ESRI and Trimble
2009 Mobile Government Grant

Article:
Implementation of Asset Management and Emergency Response Mapping Using ArcGIS Server and ArcGIS Mobile Services

Submitted by:
California Department of Transportation
District 11
Geospatial Information Systems/Project Support Branch

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ESRI AND TRIMBLE 2009 MOBILE GOVERNMENT GRANT – FINAL REPORT

Introduction

Building upon experiences and lessons learned through the 2008 ESRI and Xplore Technologies Mobile Government Grant, the Caltrans District 11 Geospatial Information Systems/Project Support Branch (District 11 GIS) developed and implemented two projects for the ESRI and Trimble 2009 Mobile Government Grant: (1) the Asset Inventory Management System (AIMS) and (2) the Emergency Response Editable Web Application (ERWEB).

AIMS integrates mobile GIS technology and asset management by collecting and delivering geospatial data using mobile devices and Web mapping applications. This project focused on collecting Changeable Message Sign (CMS) locations and key asset information, including route, direction, postmile, and status. Data collected in the field are posted to an ArcSDE geodatabase and directly viewable on a Web application. Data are also available for custom mapping, analysis, and asset management.

The ERWEB application was developed with the goal of displaying dynamic information, as close to real-time as possible, during regionally significant disaster or emergency events. Emergency response feature classes include location and type of event, road closures, detours, and Caltrans response vehicle locations. These operational data layers are overlayed onto ESRI's World Street Map service. This application is accessed in-house or in the field via a broadband wireless card using a standard Web browser from desktops, laptops, or tablet PCs. Data are posted and viewed in near real-time by District staff, and provide executive management access to the latest available information. Our original proposal was to develop a Mobile tool for evaluating damage to bridges following a major event, such as an earthquake. However, based on management feedback, this was changed to the more comprehensive ERWEB.

Goals & Objectives

The District 11 Mobile GIS program has five goals.

- Implement best practices and standards for an effective, long-term program through enhancement of current Mobile GIS concept projects.
- Add innovative methods and technology to complement the established traditional methods for the development and delivery of critical state highway infrastructure information by placing state-of-the-art tools into the hands of District 11 GIS staff and field crews.
- Demonstrate the importance of Mobile GIS technology in maintaining an organized, efficient, and prepared approach to the management of key assets for daily workflow and emergency response.

- Deliver critical information in real-time to management and emergency response staff during regional disaster events.
- Build upon District 11's multi-disciplinary team-oriented approach between GIS services and Engineering and Operations functional units within Caltrans.

