Fast-Growing City Keeps Pace by Moving to GIS

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Abstract

The City of Meridian, Idaho, has historically kept hard copy records of its utility assets. In recent years, City staff used AutoCAD mapping and Hansen maintenance management software for system inventory. These standalone systems, as a whole, did not support additional staff responsibilities resulting from record growth as building permit applications increased approximately 50 percent over the past year. GIS offers the opportunity to boost efficiency of records management as the City addresses future data management needs, such as Comprehensive Utility Planning and subdivision review, with aggressive growth. The City purchased and installed a Citrix Terminal Server with ArcGIS, parcel mapping has been migrated from AutoCAD, and utility system hydraulic models are migrating to ArcGIS, thus providing greater access to other GIS information. A GIS database for street lights was developed in the field through the use of new Trimble GeoXT hand-held Global Positioning System units and Pathfinder Office software.

Introduction

The City of Meridian had considered whether to make a significant investment in Geographic Information Systems (GIS) or not. The Public Works Department realizes a number of benefits from investment in GIS. However, some challenges are expected, including:

Organizational/Structural Challenges:

- Will GIS be used up to its potential within the Public Works Department?
- Will GIS Technicians report to Department Managers with priorities higher than GIS?
- Will GIS Technicians report to Department Managers with little background in GIS?
- Will GIS Technicians wear more than one hat making it difficult to focus on GIS?

People Challenges

- It may be difficult to attract qualified GIS staff to fill vacant positions.
- It may be difficult for current staff to move quickly into GIS duties
- It may be difficult and expensive to train and retain qualified GIS staff.

Database Challenges

- City of Meridian GIS databases have not been developed.
- There are currently no systems in place to update and maintain GIS databases.

Application Challenges

- City of Meridian does not have the software needed to use a GIS.
- Hydraulic model integration could require custom applications developed to manage the Public Works Department's data.
- For what other activities could GIS be used?

Given these questions, the City of Meridian asked HDR to assess the existing computer network as a basis for a Preliminary Assessment that addresses the many challenges noted.

The Preliminary Assessment had taken advantage of the City's prior investments to make GIS a valuable tool that is used by the Public Works Department to serve the citizens of Meridian in a more efficient and effective manner.

GIS Requirements

Existing Network

Until recently, the City of Meridian Public Works Department was not setup for GIS, although, the existing Windows NT network architecture could be used to conduct certain GIS applications. The existing network operates on a Windows NT file server.

The Public Works Department's data were distributed across a single Windows NT file server. Under this architecture, data could be easily copied and redundant, as it could be stored in several locations.

Required Applications

Overview

Several uses of GIS in a Public Works Department are summarized in this section. The relative importance of the applications is discussed and priority rankings of High, Medium or Low are assigned.

High Priority

Eight new applications were identified as High Priority. Of those, four were required to ensure that the Public Works Department complies with government regulation or accepted accounting practices:

- Comprehensive Planning Support –To accomplish the update of its comprehensive plan, the Planning Department must create several new layers of GIS data (e.g., Existing Land Use, Future Land Use, roadway characteristics), and conduct a number of spatial analyses (e.g., sociodemographic change between the 1990 and 2000 Censuses). These products are used to generate both tabular reports and maps for use in the comprehensive plan.
- Sanitary Sewer Overflow Reporting (Capacity/Management/Operations/ Maintenance, a.k.a., CMOM) – Anticipated federal regulations will require that the City quantify and report sanitary sewer spills within 24 hours; affected residents must be notified immediately upon detection of the spill. Such spills currently require an excessive manual effort to delimit the affected area, determine the affected residents for notification purposes, and calculate the statistics needed for reporting. A GIS-based application would reduce the workload associated with this task, allowing a more rapid identification of affected residents and faster reporting. More efficient spill identification would not only help the City to avoid any fines associated with non-compliance with this regulation, but would also reduce potential liability from failure to correctly identify and notify affected residents.
- GASB 34 Asset Management – Circular 34 published by the General Accounting Standards Board (GASB) requires government agencies to account for the value of their infrastructure and its depreciation over time. A GIS-based assessment management system is necessary to inventory the City's utilities, roads, buildings and other infrastructure and assist in the quantification of their value. Such a system helps to streamline the City's repair and replacement work order process, as well as provide better information for planning and budgeting of repair and replacement projects.
- Natural Disaster Cost Assessment – The Federal Emergency Management Agency (FEMA) requires an initial assessment of property losses from natural disasters within 24 hours of the event, followed by a detailed assessment within 48 – 72 hours. Using GIS to determine the limits of damage and calculating losses using the City's parcel database provides the City the means to create a more accurate damage assessment in less time.

