Low Cost, High Return on Investment Public Safety Mobile GIS

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Abstract
The need for highly reliable and accurate mobile GIS that improved upon the City of Yuma's Fire Grid analog hardcopy map book system has grown in the past few years. However, many traditional applications and approaches include high bandwidth impacts, high software and server costs, and personnel dedicated to support these implementations. This paper will present a focused outline of common needs and examples for the development of a low cost, high return on investment mobile GIS application. The highlight is the approach to developing a highly functional system that has low maintenance and operational cost. Utilizing the ESRI′s ArcGIS Publisher extension to ESRI′s ArcGIS and distributing access to the data through ESRI′s ArcReader provides an avenue to avoid high costs but retain a valuable application.

Introduction
The principles that are contained within this paper can be applied to many systems. The approach used to develop this map is not unlike many well performing software projects, however the specific approach will show that there is a unique quality to the selected software product for this application.

The integration of geographic information systems (GIS) with public safety mobile applications is not a new concept. Traditionally those applications and approaches include high bandwidth impacts, high software and server costs, and personnel dedicated to support these implementations.   However, the approach that was taken for the development of this application was a response to the City of Yuma′s fiscal environment, specific parameters and constraints related to the implementation of a Mobile Data Computer Network project. What is different about this approach is the way that GIS software changed a nearly impossible situation into a plausible and highly successful application in a very short period of time.

The goal for this paper is to use this real-world example to illustrate the approach to developing a low cost, highly useful mobile public safety GIS application that yielded a high return on investment almost immediately.

Background, Parameters and Constraints
The City had embarked on the Mobile Data Computer Network project without the integration of GIS or mapping in mind or documented. The project was in the process of implementation and was scheduled to be completed in three months when the discussion of GIS was brought forth. The short timeline and lack of adequate funding were the key factors that created impeding constraints on the Public Safety Mobile GIS application.   This created a need for an innovative and alternative approach to the application versus the traditional and existing integrated GIS systems supporting public safety.

Cost

The question that was initially investigated was how can a GIS be integrated without being costly? The Public Safety Wireless Network project had been awarded utilizing a combination of grant and matching funding. The scope of this project did not include mapping or GIS integration. The available funds for the integration of GIS were almost negligible. Therefore the total cost, above personnel and overhead, could not exceed the funding from the City's budget which was close to the end of year closing period.

Integration of Maps

The integration an digital map either static or dynamic, either tiled or continuous, was paramount to this project. With that need in mind many solutions came to the forefront, however the grant and award did not include any funds for integrated GIS. Therefore the integration of GIS was a desire, but was not a mandate for the Mobile Data Computer Network project.   The Yuma Fire and Police Departments would be happy to have digital copies of their existing grid maps in each apparatus or unit.   This was the baseline for the investigation and development of the Public Safety Mobile GIS application.

Integration with Public Safety Dispatch

A secondary interaction was requested which included using Public Safety Mobile GIS application as part of the public safety dispatch process. This was driven by the operational mandates by the City's public safety departments for accreditation, response standards, response goals, and techniques. While a direct interaction between the dispatch protocol and messaging received by the MDC was requested, an operational goal to manually search and view mapping was the threshold limitation that created the design parameter.

Therefore the design to integrate with the dispatch protocol for each apparatus/unit required that the operator at least be able to manually search and view mapping that was linked to the incident, event or call.   Full interactive integration became the highest level goal. With the cost and timeline constraints of the potential Public Safety Mobile GIS application the threshold interaction goal was utilized as the design standard for integration.

Bandwidth

The new Mobile Data Computer Network was designed for a wireless radio connection through the City's existing radio network.   The transmission parameters would need to address the generally limited bandwidth available for each MDC. The majority of the bandwidth and radio transmissions would be for dispatch of apparatus and units, unit to unit messaging, Arizona DPS inquiries, and system updates when in "hot zones" (areas of high bandwidth).   Since the bandwidth was primarily public safety dispatch this created an additional constraint parameter which created the need to minimize utilizing the radio network and focus on a stand alone application in each vehicle.

This parameter then raised the traditional questions of how will a mobile application be upgraded and upload the most current data. This was an additional feature that needed to be included in the design of the Public Safety Mobile GIS application.