Mobile GIS Workflow

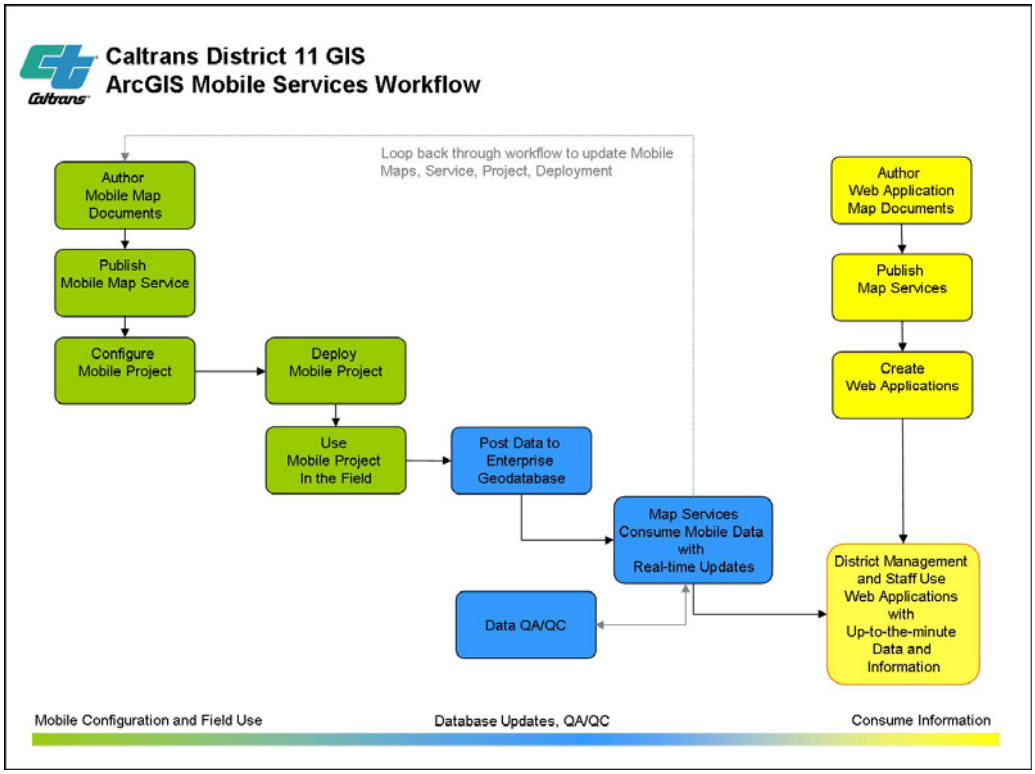

Figure 1. This graphic outlines the workflow for District 11's Mobile GIS program, There are three basic phases to the program: (1) Mobile configuration and field use; (2) database updates and quality control; (3) consumption of information though Web mapping applications.

Asset Inventory Management System (AIMS)

Background

The Traffic Operations Division maintains an inventory of field elements using Excel spreadsheets. The are several functional units within the Traffic Operations Division, each unit is responsible for maintaining and inventory of the various field element assets, depending on the type and status (planned or existing) of the asset. There is no inter-unit consistency in the schema of the inventory tables.

District 11 GIS is responsible for adding geospatial functionality and mapping field element data for the Traffic Operations Division. Historically, the primary method for generating data is to use the Caltrans Postmile Toolbar, a customized ArcGIS Desktop linear referencing application. Caltrans datasets have three key attributes: county, route number, and postmile value. With these three items, the data can be processed through the Postmile Toolbar which creates the linear or point events and a feature attribute table. Due to factors such as incorrect tabular data entry, imprecision in the postmile database system, and other

limitations within the Postmile Toolbar, the output may or may not be accurate enough for the intended use, particularly for engineering purposes. Data generated using the Postmile Toolbar often requires extensive data checking and manual editing.

Previous attempts by the Traffic Operations Division to create and maintain an accurate geospatial database of the field elements includes the collection of field element locations with handheld (recreational) GPS units and adding points in Google Earth. However, these methods and lack of standards have led to data with limited utility. Additionally, the transitory nature of employees within the Traffic Operations Division, due to factors such as job rotations and attrition, pose significant challenges in terms of staff expertise, project priorities, and continuity. Another challenge is the lack of resources. Collecting field element locations using resource grade GPS technology is a labor intensive process, and requires field personnel to spend a significant amount of time in the field while working very close to the fast-moving and hazardous travelway. Further, Traffic Operations staff typically have very limited or no GIS expertise, making data collection and database integration virtually impossible.

AIMS Project Implementation

The AIMS Project was developed to improve data integrity and efficiency in collecting and maintaining the Traffic Operations field elements inventory. Following the workflow depicted in Figure 1, we authored a Map Document optimized for the mobile platform. Because many of the data layers are large in file size, we buffered the data to 1000-feet on either side of the state routes and used scale dependent rendering to improve performance and display. The map service was published and a mobile project configured and deployed to a Trimble Juno SC and a Trimble GeoXH. The GPS functionality of the mobile units was utilized in acquiring the location of each changeable message sign along the state roads. In order to standardize and facilitate data collection, attribute domains were used whenever possible. Back in the office, the field-collected data were posted to the geodatabase and checked for accuracy.

