BIOGRAPICAL INFORMATION

Greg Ramon
Water Distribution/Wastewater Collection Superintendent
City of Phoenix Water Services Department

Specific Responsibilities

Joined City of Phoenix Water Services Department in 2000. Responsible for managing the Water Distribution/Wastewater Collection Divisions of the Phoenix Water Services Department. The Water Distribution Division is a 24-hour, 7-day per week operation and is responsible for inspecting, maintaining and repairing nearly 6,100 miles of water distribution main lines and 375,000 service connections. The Division repairs approximately 2,000 main breaks and 8,000 service leaks per year. In addition, the Division maintains more than 91,000 valves and 40,000 fire hydrants and installs nearly 700 large taps each year. The Division has 7 service yards and over 300 remote water and wastewater facilities (wells, booster stations, storage tanks, reservoirs, Pressure Relief Valve stations, lift stations). The Division has a 24-hour, 7-day per week dispatch function and a Supervisory Control and Data Acquisition (SCADA) computer system.

The Wastewater Collection Division is responsible for inspecting, cleaning and repairing over 4,400 miles of sanitary sewer lines, including 68,000 manholes and cleanouts, located throughout the City. The Division has five wastewater collection yards, a dispatch function and a SCADA computer system. The Division also manages odor control and vector control programs and performs Blue Stake locating service.

Past Experience

(Period covers 1989 – 2000)
Chief of Water Distribution and Wastewater Collection Division, City of Evanston IL. Water Services Department. Responsible for similar duties on a much smaller scale.

Educational Information

B.S. Business Management, National Louis University
M.B.A. University of Phoenix

Professional Memberships

American Water Works Association, Chairman of the Distribution O&M Committee
American Public Works Association
Water Environmental Federation

BIOGRAPHICAL INFORMATION

Chris Stern
President and CEO
Spacient Technologies, Inc.

Specific Responsibilities

Founded Spacient in March 2000 to deliver enterprise mobile GIS and field computing software solutions to the utilities industry. As President and CEO, Chris has overall responsibility for company strategy, business development, software product development and project delivery services to utility clients throughout the United States.

Past Experience

Former technology executive for the Los Angeles Department of Water and Power, the largest municipally-owned utility in the United States, responsible for IT strategy, system development and operation and maintenance for over 2,000 employees in the water services organization.

Educational Information

M.S. - Engineering, University of California, Los Angeles
B.S. - Engineering, Loyola Marymount University
Registered Professional Engineer - California

Professional Memberships

GITA
AWWA
ESRI Business Partner
ESRI California Partner Council
Council of Energy Advisors

IMPLEMENTING THE CITY OF PHOENIX WATER SERVICES DEPARTMENT ENTERPRISE MOBILE APPLICATION PROGRAM SOLUTION (MAPS)

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ABSTRACT

The purpose of this paper is to describe the implementation of the City of Phoenix Water Services Department (WSD) Mobile Application Program Solution (MAPS) project, an enterprise mobile GIS and field computing system for the City's 450 water and wastewater field crews.

Phoenix WSD provides water distribution and wastewater collection services to more than 1.3 million residents in the sixth largest city in the nation. Over the past decade, new development and rapid population growth have presented great challenges to the organization's ability to efficiently maintain the City's water and wastewater infrastructure. To address these challenges and streamline field maintenance and service operations, WSD launched the MAPS enterprise mobile GIS and field computing project.

The goal of the MAPS project is to deliver essential data and information to the Water Distribution and Wastewater Collection Divisions field service crews to enhance customer service and improve operational efficiency. To achieve this goal, an overall strategy and business case was developed to quantify return-on-investment (ROI) and justify project investments. The subsequent implementation involved development of system requirements, evaluation of mobile computing devices, wireless data networks, and the design and installation of an integrated, web-based mobile GIS mapping and field work order management system.

INTRODUCTION

The City of Phoenix Water Services Department provides a model case for implementing enterprise mobile computing to a large utility field organization. Phoenix is the sixth largest city in the US and the fastest growing over the last decade. Agricultural and desert areas have been transformed into urban communities, so that now the City's Water Services Department (WSD) serves an estimated population of 1.3 million people over a service area of 521 square miles. This explosive growth has been accompanied by the rapid development of supporting water distribution and wastewater collection infrastructure.