Greater accuracy in the damage assessment ensures that the City does not underestimate its needs and receive less than its fair share of Federal disaster relief.

The remainder of the High Priority applications include:

- Utility Billing Application – A custom application to calculate the City's utility fees.
- Work Flow & Process Improvement – Three different work flows were identified which would benefit from automation using GIS: Site Plan Review; Residential and Commercial Property Valuation; and Subdivision/Plat Revision and Recording. Each of these applications relies on an updated parcel database and the ability to look at that database in both a tabular (i.e., text data) and visual environment (including maps). The existing processes used are very tedious and time consuming. Automating these work flows with a GIS allows Public Works Department staff to process these flows faster and free up staff resources for other tasks
- *Ad Hoc* Mapping and Queries – These tasks involve generating maps and/or spatial analysis of any arbitrary area of the City in response to inquiries from residents, businesses, developers, or the Economic Development Department. Three kinds of map production were identified: Parcel Map Production; Economic Development Queries; and Neighborhood Condition Queries. Although the specific requirements for the three applications differ, they share a number of basic requirements including the data they need (e.g., parcels, zoning, digital aerial orthophotography).

Medium Priority

Only two Medium Priority applications are associated with a regulatory requirement:

- Project Planning Maps – The Engineering Division could use large-scale (1" = 100 ft.) maps of proposed construction and repair routes to evaluate alternative project alignments. Small-scale maps providing and overview of projects are also frequently required.
- Adjacent Property Owner Notification – Property owners adjacent to, or within a given distance of, a property that is under consideration by the City for a zoning change, use permit, or a zoning appeal must be notified. The notification includes a map of the subject property. Although this process was being handled adequately by manual techniques, automation using GIS provides a faster and more labor efficient approach to creating the maps and generating the mailing lists for notifying property owners.
- Potable Water Quality Monitoring – Sampling of the potable water system is required by regulations. The historic method for tracking and reporting the potable water sampling complies with minimum regulatory requirements, but the data is of greater benefit when maintained in a GIS form. By combining the sample site locations with an updated potable water system network, Public Works Department staff can more easily identify those parts of the water system affected by contamination detected by the water quality sampling program. This allows the Public Works Department to notify residents faster, thereby reducing potential liability, and can assist City engineers in more rapidly locating the source of the problem. Contamination events are infrequent, but such a system is even more valuable during a natural disaster, when the number of contamination events may soar and demands on Public Works Department staff are very high.

Two of the remaining applications (Utility Maps and Utility Public Information Requests) generally addressed the need to accommodate requests for information by citizens. Previously, much of the data needed to satisfy such requests existed only in hardcopy form, and required considerable staff time to locate, organize, and photocopy. By making the data storage and retrieval system for these records electronic, the records are accessed more rapidly and require less staff time.

The final Medium Priority, Emergency Response History, tracks the locations of EMS and fire response calls. These data have been maintained in the Fire Department's "Firehouse" database management system; what is required is a routine way to export the data for geocoding to the street network (or parcels) in the City's GIS database, so that emergency response events can be mapped. This mapping capability allows the emergency response planners to identify spatial trends that point out ways to reduce or eliminate calls, and provides a basis for re-allocating resources between stations or budget preparation.

Low Priority

Low Priority was assigned to four applications. The Low Priority designation does not indicate that these applications are not important, merely that they represent ways to improve or enhance City services rather than address an immediate, existing need.

- Infrastructure Condition Rating – This system tracks leak history, CCTV inspection condition ratings, and repair history. This is useful in developing Public Works Department future budget requests. A GIS database of infrastructure condition is based on an external computerized maintenance management system (CMMS) database.
- Work Order Maps – This system produces work order maps for field crews to identify the location and extent of the repair, replacement, or maintenance work they are assigned.
- Emergency Response Equipment Inventory – In the event of a natural disaster or other large-scale emergency, a current database of the whereabouts of all this equipment is invaluable in ensuring the right resources from the right location are brought to bear.

Required Data

Overview

The priority data requirements needed to satisfy the highest priority applications are as follows.

- Parcels – Update existing coverage to current conditions, from the Ada County Assessor, and develop a process for routinely maintaining parcels in the GIS database.
- Planimetrics – Update and extend existing coverage, accuracy, and methods to be determined.
- Utilities (Water and Wastewater) – Accurate to 1 meter, 2-dimensional (x,y) location only. Record invert elevations of the collection system to 1 centimeter.
- Street Centerlines – Including address ranges for geocoding.

- Digital Orthophotography – Update 2003 imagery, 0.5 ft to 1.0 ft ground sample distance (pixel size) resolution required. Target high growth areas for frequent updates.
- Zoning – Parcel attribute to be updated and extended as parcels are updated.