Utilizing ArcGIS mobile to its fullest capabilities was somewhat constrained by connectivity issues between the field computers and Web services within the Caltrans firewall. Therefore, we are unable to connect the GPS units to our internal server which hosts ArcGIS Mobile while outside of the network. Our work around was to collect features and attribute data with a handheld GPS unit, and post the data to an ArcSDE geodatabase back in the office. Once posted, the data updates are verified. If necessary, spatial adjustments are made to the locations of the CMS features. For example, if the CMS is located in the median of the freeway, and the asset was either inaccessible or deemed too hazardous to collect, the feature is edited and moved to its correct location. These location adjustments are aided by the use of high resolution aerial imagery in ArcMap.

In conjunction with the Mobile map service and project, we authored a map service for use in a Web application. This Web application was used to view progress of the field collection effort. The base map service for the Web application consists of local roads, annotation, postmiles, and city boundaries. It also contains an ArcGIS Image Service of the District's aerial imagery. The CMS operational layer is symbolized on the status (existing, under construction, or planned). Query tools to select CMS elements by route or status were added to increase the functionality of the Web application. Once the data collection is complete, the Web application will be promoted to the Traffic Operations Division, and the

rest of Caltrans District 11 staff, as a tool to view and query the District's CMS inventory. Current enhancements planned for the CMS system will include an XML feed of posted messages, which will enhance the value of the CMS asset for real time monitoring purposes.

AIMS Project Summary

In summary, mobile GIS data collection improved the workflow for maintaining and updating the Traffic Operations field elements database. Mobile GIS technology resolves issues with the current workflow, and its inherent flaws in creating and maintaining field element inventories. Additions and updates to the data can be viewed immediately on a Web mapping application; there is no need to create new hardcopy maps whenever the inventory is updated. Over the next year, this project will be expanded to include the remaining Traffic Operations field elements of CCTV, vehicle detection sensors, and ramp meters. The ultimate goal of AIMS is to develop a comprehensive Web mapping service that includes all Traffic Operations and Maintenance field elements and associated real time data feeds. This service will be available for daily monitoring and emergency response use.

Emergency Response Editable Web Application (ERWEB)

Background

During region-wide disaster events, such as earthquakes or wildfires, the District's emergency operations center (EOC) is activated at the Traffic Management Center (TMC) to handle road closures, detours, damage assessment, and other incident management issues. A command center is also established at the District Office for executive management oversight, outreach to our partners, and public and media information. Keeping both centers updated at the same time with the same information is imperative, but challenging because the two centers are located approximately seven-miles apart. An additional challenge is effectively delivering incident and response information to the County Office of Emergency Services' WebEOC program.

The 2003 and 2007 San Diego wildfires provided experience in responding to region-wide events and providing up-to-date information to management, key functional unit leaders, and field responders. Prior to the 2003 wildfires, we had limited practical geospatial experience with regional events such as these. During the 2003 event, data were not created or distributed quickly, and communication between agencies was inconsistent. There was a marked improvement in inter-agency communication, data creation, and data distribution during the 2007 wildfires. The implementation of WebEOC by the County of San Diego has greatly benefited the GIS community in communication and data sharing. Throughout the 2007 event District 11's GIS staff plotted hardcopy maps and exported MXDs to PDFs several times a day with updated incident information for the command center. Staff also provided Caltrans GIS incident data to the County WebEOC and exported ArcGIS data layers to KML for viewing in Google Earth. The use of browser-based applications to share data with a dispersed audience was an effective tool for distributing the dynamic data, and no special software was needed. But distributing the KMLs to those who needed them was still a challenge. The best solution at the time was to directly email the KMLs to users and also to post them on a server for anyone within the District network to access.

Since the 2007 wildfires, the region has participated in the 2008 and 2010 State of California Golden Guardian exercises. These exercises are drills that support the development and

testing of emergency response operations through simulated statewide catastrophes. District 11 GIS has implemented ArcGIS Server technology, and has experimented with and refined the use of ArcGIS Server Web applications to provide incident and operations information to our stakeholders. During the 2010 Golden Guardian, we pushed data to an FTP server hosted by California Resources Agency (for CalEMA). The Agency pulled our data at five minute intervals and consumed them in an Adobe Flex Viewer map service, name SABER, which served as the prototype for California's Common Operating Picture, and was available over the internet.