The City's Water Service Department has a mission to become the "Best of Class" utility and is focussed on maintaining high quality, reliable infrastructure helping to satisfy its prime objective of excellent customer service. The project outlined in this paper, named the Mobile Applications Program Solution, or MAPS, involved extensive investigation into field operations work practices and efficiency opportunities, including development of a business case with real world return-on-investment (ROI) figures, along with the design and implementation of a mobile computing solution to support the more than 450 field personnel in the City's combined Water Distribution and Wastewater Collection Divisions.

The City of Phoenix retained CH2M Hill and Spacient Technologies, Inc. (SPACIENT) to develop the functional specification and deliver an enterprise mobile GIS and field computing system for the Water Distribution and Wastewater Collection Divisions (WD/WWC). The overall objective of the MAPS project is to deliver and record essential data and information, in electronic form, for distribution and collection field service crews to enhance customer service and to improve operational efficiency.

PROJECT PHILOSOPHY

At the outset of the project it was recognized that there are several risks in implementing mobile technology; the key ones were identified and addressed throughout the project:

- Field staff are generally inexperienced at computing and this should be a key consideration in system design and implementation
- IT projects have a high failure rate and this is even more likely when dealing with staff not familiar with computers. Implementation should be incremental and not planned as a single roll out with full functionality
- Field devices are exposed to harsh conditions and need to be robust ***and legible***
- Field staff should only be exposed to a single system and not multiple field modules originating from office information systems
- Implementation in a large city will be lengthy and so a continuing program of communications with all staff is essential. And this needs to be in plain English
- The mobile system should primarily address field staff needs; management requirements can also be addressed but the design should not be 'top down'
- Support of a mobile system is a major commitment and needs to be addressed early
- Mobile systems are of particular concern to IT departments because of security and so the IT staff should be engaged throughout the project.

STAFF ISSUES

The potential reluctance of staff to use a mobile computing system was perceived as the single greatest risk to the project, more through individual reaction to change and/or the use of a technology with which they were unfamiliar, than through organized rejection. This was addressed by three guiding principles throughout the project.

Firstly, an extensive and continuing ***information campaign*** was sustained throughout the project, telling the staff what the objectives were, soliciting their detailed input, reporting on progress and forthcoming planned implementation. In addition, user reaction was actively requested through regular visits to the users, a comments page facility within the mobile system and user surveys.

Perhaps most importantly, their reactions were reported back to them and resultant actions defined.

Secondly, the user interface was designed to be ***easy to use***, consistent and wherever possible, a reflection of the paperwork with which they were used to working.

Thirdly, it was recognized at the outset that field users need information from Geographic Information Systems (GIS), Computerized Maintenance Management Systems (CMMS), Customer Billing (CIS) and Relationship Management systems (CRM), locating services and HR, inventory and document management systems. From the outset it was determined that users should be presented with ***a single interface*** and that the field system should deal with all of the differences between the applications. These back office systems are all complex and are only effectively used by 'power users'. Many offer field modules, but the prospect of field staff becoming familiar with the idiosyncracies of all of these system was obviously impractical – no management staff have that capability so why should they be expected to be able to deal with such a high level of complexity.

BUSINESS JUSTIFICATION

The City had two prime drivers for implementing a mobile computing system:

- Improved customer service
- Increased efficiency

It was recognized at the outset of the project that the identification of needs and functional requirements must encompass the full breadth of the organization and that different groups of users would have differing needs. A detailed requirements analysis and business case was undertaken, to identify and prioritize high-level required functionality of the system based on overall and functional-specific benefits and return-on-investment (ROI). This was designed to establish the needs and requirements of potential MAPS users throughout all levels of the WD/WWC Divisions, and to establish levels of priority for each requirement or group of requirements based on benefit and overall ROI.

The requirements analysis involved extensive consultation with the key management stakeholders, field crews, and their supervisors. The requirements that were identified range from clear needs to desired functionality, with a wide range of variability between the twelve yards, crews, and even individuals, reflecting the varied work activities and practices in the organization. This analysis defined functionality of the mobile system, and provided the first step in achieving the overall project goals, while the business case helped justify the necessary investment and encouraged focus on the functionality delivering the best return.

The requirements analysis:

- Identified user and associated system technical functionality requirements
- Identified overall and functional-specific benefits and ROI (return on investment) opportunities
- Prioritized functional implementation based on ROI priorities

The formal identification, evaluation, and prioritization process was the prime means by which a rational order of system functionality can be developed and accepted by the stakeholder community, even though individual priorities cannot all be met in the early implementations.

