A Simplified Approach to Asset Information Management for Mid-Size Utilities

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ABSTRACT

The number of utility service providers implementing asset information management systems is growing fast. Many are faced with the question: which type of system is right for me? The asset management software market is mature and there are many choices of platforms and vendors. This paper discusses advantages and disadvantages of different types of computer software for asset information management based on case studies of their implementations in the past three years. The information gathered support the classification of three very different implementation schemes: desktop-based, web-based and a desktop / web hybrid system. We will show that the hybrid platform provides agencies with the most flexible, scalable and user friendly implementation that integrates existing tried-and-true procedures, applications and databases – or 'haystacks' – into a single user interface, enabling users to find that one piece of information – the 'needle' – quickly and efficiently. A case study of a hybrid system implementation is showcased for a medium sized water utility provider.

KEYWORDS

Asset Information Management, AIMS, CMMS, collection system, GIS, CMOM

INTRODUCTION

In today's business environment of tight budgets, stricter environmental regulations, and complex operating procedures, water and wastewater agencies have sought out a variety of automated asset management systems to address their specific information needs and support well-informed decision making. Asset management is a means of managing utilities to minimize the costs of owning and operating them, while delivering the desired level of service. A key component in asset management is unsurprisingly the quantitative information provided by Asset Information Management Systems (AIMS) which are designed to assist agencies (districts) to achieve three objectives:

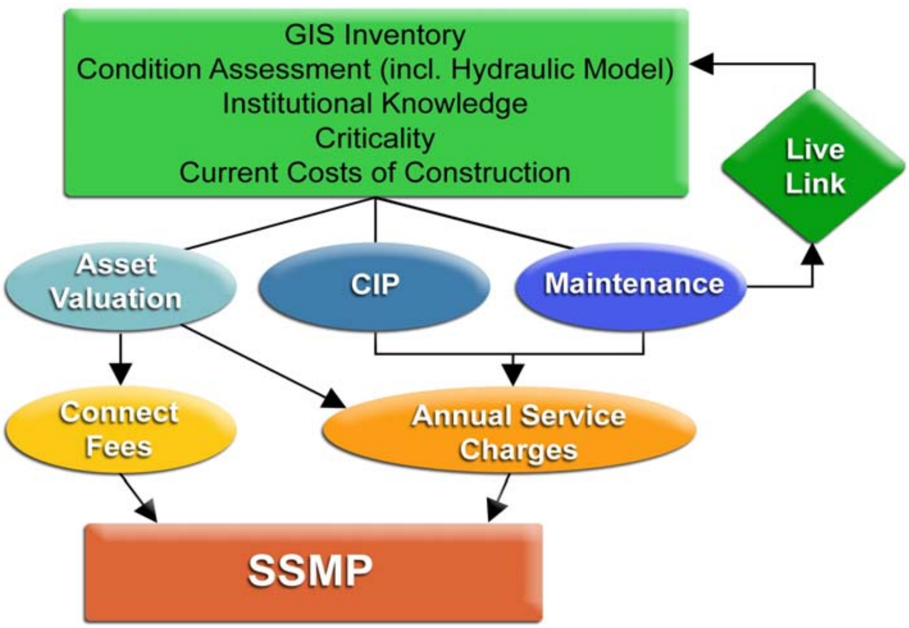
- Retention of knowledge: Assist in staff training, increase accuracy and completeness of legacy information, and far-sighted use of resources

- Cost-effective regulatory compliance: Maximize system reliability and manage risks to meet public health, safety, and security objectives

- Prolong system life cycle: Proactive maintenance, predictive repairs or replacements; risk management, and responsive to failures

AIMS can be especially useful for wastewater collection system management, where access to asset information is often a critical element of gaining support for the level of funding required to replace or rehabilitate failing infrastructure. Necessary information sharing in a typical asset management concept (Figure 1) include databases for asset inventory and condition assessments, geographic information systems (GIS) for location tracking and capacity modeling, financial calculators for asset valuation and construction costs which translate to service connection fees, maintenance work orders processing, and Sewer System Management Plan, or California enforcement of CMOM. These disparate types of information are computerized (live linked) in an integrated decision support tool or AIMS.

Figure 1 - Collection System Asset Management Concept



(Source: 2006 Kennedy/Jenks Consultants)

ISSUE

There are many varieties of software used to implement the various functions of AIMS, such as financial calculators for capital improvement plans, spreadsheets or databases for equipment inventory, and GIS for distribution and collection systems mapping and capacity modeling. Many agencies serving the smaller communities have the same issues as larger communities, but need asset management solutions that are very cost effective, exclusive to their needs, straightforward, don't require fundamental organizational change, and can be implemented incrementally over time.