ERWEB Project Implementation

The ERWEB application was developed to improve situational awareness and efficiently disseminate information to dispersed locations during regional disaster events. Two primary map services were authored, base layers and operational layers. ESRI's Word Street Map service is used for the base map layer with Caltrans maintenance facilities, postmiles, and regional assets included in an additional base layer service. The operational layer is comprised of six feature classes: incident type, road closure, lane closure, detours, asset damage, and Caltrans field response vehicle locations. The operational layers use attribute domains to facilitate fast and consistent data entry. The main consideration in creating these feature classes and domains was that the data would be created in high-stress situation and the need for fast, easy, and accurate information was top priority. Real Time Traffic, an additional layer of importance for emergency response, was successfully added to ERWEB to test the functionality of scripting updated traffic speed data to the web services. The symbology used in the Web Application is simple and bold for fast viewing and easy interpretation, and whenever possible made consistent with FGDC Homeland Security element symbology standards.

Because the Web application is accessed via a browser, no data deployment or software installation is required. Data can be edited from tablet PCs or laptops in an office environment or out in the field. Broadband cards enable the field users to VPN into the Caltrans network and edit the ERWEB application. Users can add or delete features, as well as update the situational attributes. The edits are seen in real-time back in the command and emergency operations centers.

ERWEB uses the same base layers and symbology as the CalEMA SABER application, resulting in a similar look and feel to promote the project concept, and also to promote interagency collaboration and consistency for emergency response. Currently, the District is working on a prototype Flex Viewer application to further develop ERWEB.

ERWEB Project Summary

The ERWEB application streamlined workflow during emergency situations. It improved communications by making real-time event information visible to District management and other employees via standard Web browsers. Now, anyone within the District who needs up-to-the-minute situational data has access to the exact same information at the same time.

Initial designs of this project included using ArcGIS Mobile projects and concepts. However, the fact that Web applications do not have to be deployed to individual mobile devices made this option the better alternative for this type of scenario.

Conclusion

For the ESRI and Trimble 2009 Mobile Government Grant we designed and implemented two projects. AIMS integrates mobile GIS technology and asset management by collecting and delivering geospatial data using mobile devices and Web mapping applications. The ERWEB application displays incident information, in near real-time, during a regionally significant disaster or emergency events, and makes this information available to everyone within the District. Collaboration with Resources Agency and CalEMA further exposed these services to the public domain, and provided a valuable proof of concept, as well as enhanced interagency coordination.

Constraints with the mobile field computers and the Caltrans firewall limited the disconnected functionality of the ArcGIS Mobile projects. However, ArcGIS Mobile is an effective alternative to maintaining an accurate asset inventory of Traffic Operations field elements as well as other Caltrans field assets.

The ability to post real-time data during regional emergency situations improves communication and distribution of incident data and maps. Additionally, it can improve the Department's effectiveness in mobilizing staff and sharing vital information with other agencies and partners, the media, and the general public.

By developing ArcGIS Mobile and Web mapping applications, the District demonstrated the effectiveness of mobile and server-based GIS technology in maintaining an organized, efficient, and integrated approach to the management of key assets for daily workflow processes and emergency response preparedness.