The list of user requirements which was developed (some 130 items) was related to the vision and goals of the organization, the existing work processes, return on investment (ROI) and benefits of implementing specific functionality, and the associated costs and "infrastructure" limitations (including communications, supporting applications, and organizational issues).

RETURN-ON-INVESTMENT (ROI)

An analysis of the requirements showed a prevalence for reduced/automated paperwork, GIS, and CMMS functionality. The initial vision for the project was based on delivery of GIS maps and maintenance management information to the field crews, so the identified requirements are broadly in line with that original vision, although the extent and importance of paperwork in the field was, perhaps, underestimated initially.

The return on investment opportunity for field mobile computing systems is immense and immediate, because savings can be achieved on a daily basis. In the City of Phoenix there are close to 450 staff in the Distributions and Collections operations and maintenance divisions, 420 of who are engaged full time in field operations. The labor costs of the workforce represent a major element of the operating budget and it is efficiencies in this component that offer the greatest performance improvements.

Efficiency Benefits

The simplest approach to evaluating efficiency gains is to address the time savings that would accrue if field staff were provided with a mobile computing system and yard staff with a desktop application. During their working day, the foremen, field staff, and administrative staff undertake a number of tasks that could be either eliminated or reduced. The amount of time saved varies by individual and from yard to yard according to specific work tasks and practices.

Efficiencies were estimated for each major area of system functionality, on a divisional basis, taking into account the numbers of individuals affected, the time saved, and labor costs. This process of estimation was developed with several supervisors from different yards and with management staff.

Table 1 presents the key field work activities and general field and office tasks that would benefit from mobile computing together with the prime functionality required of the system for these activities and tasks.

The potential time savings that could be achieved by mobile computing were evaluated for each of the activities listed in Table 1. Efficiency benefits were calculated on the basis of the number of individuals affected, and staff costs.

Table 1. Mobile System Functionality Requirements by Activity

Activity	Automated Paper	GIS Maps	CMMS	ABS[1]	GPS[2]
Key Field Activities					
Main Repairs	*	*	*	*	
New Service Taps <= 2 in.	*	*	*		
Service Line Repairs	*	*	*	*	
Service Turn-ons/offs	*	*			*
Small Valve Maintenance	*	*			*
Hydrant Replacements	*	*			
Blue Stake Locates	*			*	
Transmission Line Repairs	*	*	*	*	
New Service Taps > 2 in.	*	*	*		*
Large Valve Maintenance	*	*	*		
Hydrant Repairs	*				
Line Flushing	*		*		
Fire Flow Testing	*		*		
New Sewer Taps	*	*	*		*
MH Repairs	*	*	*	*	
MH Inspections	*	*	*		*
Sewer Stoppages	*	*	*		
Sewer Spills	*	*	*		*
Vactor Cleaning	*	*	*		
Rodder Cleaning	*	*	*		
Die Testing	*		*		
Smoke Testing	*		*		
WWC Construction	*			*	
General Field & Yard Activities					
Industrial Accident Hours	*				
Crew Paperwork	*				
Foremen Paperwork	*				
Supervisors Paperwork	*				
Admin. Staff Data Entry	*		*		
Locating Foremen GIS		*		*	*
GIS Problems		*			
Squaw Peak Research	*				
External Billing	*				
CSD Communications	*		*		
WDSR Search			*		
Valve Shutdown	*	*			
Routing (Foremen)		*			
Street Repairs	*				
ABS Access (pre dig)				*	
Inter-shift Information (Foremen)	*		*		
Flexibility within Divisions	*	*	*		
Flexibility across Divisions	*	*	*		
Better Coordination	*	*	*		

[1] *ABS is the Arizona Bluestake locating service*
[2] *GPS is Global Positioning System*

Table 2 presents the relative magnitude (percentages) of annual time-based efficiency savings for each major element of system functionality. It should be noted that each of these high level functionality components comprise several elements which must be developed and implemented incrementally, requiring development within several of the functions to be undertaken in parallel.

Table 2. Annual Efficiency Savings by Functional Component

	Automated Paperwork	GIS Maps	CMMS	ABS	GPS
% OF TOTAL ANNUAL SAVINGS	**55%**	**20%**	**14%**	**10%**	**1%**

The overall time based efficiency savings indicate an annual potential benefit of $6,734,579. These potential efficiency gains of different groups of functionality were assessed at a basic level by evaluating time savings by individuals or groups of individuals. This does not address efficiencies gained through better asset management and maintenance, which will be delivered by integration with a functional maintenance management system, or benefits that could arise through improved inventory and materials management, and a more accurate and up-to-date GIS system enabled by improved GIS data availability to the crews.

