC GIS personnel can provide GIS support on two laptop computers, project the images via LCD projectors, print out hard copy “E-size” plots and laminate the plots for use in wet field operations. We can also “build” an actual 3D model of a location for hostage type situations. (See section D-2 for details)

OLD WAY	NEW WAY
COUNTIES	
9-1-1 operator uses paper, CAD or GIS maps to visualize the call	9-1-1 Operator uses oblique imagery with overlaid GIS data to see a picture of the call location
Fire chief on the way to the fire operates the fire truck siren and horn	Fire chief on the way to the fire gets XY coordinates of the location and studies oblique image with GIS data of the site and pre-plans action saving 20-50 seconds of time starting their response (See section E-1 for images)
Police use road maps and flip chart to plan action	Police have oblique imagery and GIS data to visualize pre-plan action. (See section E-1 SWAT team)
Sheriff's Deputies serve warrants with no pre-plan images	Sheriff's Deputies serve warrants with pre-plan parcel data and oblique imagery to visualize and block escape routes
Tax Assessor using paper maps and field trips to identify taxable facilities	Tax Assessor uses GIS data and 4 way high resolution oblique imagery to identify taxable facilities even in fenced backyards. Reduces field trips significantly while improving tax equity.
Finance Department maintains and conducts GASB 34 infrastructure inventory via field trips	Finance Department maintains and conducts GASB 34 inventory by using GIS data and high resolution oblique imagery to reduce the number and/or length of field trips and revisits.
Public works uses tape measure to estimate roof repairs, lawn maintenance, paving work, etc.	Public works uses GIS data and high resolution oblique imagery to help estimate roof repairs, lawn maintenance, paving work while reducing field trips for estimation and follow-on questions from contractors.

Hardware and Software

ARC maintains this system on a Microsoft Windows-based network, supported by Windows servers, with Windows XP on desktops throughout the agency. Most desktops are Dell Optiplex computers, 1.6ghz or higher with 256-512mb of memory, though GIS Division staff use machines with 1gb of RAM for editing and processing. Throughout our enterprise are 175 Windows XP desktop computers, 25 Windows laptops and over 25 networked printers, plotters, scanners and copiers. Our infrastructure consists of 20 Windows servers running Windows 2000 Server/Advanced Server and Windows 2003 Server with nightly backups powered by Commvault's Galaxy software for online recovery capability of recent data and weekly/monthly tape backups offsite. Wireless communication within the building is provided via 802.11g access points on ARC's 3 main floors, and outside the building via wireless access card provided by Cingular Wireless. Web/internet services are provided to ARC's entire network of desktop computers and servers through dual T1 lines.



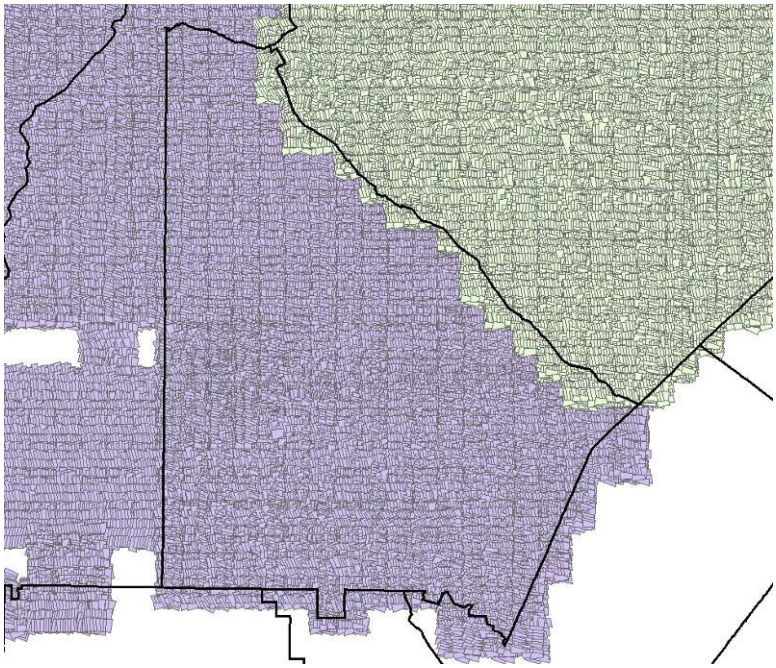
Screen capture of EFS software interface

The primary software used for imagery access is Pictometry's Electronic Field Study (EFS) version 2.6 and ESRI's ArcGIS version 9.0 with concurrent and single-use licenses at the ArcINFO, ArcEditor and ArcView level. The EFS software has the capability of viewing and querying ESRI Shapefiles, such as the Atlanta Region Streets database (ARstreets), on top of Pictometry's oblique imagery at both the Community and Neighborhood scale.