GIS Implementation

Staff

A "distributed" staffing model, by which technicians are placed with each major division, would not likely work for a fully-integrated system. GIS technicians working alone in each division, generally, do not have the skills or resources to tackle significant GIS applications, or maintain GIS databases. Such technicians have inadequate technical direction without direct supervision from a more experienced GIS professional. Due to the understaffed conditions in each department, technicians in the Public Works Department would likely be required to perform non-GIS tasks deemed essential. For example, a GIS technician in a decentralized system is commonly expected to perform the following tasks:

- Prepare exhibits for City Council and Planning Commission meetings.
- Assist with delivery of Planning Commission agendas.
- Manually update of Zoning Maps and Zoning History Maps.
- Assist with inquiries from phone calls and walk-ins regarding Flood Zone information.
- Provide general graphic support various departments.

While in the Public Works Department, in a decentralized system, the GIS technician is expected to perform the following additional tasks:

- Manually draft updates for water and sewer system
- Update sketches for billing and update index cards recording completed work
- Maintain field copies of sketches
- Review use permit, zoning, and site plan applications
- Update fire hydrant database with new data
- Assist field inspectors in obtaining and verifying data
- Aid the public and consultants in finding information from existing drawings and records.

The use of GIS personnel this way discourages anyone who intends to be a full-time GIS professional from remaining in the position. The solution is to group the Public Works Department's GIS staff positions together under a GIS Manager. This approach ensures that the GIS staff receive adequate technical guidance from a more seasoned GIS professional. This structure also provides for more efficient and effective use of GIS resources, since the GIS Manager is able to balance workloads and set priorities as necessary based on overall Public Works Department requirements, rather than the narrow focus of a single department. Grouping the GIS

staff together also provides the members of the GIS team opportunities to work collaboratively, cross-train, and take advantage of each other's technical strengths. The result is improved GIS products and services for the Public Works Department and its customers.

Some of the key issues inherent in this organization are:

- Department Requirements Drive the GIS Program – Requirements are set by the consumers of GIS products and services in each of the Public Works Department divisions. Those requirements are communicated to the GIS Manager as part of the annual budget cycle, through the work of the Division heads.
- GIS Manager Establishes the GIS Work Program – Based on the requirements set by end-users, the GIS Manager establishes priorities and direction for her staff. Requirements also dictate the scopes of work published in Requests for Proposals for that work which is more effectively performed by contractors.
- GIS Staff Generates Multiple Products and Services – At present, the GIS staff mostly generates maps to GIS consumers within the departments. Under this plan, the role of the GIS staff will shift to that of creating (and maintaining) GIS data and applications that will allow end-users who are not GIS professionals to use GIS directly.

Based on the initial findings of this needs assessment, and the workload associated with GIS database updates and other improvements, the Public Works Department has hired a GIS Analyst. The Public Works Department is also considering the hire of another GIS Technician as the workload associated with maintaining newly updated GIS coverages begins to increase.

Software

Recommended Software

The Public Works Department has invested a considerable amount of money in implementation and maintenance of a GIS. The total cost of recommended new software products was approximately $30,000 (2004 dollars).

- ArcGIS 9.0, ArcPublisher, Concurrent Use – ArcPublisher is an ESRI ArcGIS extension that will allow the GIS staff to produce "read-only" ArcMap documents that can be read by anyone in the Public Works Department using the freely distributed ArcReader utility. That is, ArcReader can be deployed to the computer of every employee in the Public Works Department at no charge. Then a map document created by the GIS staff and published using ArcPublisher can be opened in read-only mode by any staff member, as long as that person's computer has access to the network drives on which the map's GIS data resided. End users can zoom, pan, query, reconfigure, and plot maps from ArcReader. This product alone reduces the need for Public Works Department staff to request map products from GIS staff.
- ArcGIS 9.0, Survey Analyst, Concurrent Use – Survey Analyst is a relatively new product by ESRI. It provides tools for editing the vertices of GIS features to conform to the established corners of survey data. This application is very useful in maintaining and updating the City's parcel layer as part of the parcel subdivision process.