The evaluation in potential time savings was undertaken in conjunction with senior WD/WWC staff and is considered to be conservative, both in terms of time-saving estimates and operating-cost rates. However, it should be recognized that although these potential savings were estimated conservatively, in practice they will not all be achieved because of other issues that will inevitably arise to inhibit work effectiveness, and a natural reluctance to change work practices. However, a reengineering project due to be completed in 2004 will provide the opportunity to devise amended work practices that could deliver the projected efficiency savings.

The key tasks that will deliver the most benefit are presented in terms of the MAPS system functional requirements in Table 3 (as percentages of the total efficiency savings). Again***, the greatest savings are in those activities where significant time is saved by the greatest number of crews***. By aggregating the savings into high-level functional groupings, the areas of greatest potential efficiency savings can be identified (converted to annual savings).

Table 3. Individual Items of Functionality that Will Deliver the Most Benefit

Activity	System requirements	Potential % of Annual Efficiency ($)
Crew Reports and associated paperwork	Automating Paperwork	23%
Better control of street repairs	Automating Paperwork /link to Streets Dept	17%
General crew problems with GIS	Automating Paperwork /GIS integration	16%
Administration staff data entry	Automating Paperwork /CMMS integration	16%
Delays waiting for ABS locates	Automating Paperwork /ABS integration	9%
Foremen’s paperwork	Automating Paperwork /CMMS integration	6%

Better Coordination	Automating Paperwork /GIS/CMMS	5%
Supervisors' paperwork	Automating Paperwork	4%
Better information and co-ordination with CSD	Automating Paperwork /Dispatch	4%

Other Efficiencies

In addition to the labor hours saved through automation, other benefits will accrue including reduced gas consumption and vehicle wear through optimized routing, improved inventory and materials management, reduced duplicate visits to the same job site, and elimination of transportation of paperwork. Additionally, an extensive analysis of "intangible savings" opportunities was performed, resulting in savings that are near or equal to those delivering in the time-based savings analysis.

THE MOBILE SOLUTION

It should be recognized that not all desired functionality can be immediately implemented and that different features will require very different levels of investment and implementation time frames. During the first phase of the project existing hardware, communications, and software systems within the WD/WWC divisions were reviewed in the context of the project. These have an important impact on the implementation sequence since aspects of all three components are necessary as building blocks for particular elements of functionality. The key components of the MAPS system that was ultimately delivered were:

Hardware

The selection of mobile computing devices for the MAPS system required rigorous evaluation of hardware due to the climate and operating conditions, and the known fact that many projects fail due to unreliable or poorly performing mobile devices. For MAPS, two ruggedized mobile computing device manufacturers that best met the requirements of WSD field crews, Microslate and Panasonic Toughbook. Additionally, each device was delivered with built-in GPS and wireless capabilities for WiFi and/or wireless data services.

Software

Mobile Application Software
MAPS was designed using FIELDPORT® mobile GIS and field computing software from Spacient, a web-based application that works with the ESRI ArcGIS platform. The software has functionality for system administration, field workflow, work orders, paper work and forms, mobile GIS mapping, timekeeping and management performance reporting.

System Integration Application (EAI)
During the project, WSD also commissioned development of an enterprise integration software application (EAI) that will ultimately provide a common interface to many of the software applications in the department. This should ease the MAPS integration effort, since a common portal can be integrated rather than a number of disparate applications. However, this project is in the initial phases and the sequence and timing of development has not yet been defined.

ESRI GIS

Migration of WSD's ESRI GIS to the geodatabase structure of Version 8 precluded early integration. This situation was further complicated by the planned release of ESRI's Version 9 in 2004, which is expected to include some functionality that would be significantly beneficial to the MAPS project. Therefore, initial mobile GIS functionality focused on delivery of water/wastewater quarter section maps, followed by ESRI ArcGIS 9 integration.

Hansen CMMS

The implementation of the Hansen CMMS was delayed and integration with MAPS may be superseded by the enterprise integration platform development described above.