Mobile Data Computers

The mobile data computers (MDCs) were touch screen enabled and primarily made for installation for rugged mobile use within vehicles.   This eliminated the use of an

external, traditional mouse and created the need for touch screen via stylus and integrated laptop pointing devices.   The screen size, image quality and pixel viewable areas were also considered as parameters.

Hard drive space was also limited and the units were not to have CD-ROM nor DVD drives installed. This parameter was critical to the application. This created the need for a compact, non-complex GIS application that would rapidly store and retrieve files from the MDC hard drive.

Existing GIS Layers and Digital Data
Building on utilization of existing data and resources the City's GIS provided several foundational layers that were able to be used to support the application (*Bowman, 2005*). The critical layers for query for addressing and location information did not require any manipulation to work with the application design. Those layers included in the design were:

- City Limits
- Fire Grid Map Boundaries
- Streets
- Mile Markers
- Parcels
- Water Lines
- Hydrants
- Airport/Marine Corps Air Station - Yuma
- Hydrography
- Structures
- Run Zones
- Fire Management Zone
- Aerial Photography
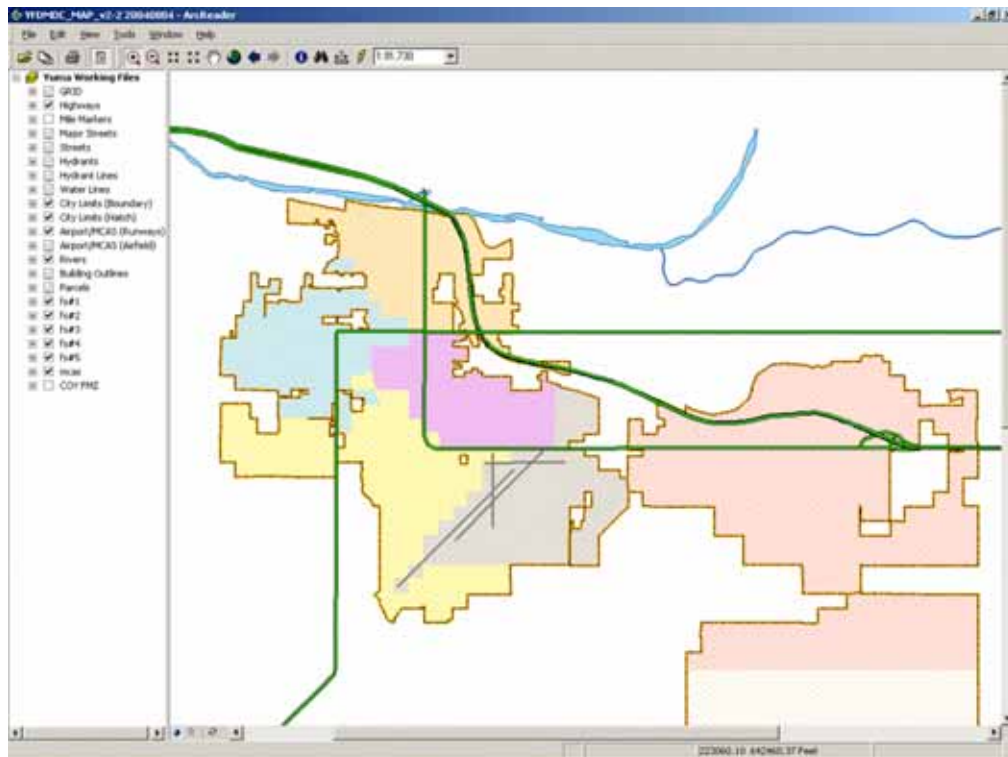
The Yuma Fire Department as part of their grid map book publication process had already created image files (.jpeg) that were compliant with existing free viewing software loaded on the MDCs. An example is shown below. These images covered a large majority of the City of Yuma, but there were areas that lacked data making the GIS layers a necessity for an operational application. These areas included many frequent mutual aid response zones adjacent to or partially within the City limits.

The Yuma Police Department also had many of their layers available covering their beats, sub beats and other administrative areas.

Scope and Design
The scope of the evaluation was to integrate a digital copy of the existing Fire Grid map with the MDCs. The initial request came from the Fire Department therefore the design and evaluation was focused on their version of the Public Safety Mobile GIS application.