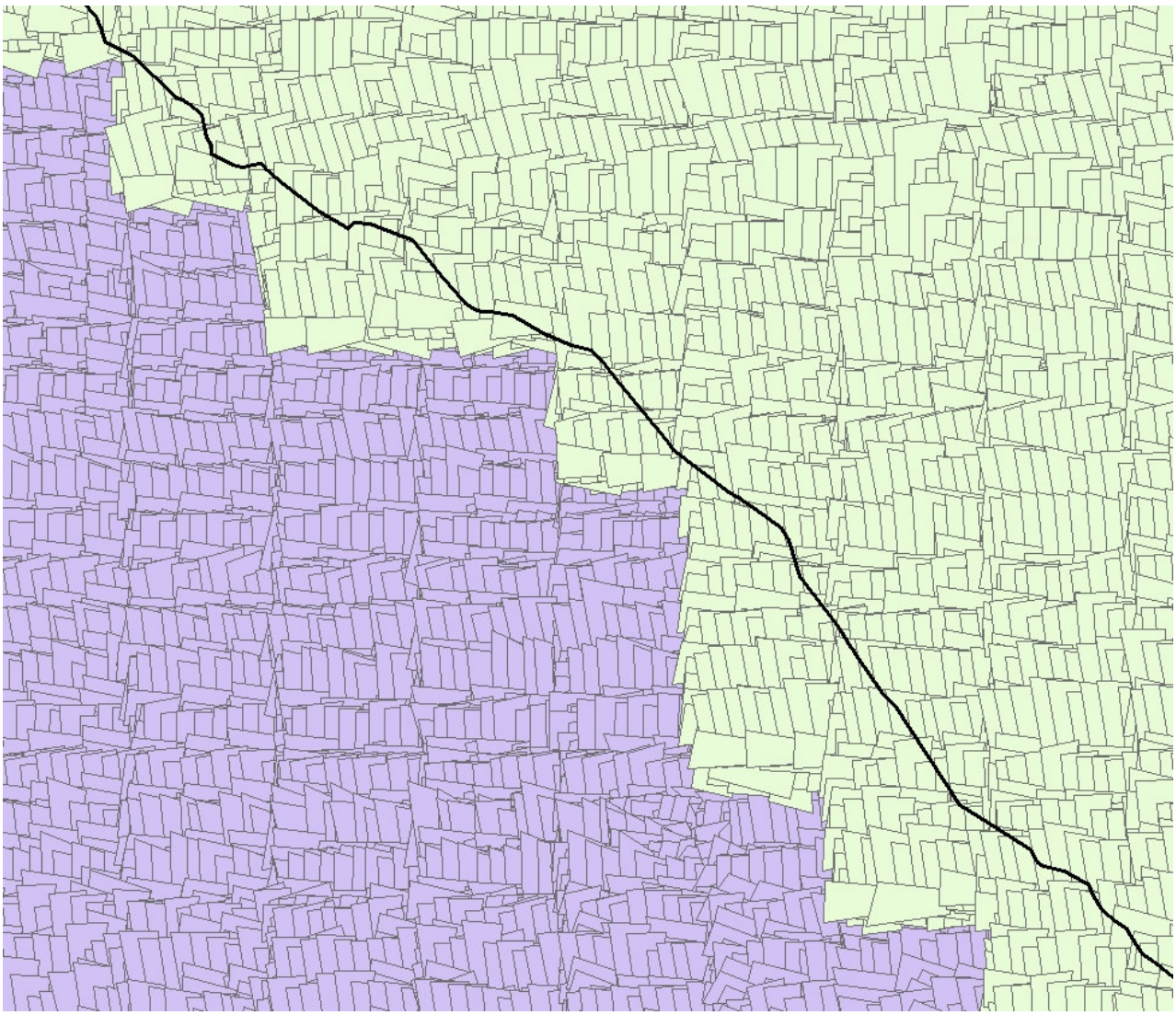
Based on this interface and other collateral data sources, edits to the ARstreets database are made within the ArcMap environment of ArcGIS. As needed for production, maintenance and administration, all GIS and IT staff use Microsoft's Remote Desktop for access to their workstations and servers. The use of ArcSDE is expanding for database management of enterprise-wide raster and vector GIS data.

Databases

The principal vector dataset of this system is ARstreets, ARC's street centerline database covering 10 counties and 3,000 square miles of the Atlanta metro area. The current version of this database represents a cooperative effort between the Georgia Department of Transportation (GDOT), with their contractor ITOS, and the Atlanta Regional Commission, with our constituent county governments. A variety of other vector datasets are used for collateral information in the maintenance of this system, such as local and federal streetbases, regional and state community facilities, and county parcel databases. The principal raster dataset of this system is Pictometry's oblique imagery which is organized in warehouses by county in JPEG format. A variety of other raster datasets are used in conjunction with the oblique imagery, including ortho-photography from Pictometry and Aerials Express, Inc. and digital raster graphics from the U.S. Geological Survey.



Oblique image footprints for DeKalb County, GA



Closer view of oblique image footprints for DeKalb County showing typical 66% overlap

Summary

The pilot project has succeeded well beyond our expectations. Although the technology has raised the level of all GIS operations in the Region, the reoccurring opinion is that it is creating more GIS users and more support for top notch GIS data. Most important, everyone now believes that the technology will save lives.

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