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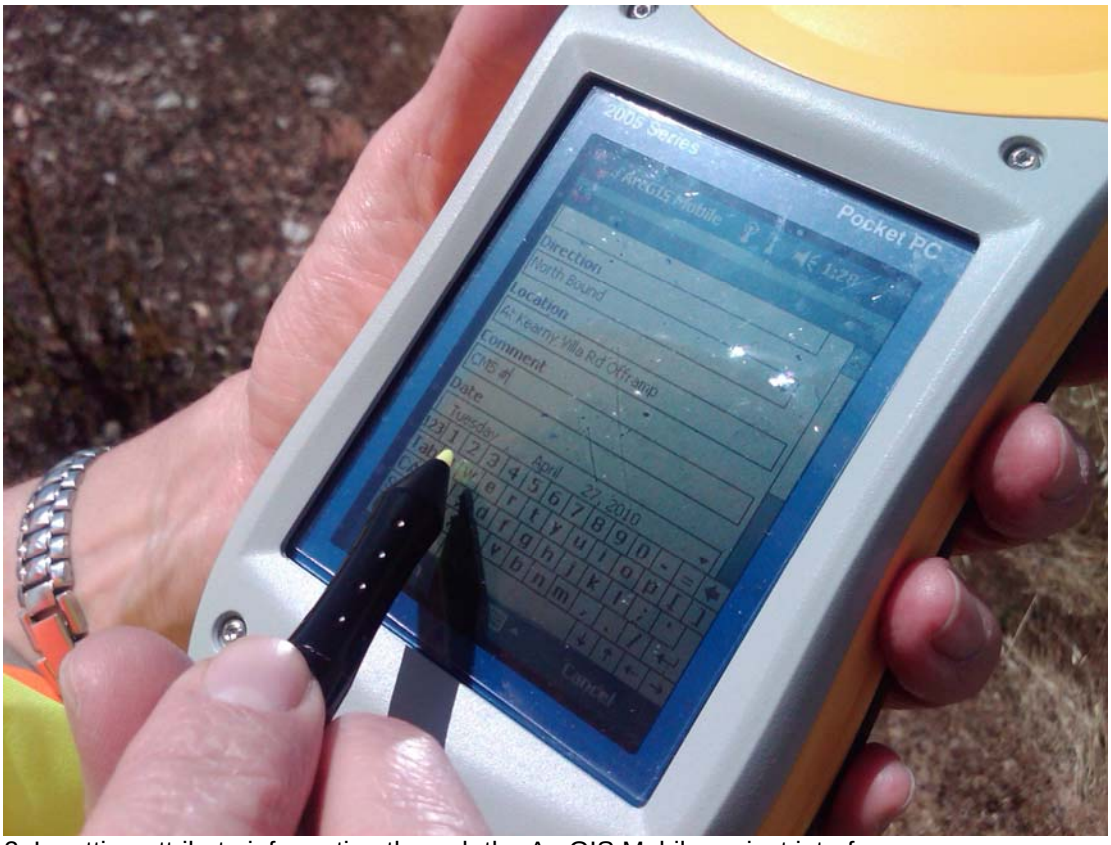
Appendix A – Photos and Screen Captures

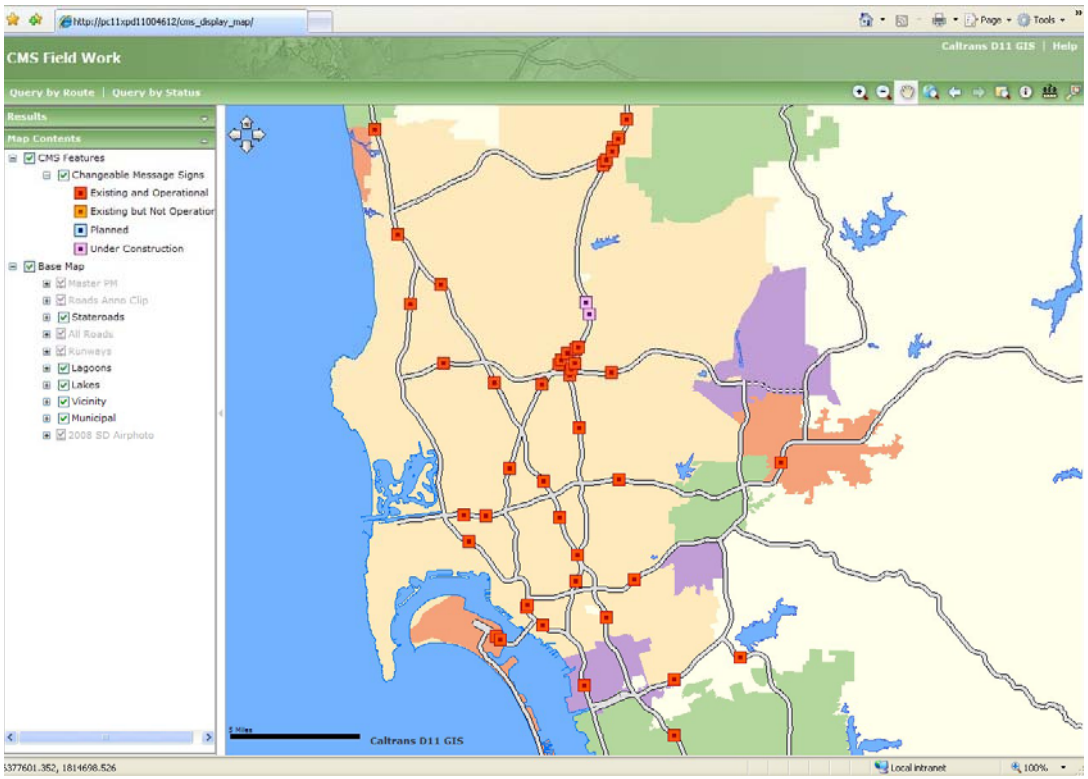
1. Collecting GPS location of a Fastrak changeable message sign along Interstate 15.