The key constraints listed as part of the previous section helped shape the scope of the application. The result was the following scope elements:
- Integrated GIS,
- Integrated digital Fire grid map run books,
- Keep costs to a minimum (if any),
- Eliminate the need for special licenses,
- User friendly,
- Use radio network to perform updates,
- Support touch screen use,
- Common screen interface between applications,
- Stand alone application and data,
- Utilize the MDC preloaded software, and
- Tie in with CAD application.

Solution
There are many solutions that were looked at before arriving at a solution. Many of those included "freeware" applications from GIS vendors. Another area of interest was a browser format however the need for transmission over the radio network made that approach not reasonable. The need to keep from any significant costs any licensed product was not able to be implemented. Another possible solution that was eliminated was the existing public safety vendor and associated third party products, since they carried a much higher implementation and licensing costs.

While there were many solutions that could be made the GIS Administrator determined that the most appropriate application would use ESRI's ArcPublisher and ArcReader software. This determination was made upon the requirements, constraints, and scope of the application. The primary factors for selection included:
- User friendly light application with a fast start time,
- Compact and light look and feel for the user,
- Retained GIS quality and functionality without need for a license,
- Application and data could be shipped via the radio network "hot spots" during down time,
- Easy Query tool,
- Maptips showed primary display field,
- Hyperlinked objects and features to multiple images and documents, and the
- Cost of the extension was very low.

Evaluation of the Prototype Application
Upon selection of the solution an evaluation period was performed. The design developed from the scope and constraints, and the key features from ArcReader were compiled to build a prototype application. This included the development and evaluation of experimental hyperlink layers that supported video files, images, sound files, and brought up web browser pages (that were internally held rather than the internet).

Evaluation Setup
A free thirty day evaluation license the ArcPublisher extension for pilot testing of the entire City area was applied to a single use copy of ArcView on one computer in the Information Technology Services Department.

Evaluation GIS Layers
Existing GIS layers that were current were the basis for the application included:
- City Limits
- Fire Grid Map Boundaries *(area labeled)*
- Streets *(street name, street type labeled)*
- Mile Markers
- Parcels *(addressing labeled)*
- Water Lines *(diameter labeled)*
- Hydrants
- Airport/Marine Corps Air Station - Yuma
- Hydrography
- Structures
- Run Zones (labeled)
- Fire Management Zone
- Aerial Photography

Hyperlinked Test Layers
Those layers that were tested included video segments of structures simulating pre-fire planning. Interior and exterior video segments were compiled into either point locations or were tied to structures through a hyperlink. Still ground photos from many angles also included to illustrate the location of such items as Knox boxes, fences, critical infrastructure, hazards, and other features.

Sound files were included to illustrate how post incident radio transmissions, 911 calls, or witness recordings could be integrated to support incident reconstruction or case development.   This when combined with wireless or stationary 911 caller locations, when combined with images or video, can help to reconstruct the incident from the caller's point of view.

The layers that were linked via shapefiles were:
- Video Segments
- Ground Photos
- Sound Files
- City Web Pages

Additional Layers Tested
During the evaluation process some of the Pre-Fire Tactical Plans had been provided in Adobe PDF format. These files were then hyperlinked through a point shapefile and were placed in the location of the appropriate site.   This same format was followed for all the Tier II hazardous materials sites within the City.   Those layers that were tested included:
- Pre-Fire Tactical Plans
- Tier II (Hazardous Materials)

Feature Evaluation
The following application features were evaluated for use on the laptop and MDC system version of the Mobile Data Computer Network project:
- Scale dependant display
- Zoom to Selected
- Integration through hyperlinks
- Hyperlink to the existing Fire Grid Map image
- Zoom to Layer
- Measuring distance accurately
- Query
- Integration of Aerial Images

Results of the Evaluation
The evaluation of the ArcPublisher and ArcReader solution were clearly above what the scope called for.   It was determined that the solution as evaluated was the best approach for this project because it met all areas of the specifications, design, scope, and fell within the constraints. This included having a majority of the GIS layers as a foundational base eliminating overhead costs.

The costs that were realized through this integration were very minimal. The entire costs that exceeded staff overhead were under $2,000. The staff put in 46 hours of time over six weeks on this project, leading to a minimal impact in actual staff time. The continuing

overhead was estimated at 3 hours per week.   The staff for this project included the GIS Administrator and a Computer Support Specialist (software and applications) for Fire.