Many agencies utilize software systems from a variety of vendors, selecting a 'best of breed' solution to address each specific management function. Unfortunately, many of these systems are expensive, require recurring license fees, and employ proprietary reporting procedures to access information. Additionally, they do not communicate well with agency's legacy information system and workflow. The resulting problem is that commercially available and more advanced but simpler management tools will never be used because of costly adaptation that require fundamental changes in organization and procedures. Furthermore, in many cases, end users need to learn a variety of processes to find one piece of information (the needle) from a collection of computer tools and data sets (the haystacks). *There is a growing need to simplify information retrieval once it has been stored into a system.*

NEEDS – The Concept of Total Assets and Operations Management

The most commonly implemented asset management tool is the Computerized Maintenance Management System (CMMS) which includes the management of asset inventory, condition and value of assets, tracking of operations and maintenance procedures, and most commonly used for generation of work orders. This is represented by the green box at the very top of the flow chart in Figure 1.

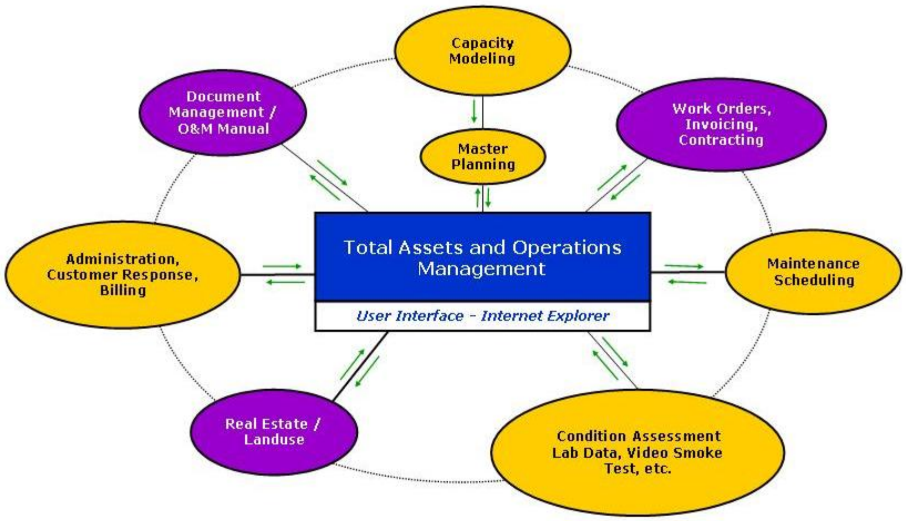
With more cost effective and easy to maintain computerized database systems than ever before, the new concept of automated Total Assets and Operations Management is reality – an adaptation of the concept of Dynamic Management Approach to collections system operation and maintenance (EPA, 2002). Such a system can be visualized as a hub-&-spoke model as illustrated in Figure 2. The concept and its various implementation schemes contend that it is not enough to just know the where about and conditions of your asset which equate to their valuation - but also knowing how to efficiently operate them. The hub-&-spoke model encourages data generators ("spokes" or departments within an agency) and experts within departments to collaborate by first sharing information through the hub (Web browser) on a daily basis, making joint decisions can hopefully avoid potential redundant initiatives and action items.

Achieving regulatory compliance and prolonging the operating life of utilities which are the two primary goals in asset management can then be under a combined management of both assets inventory (equipment vendor, appurtenance location, and utility conditions) and operations (O&M and repairs). A Total Assets and Operations Management approach can assist managers to move away from reactive maintenance at all levels to make well informed and quicker decisions and take on proactive and perhaps preventive maintenance budgeting and planning of utility assets.

The details of database and GIS mechanics are beyond this discussion. The latter section in this paper explores the implementation requirements in a case study of a Total Assets and Operations Management approach at the Carmichael Water District in Sacramento County, California. Although this particular case study is of a water distribution system, very similar requirements can be applied to a collection system which is illustrated in Figure 2. The authors of this paper want to show case a more leading edge solution in addition to a comparative analysis of two other AIMS approaches.

As mentioned, the user interface is simply an Internet Explorer web browser which serves as a "traffic policeman" to integrate disparate data, sharing them amongst departments within a small agency and thereby making well informed and collaborative decisions.

Figure 2 – Total Assets and Operations Management



METHODOLOGY

This paper presents a comparative study of AIMS solutions that have been put into practice by public agencies. The criteria used for selecting the case studies are: A) cost-effectiveness and B) ease of implementation and maintenance in addressing the needs of small to medium sized utilities. Selected cases are then rated by a combination of three factors: *Contents*, *Functionality*, and *Accessibility*.