Arizona BlueStake

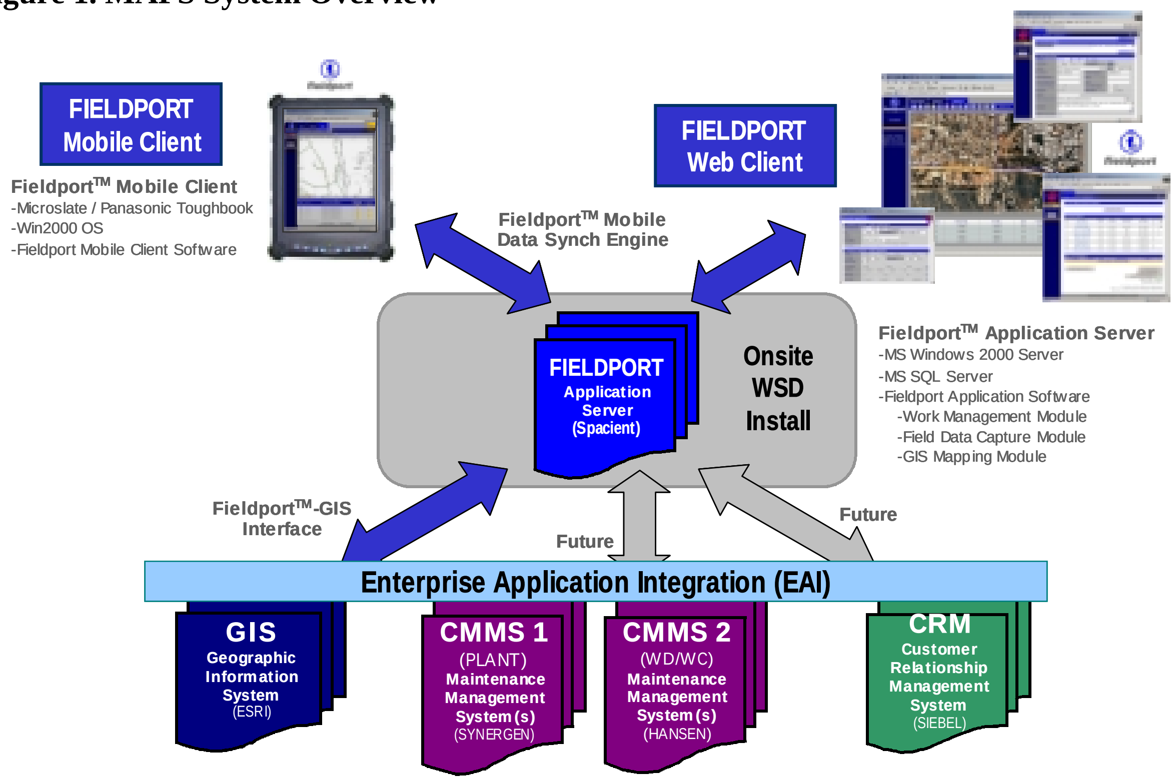
Arizona Bluestake has implemented a web-based locating service that is currently being tested. This new system provides improved functionality for both requestors and locators and will ultimately be integrated within the MAPS system.

Yard Infrastructure

Maintenance yards are inevitably robust working environments and issues regarding intranet connectivity, work station space and power outlets had to be addressed at several yards prior to implementation of the MAPS system. However, these efforts were less demanding in some yards than others and this was one of the drivers in determining the sequence of roll out to the yards.

Each of these could have been perceived to present an obstacle to implementing a mobile computing system. However, in this project the approach has been to identify valuable functionality that ***could be achieved immediately*** and implement that rather than wait for other systems to be completed. In retrospect, this approach has been extremely beneficial allowing early adoption of mobile technology and incremental training of the staff.

Figure 1. MAPS System Overview



CONCLUSIONS

The City of Phoenix Water Service Department field mobile computing project has been in operation since December 2002 and has been perceived as highly successful at all levels of the City, from the field staff, through yard and divisional management to City IT staff and managers.

From this experience, we offer the following thoughts:

1. Field computing is feasible, essential and can be started today with what you have – do not wait for the back office systems to be updated, revamped, or replaced
2. Look at your entire field operations to see what the requirements are and where the ROI could be achieved – it might not be obvious
3. The return-on-investment (ROI) is perhaps unparalled in operations and maintenance activities
4. Field staff are perfectly able to adapt to new technology – if they are properly engaged in the process
5. Keep the application simple to use – don't take attractive short cuts and end up with a myriad of different systems on the devices
6. Support and maintenance will be a big issue