The entire data for the whole city, including aerial images as a backdrop, was only 337 MB. This combined with the ArcReader software allowed for a stand alone application that met the specifications of the MDCs.

Implementation and Training
The critical step to any application success is a smooth implementation and training period.   For this application the implementation was very simple where the ArcReader software was installed and the data supporting the application as part of the system imaging process. Since each instance was stand alone there were not any network issues to be concerned with, and the implementation of the application was successful.

Training for the 110 units was performed by the train-the-trainer method. The ArcReader product proved to be very user friendly and was able to completed without any major issues.

Following are some photographs and images of the system that was initially implemented.
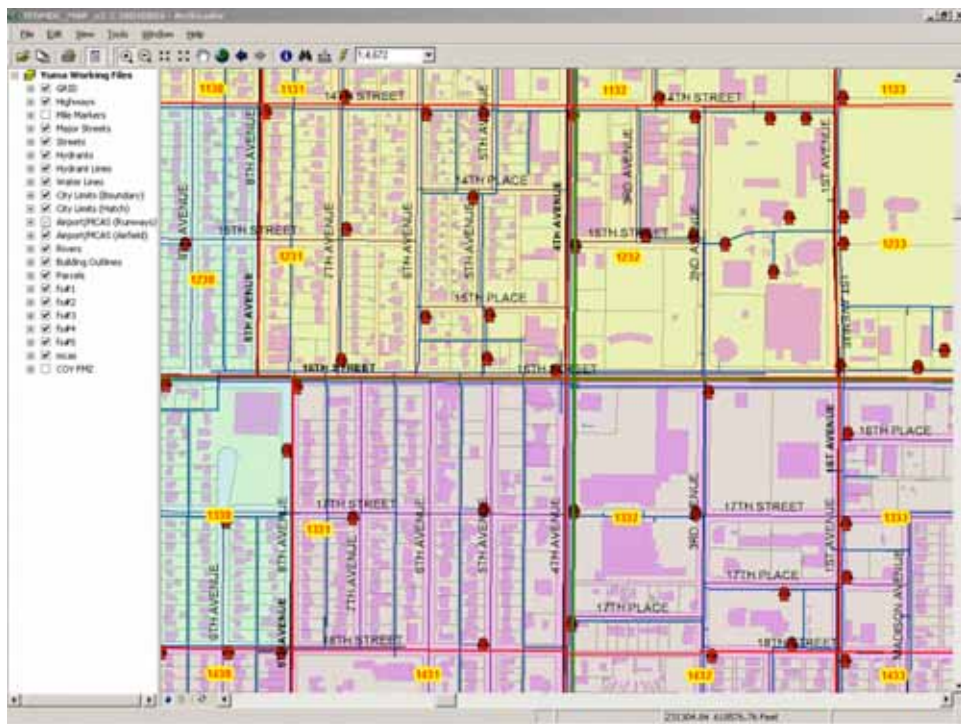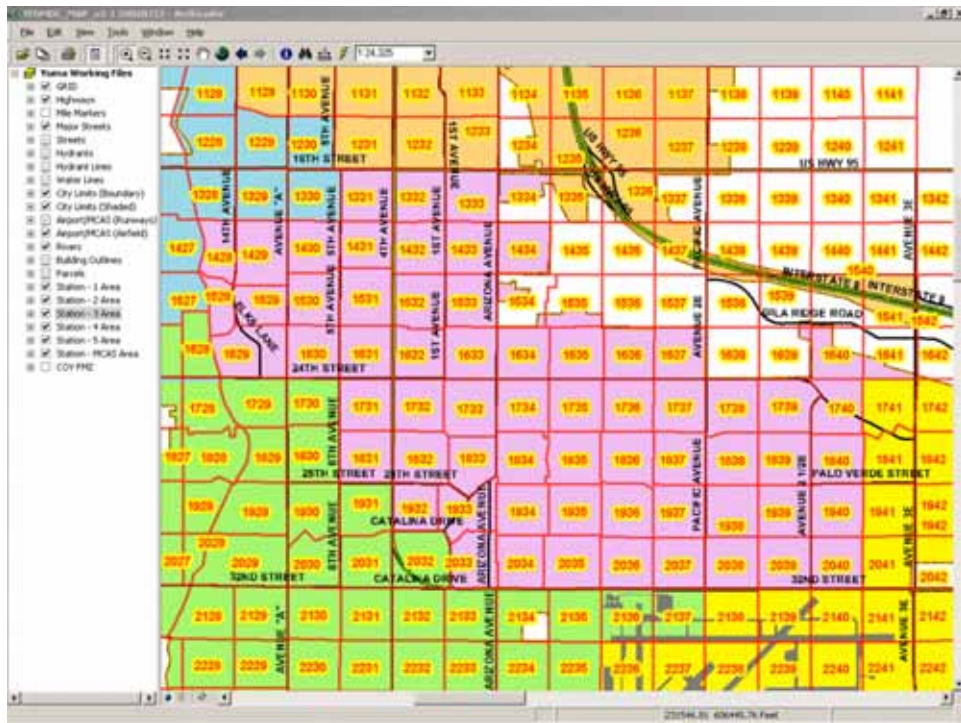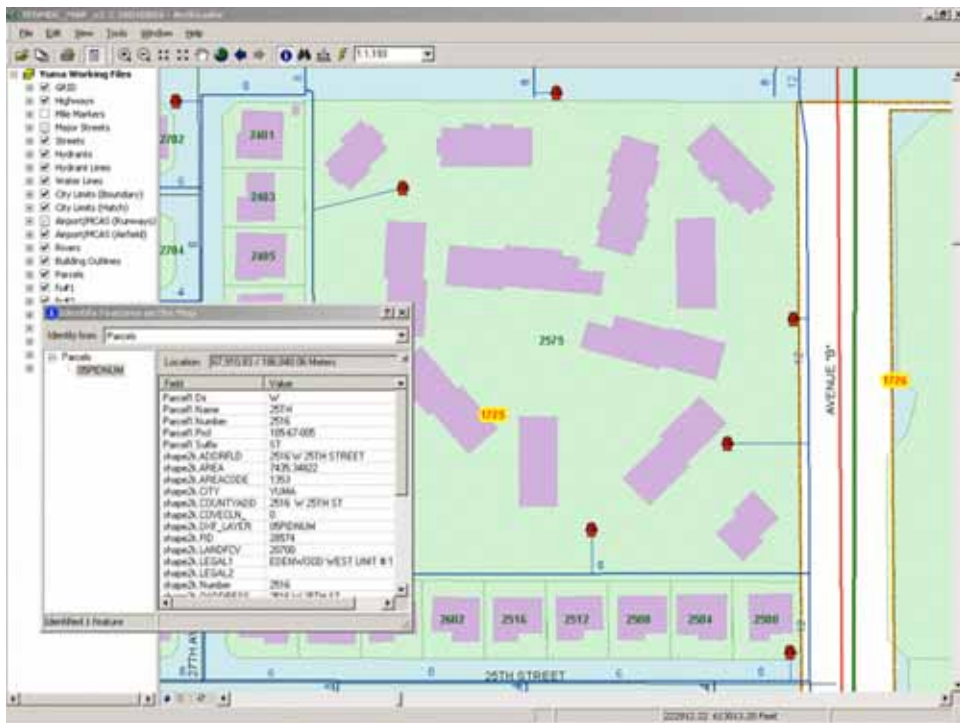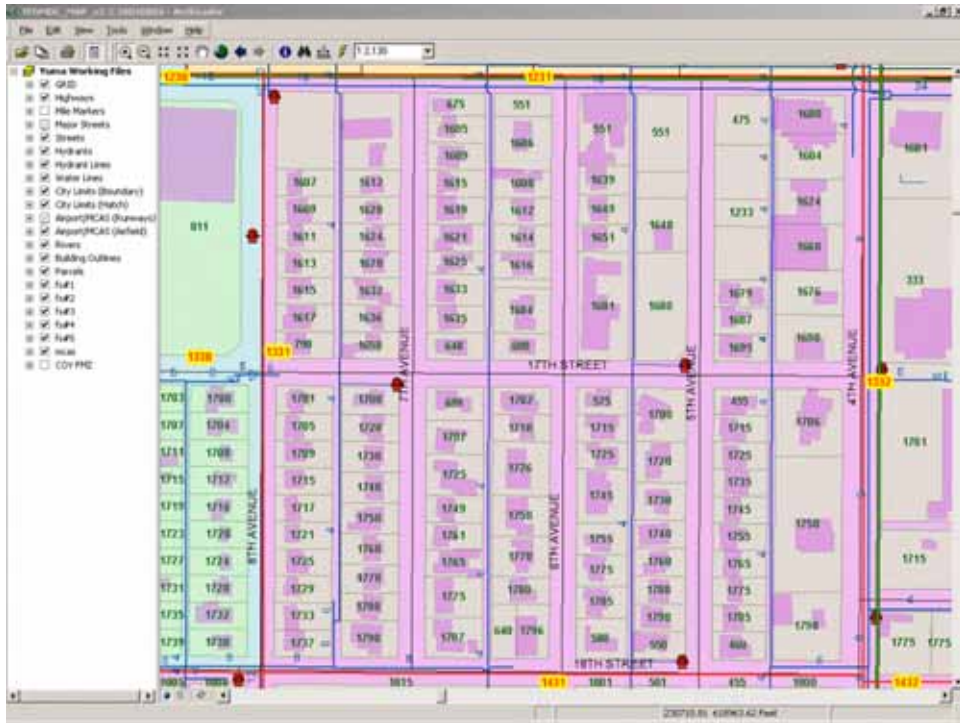
Outcomes
The application was ready before the Mobile Data Computer Network project was ready for implementation. The 110 MDCs were imaged prior to their installation in the apparatus or units making the implementation effortless. The system was ready for use immediately as soon as the Mobile Data Computer Network project was implemented.

