URBAN WATER INFRASTRUCTURE MAINTENANCE USING GPS AND GIS

Elizabeth K. Burns, Gabriel Bey, and Darlene Reynolds

Professor Elizabeth K. Burns, Department of Geography
Arizona State University, Tempe, AZ 85287-0104
(480) 965-7533, ekburns@asu.edu

This study documents a continuing university-city partnership that improves urban water infrastructure maintenance through the use of the Global Positioning System (GPS) and Geographic Information Systems (GIS). A brief discussion of the changing context for water infrastructure management is followed by presentation of the GPS data collection pilot project conducted in a 54.39 square kilometer area of the City of Phoenix, Arizona by Arizona State University faculty, staff, and students. Key findings focus on differences between the expected and actual experience during the first project year.

CONTEXT

Precise locations are essential data for management and security of urban water distribution and collection infrastructure. Integration of this information within large city databases is both a technical and managerial effort, however. There is a broad shift toward understanding large technical systems in a social-institutional context of changing actors and management participants (Graham and Marvin, 2001). Guy, Marvin, and Moss (2001) characterize the current rationale behind infrastructure development as "a supply-oriented logic" that facilitates utility provision through large scale, highly capitalized networks providing uniform services. However, they conclude that management of large infrastructure systems does adjust to changed demand and supply conditions more flexibly than had been previously assumed.

This responsiveness is an indication that local utility managers can move from the reactive approach of the recent past to a stance of active anticipation of changed conditions. If routine operations and maintenance events are currently conducted on an as-needed or intermittent basis, maintenance and operations costs of travel, personnel, and equipment assembly can, presumably, be minimized by use of improved spatial data for incident location, preventive maintenance, and emergency scenario modeling. Water infrastructure managers can be expected to consider a range of possible responses to routine and emergency events and, possibly, to anticipate and address longer-term shifts in demand and supply conditions.

This shift toward an active management stance is underway in the City of Phoenix, Arizona (Bey, 2002) where GIS water pipe and appurtenance features are part of a water services department geodatabase. At this time, spatial data for critical water infrastructure features is limited or missing. As-built plans are the basis for GIS layers and mapping. Water feature locations were mapped as submitted by private developers and without field checking by city staff. The conversion of infrastructure data from paper maps to GIS digital files also left water feature location offsets of 1.83 to 2.44 meters and more. This pilot study identifies GPS technical, field, and management issues and recommends approaches for eventual GPS data collection of all visible water and sewer features in the 569.80 square kilometer water service area. Although this city includes almost 1,295.00 square kilometers within its boundaries, its 1.3 million inhabitants are concentrated in the water service area.