- ArcView 3.3 for Windows – The Public Works Department has purchased one copy of ArcView 3.3. Staff requiring simple GIS functionality may use this desktop GIS software. ArcView 3.3 contains the latest improvements and bug fixes in the ArcView 3 line of GIS software.
- ArcView 9.X – Although ESRI continues to support and upgrade the ArcView 3 line of GIS software, users should migrate to the more powerful ArcGIS 9 platform. Users familiar with ArcView 3 have the opportunity to explore the ArcGIS 9 interface by using ArcReader (whose interface looks similar to ArcMap 9). Users can take free online training in the transition from ArcView 3 to 9 at http://campus.esri.com using a license of ArcGIS 9.X.
- Windows XP Terminal Server and Citrix Metaframe XP – As noted under Hardware, below, the Public Works Department established a Windows Terminal Server as its centralized GIS software applications server. To support the GIS staff, plus other Public Works Department GIS users, the Terminal Server was equipped with Citrix Metaframe XP and Terminal Services licenses for up to 10 simultaneous users. Although Windows XP Terminal Server could by itself provide for remote access connections to applications on the GIS server, the Citrix Metaframe XP product allows for a higher-quality, lower-bandwidth connection more suitable for GIS use.
- Annual License Maintenance – The Public Works Department has budgeted for the annual maintenance associated with the entire inventory of ESRI software products, both existing and proposed. New ESRI extensions, such as Survey Analyst or ArcPublisher, include 1 year of maintenance in their purchase price.

Hardware

During the GIS System Inventory, HDR noted the need to install a Windows-based terminal server platform for ArcGIS, coupled with the need to remove data from existing Windows file servers.

Windows Terminal Server

The Public Works Department has installed a powerful Windows XP Terminal Server (Figure 1). Under this architecture, a multiprocessor Windows server stores both the Public Works Department's GIS data and the GIS software. GIS software is not installed on individual desktop machines. Instead, individual users connect to the Terminal Server using a distributable Citrix Metaframe client, which give the user the appearance of a "second desktop" on his/her PC that represents the remote computer. GIS software runs directly on the remote Terminal Server from the user's desktop; the user has access to the software on his/her local PC (such as Microsoft Office, email, or graphics programs) at all times while connected to the Terminal Server. There are several advantages to this architecture:

- Higher Performance – Benchmark testing by ESRI and HDR have shown that GIS performance is substantially higher when the GIS software and data reside on the same computer, as compared to accessing GIS data on a remote file server. HDR testing showed a six-fold improvement in processing time when using a Terminal Server architecture, compared to using the same computer when accessing data remotely on a file server.

- Lower Network Traffic – GIS analysis is *very* input/output intensive, and results in large amounts of network traffic when accessing data on a remote file server. HDR benchmarks documented that a Terminal Server solution produced negligible network traffic, barely discernible against background on a completely quiescent network, but that a file server based approach could result in hundreds of megabytes of data transferred over the span of a few minutes.
- Centralized Data Storage – Since the Terminal Server approach obviates the performance advantages of storing GIS data locally, it is possible to maintain a single, centralized repository of GIS data accessible to all users. This greatly improves the ability of the GIS staff to maintain data, eliminate redundancy, and ensure adequate backups are performed.
- Easier Software Administration – A single copy of GIS software was installed on the Terminal Server. The ArcGIS license manager tracks authorized connections and only allows as many uses of ArcGIS and each extension as the Public Works Department's licenses allow. Upgrades to the software are also easier, since only one installation must be managed.
- Reduced Hardware Demands for Desktop Computers – Because the powerful Terminal Server does all GIS processing, GIS users do not need high-end computers at their desktops (unless their work otherwise requires them). The Public Works Department's standard PC platform is more than adequate as a GIS client.
- Better Remote Access – Due to the low bandwidth requirements of the Citrix Metaframe client, GIS sessions with acceptable performance will eventually be run over a Wide Area Network (WAN), once the City Information Technology staff complete WAN connectivity. Again, this would provide GIS accessibility to remote offices using a centralized database and no I/O transfer penalty, and without requiring high-end computers and redundant data storage at the remote site.

Conclusion

The Public Works Department has accomplished several of its objectives and plans on executing several new objectives in the near future to support its business practices. These objectives are:

First Year

- Establish a centralized GIS staff answering to the Public Works Director. A GIS Analyst was hired during 2004 to begin the implementation of a GIS program. Evaluate additional staff requirements in the Engineering Division.
- GIS staff are implementing ArcReader solutions to disseminate GIS access to all Public Works Department staff as quickly as possible.
- GIS staff are preparing data for comprehensive plan, subdivision/plat recording process, and site plan review process.

- A Terminal Server approach to GIS implementation provides an increase in performance, saves on network bandwidth, centralizes data storage, lessens administrative burdens, and enables greater remote access to GIS capabilities.

Following Years

- Public Works has budgeted for annual GIS staff training and annual software maintenance.
- The Public Works Department has installed a Windows-based ArcGIS 9.X platform on a Windows Terminal Server.
- The Public Works Department has could hire another GIS Technician to assist with maintenance of updated GIS databases.
- The Public Works Department should eventually evaluate the performance of the Windows Terminal Server and determine the need for acquiring ArcSDE and a high-performance external disk array and budget accordingly.

Figure 1. City of Meridian GIS Architecture