The application showed a return on investment quickly after implementation. In one case just after the initial implementation for the Fire Department the Public Safety Mobile GIS application played a key role during a significant structure fire event located on the edge of the City in a light industrial area. Dispatch received the call and the City computer aided dispatch (CAD) system indicated the City had jurisdiction as the primary responder and with Rural/Metro as the back up responding agency. Since this was a significantly large and hazardous industrial fire event both agencies responded. Upon arriving on scene and seeing the location of the fire, the City Incident Commander determined that the scene was actually out of the jurisdiction of the City. Thus the disposition of the incident, all responsibility for inspections, investigations, code enforcement, and follow up went to Rural/Metro rather than the City of Yuma.

Additionally there were not any hydrants or water sources that were within a reasonable distance of the incident. The structure did not have a sprinkler system or fire suppression infrastructure, therefore it did not comply with existing City codes. The structure and all of the property related to the event were outside of the City Limits.

The event was promptly reviewed in the media related to the codes since the structure was not up to the City standard. Since it was properly determined immediately on scene to be outside of the City, this allowed the City of Yuma Fire Department Public Information Officer to defer questions to the County alleviating public outcry.

The application was initially evaluated for the Yuma Fire Department, but also was developed and implemented to support the Yuma Police Department.

Summary
Like many projects in public GIS the GIS Manager is asked to present a solution to a problem that was unforeseen as part of the original project. Many times this is a short-term, quick response project that is needed immediately. The traditional software and system development project approach is not able to be utilized, forcing the GIS Manager to expedite investigation and development. A key approach is to remain flexible and look for solutions throughout the spectrum of GIS options, rather than keeping to a traditional approach.

In this case the best option was realized prior to the implementation of the Mobile Data Computer Network project because the City remained flexible and searched for solutions, rather than just accepting the images of the grid maps as good enough. The result was a low cost, high return on investment public safety mobile GIS that is integrated with the Mobile Data Computer Network project.

Author's Note
Prior to February 2005 the author was employed by the City of Yuma, AZ as the GIS Administrator. The accounts contained within this paper do not specifically identify the vendors of the Public Safety Mobile Data Computer network, system, or related software as they are generic and only used for a reference framework to support constraints in the project that this paper describes. Additional information related to the continuing effort of this project may be obtained from the City of Yuma, Arizona Information Technology Department directly at (928) 373-5000.

References

Bowman, Scott. "Building an Enterprise GIS in a Limited Fiscal Environment." ArcUser. January-March 2005. Vol. 8, No. 1, p. 10-11.

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