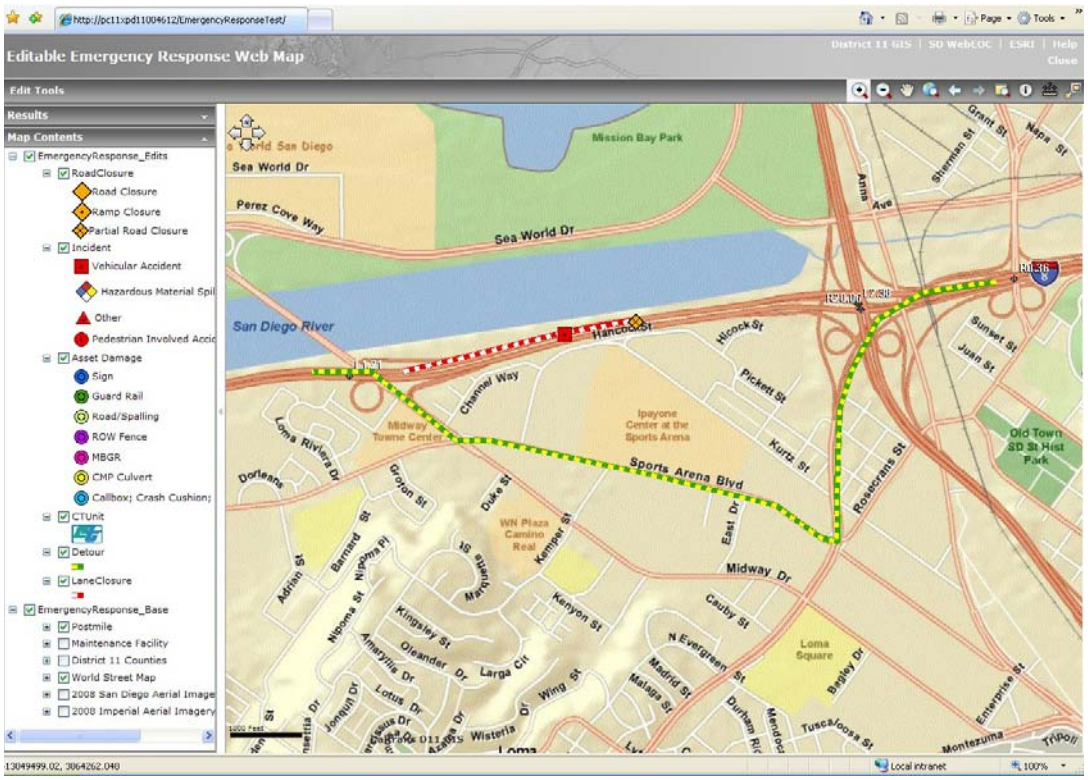
2. Inputting attribute information through the ArcGIS Mobile project interface.

3. Collecting location and attribute information for a changeable message sign on Interstate 5.

4. Collecting location and attribute information for a changeable message sign on Interstate 5.



5. ArcGIS Server Web Application of Changeable Message Sign Field Work. Scale dependent rendering was utilized to improve draw time and usability of map display.



6. Editable Emergency Response Web Map