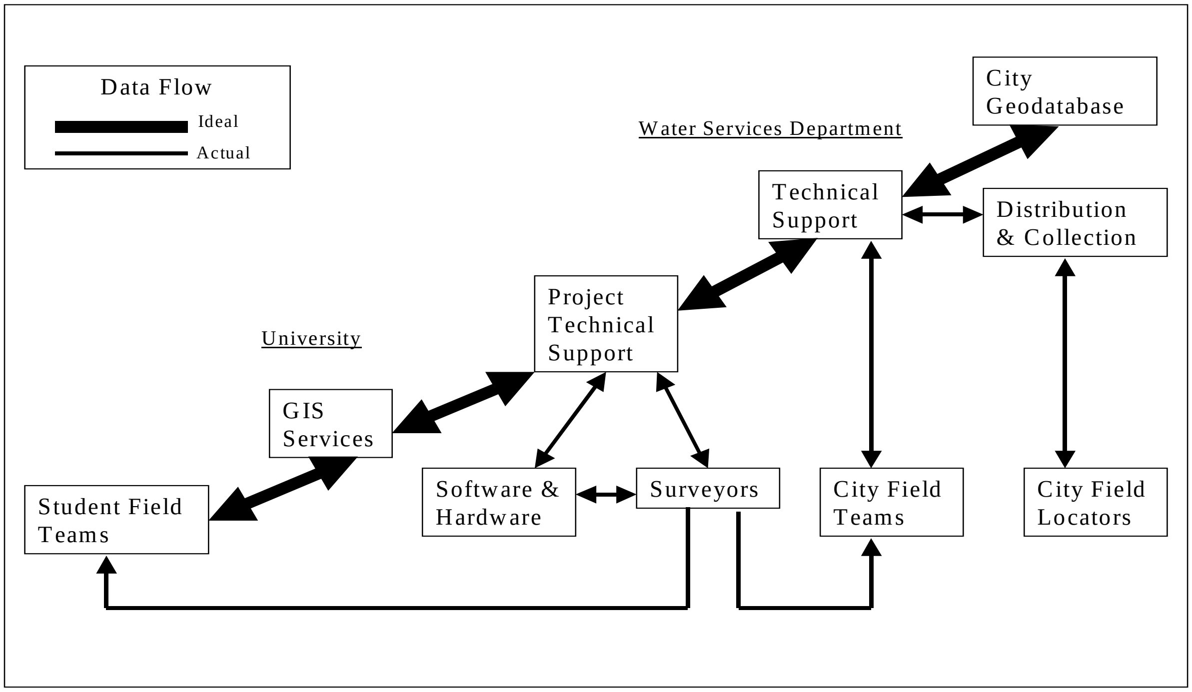

Figure 1. Ideal data flow and actual data flow.

FINDINGS

This pilot study shows that incremental changes in water infrastructure management practices incorporate a wider set of city decision makers than the current technical mangers and operators. The expected flow of GPS data from student workers to processing with the technical support division was revised to include additional software and hardware modifications, registered land surveyor GPS training, and GPS data collection by city field teams and specialized city field locators (Figure 1).

Five GPS and GIS water data management lessons emerge. First, a large-scale city-university partnership creates institutional awareness of current city business practices and highlights the value of university flexibility. Water Services Department staff had some difficulty in getting broad city acceptance for changing current practices and procedures toward a spatially accurate system including GPS location attributes. Similarly, the university affirmed the educational and exploratory research roles of the pilot project, but had difficulty developing legal language for electronic sharing of proprietary city information.

Second, a pilot study by definition is not a routine activity. It has elements of uncertainty that benefit from additional pre-planning and continuing flexibility. Changes in initial field procedures, additional time for added computer software customization, and some difficulties in field scheduling occurred and should be expected. Such changes result in delays in GPS data collection.

Third, the opportunity to integrate more city processes into a GIS and GPS framework quickly emerged. The pilot study expanded as other department and city staff recognized the benefits of GPS infrastructure data attributes. This project now includes GPS locations for water meters of every customer and GPS data processing for water infrastructure features in the transit corridor where light rail construction will start in early 2004.

Fourth, unexpected results created opportunities for improved city business practices. Existing GIS files had identified 17,127 visible features for GPS data collection (Burns, 2002). Over 2,205 GIS features could not be found in the field, however. These missing features are being researched by specialized city field locators and identified as found, lost, or abandoned so that technical support staff can correct the GIS database. Reassignment of city staff to complete this crucial step created schedule delays.

Finally, city policies are under revision as a result of unexpected GPS results. Actual GPS data collection included 3,283 new features found in the field that are not in current GIS files. This finding highlights delays in technical support staff processing of approved construction permits into the GIS database. A new city policy, recommended by the Water Services Department Director, is now under review. All future construction permits may be required to include differential GPS locations of plus-or-minus three meters as certified by a registered land surveyor.

CONCLUSION

To date, the integration of GPS data with existing GIS databases reveals unanticipated implementation issues in current water infrastructure management practices. These practices are now being revised, although GPS locations on GIS files are not yet available for routine and non-routine water infrastructure management situations. This city-university pilot study has been extended in time and scope. Positive recent experiences with student internships and student GIS updating activities had built mutual city and university capacity to support the present effort. Lessons learned here should be applicable for other cities and universities that develop similar partnerships.

REFERENCES

Bey, G., 2002. “Spatial Data Development and Deployment: Opus 94.” *City Connection.*

Burns, E. K., January 8, 2002 memorandum to G. Bey. 2 pp.

Graham, S. and S. Marvin, 2001. *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*. New York: Routledge.

Guy, M., S. Marvin, and T. Moss, 2001. *Urban Infrastructure in Transition: Networks, Buildings, Plans*. London: Earthscan Publications, Ltd.