Ideally, an AIMS should provide *Contents* related to:

- *Asset Inventory* – Location, category and pertinent information of individual assets, stored in any combination of database, GIS and CAD warehouses.
- *Asset Condition* – Information related to the useful life of assets, based on any combination of age, material type, local environment and actual observations and sampling of assets.
- *Asset Value* – Information related to the depreciated value of assets, as well as replacement costs for assets at current market price and future price based on estimated inflation rates.
- *Capital Improvement Plan and Master Plan* – Location, schedule and cost of Planned System Maintenance (PSM) projects, fully integrated with an agency's Master Plan and tied to Inventory, Condition and Value parameters.
- *Maintenance Management* – Work order generation against individual assets, and maintenance history tracking by frequency, type and descriptions of service.
- *Utility System Network Tracing and Modeling* – Analysis of the utility's collection or distribution system through capacity modeling, upstream / downstream tracing and main and valve isolation.
- *Customer Service Administration* – Tracking of customer data including service call history, usage, priority and assessor's office parcel information, linked to a utility billing system.
- *Document Management* – Storage and retrieval of a variety of documents and other media including construction drawings, operations and maintenance manuals, and photographs and videos of asset locations and conditions.

Any of these content categories should provide the user with *Functionality* to manage, report, visualize, and analyze assets both individually and system wide:

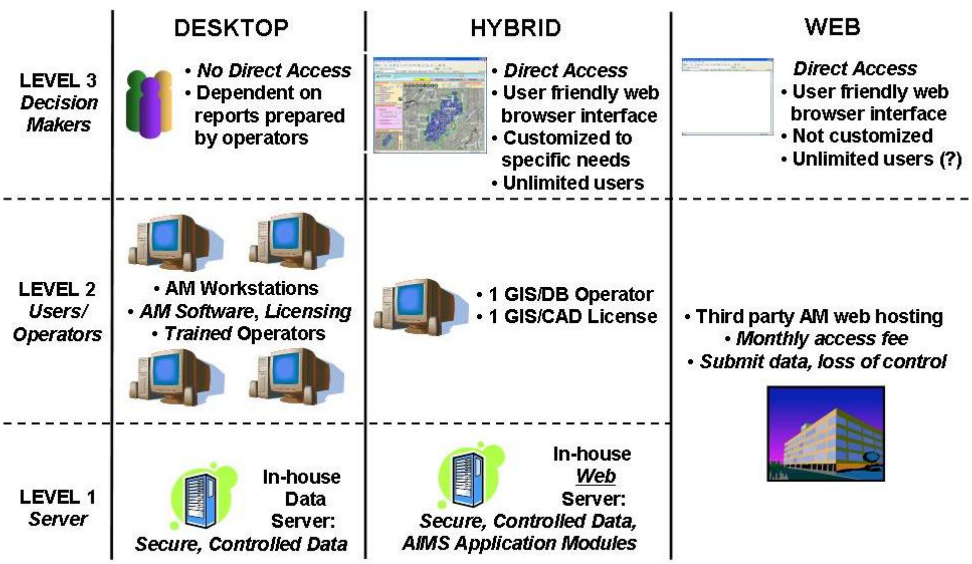
- *Manage* – Add, edit or delete assets and their information.
- *Report* – Generate custom reports that fit the agency's operations and are compliant with regulations.
- *Visualize* – Provide a wide variety of visualization options that lets the user create tables, graphs and maps appropriate for the type of content in question.
- *Analyze* – Enabling the user to run cause-and-effect scenario's including utility system operations and budget planning.

Finally, *Accessibility* of an AIMS should not be hampered by expensive and limiting licensing agreements, or cumbersome installation and update procedures. Furthermore, AIMS functionality should be accessible from a user friendly interface that does not require extensive training and a high level of expertise. Regularly used functions and information need to be accessible by as few mouse clicks as possible. AIMS should be seamlessly integrated in agency operations, enhancing existing procedures both in the office and in the field. Lastly, all AIMS modules should be fully integrated into a single interface, without having to open additional third party applications requiring further computing power and software licenses.

COMPARATIVE ANALYSIS

There are a number of software packages available commercially that contain some or most of the needed functionality. Survey results of several west coast sanitary districts are presented in Figure 3. It is not the scope of this paper to provide detailed descriptions of these implementations or to compare the details of the specific commercial software that serves the AIMS need at each district. Survey data are generalized into three levels of involvements: Level 3 is management or the end user who makes decisions based on accurate systems performance and condition information; Level 2 is the operator of the AIMS who is responsible for maintaining the information at the user end; and Level 1 is the data repository or server which can be the agency's information technology (IT) services.

Figure 3: AIMS Implementation Architecture Comparison



<u>Desktop AIMS</u>

In general, off-the-shelf (out of the box) desktop implementation of AIMS is the most involved in terms of setup they are very large, desktop-based software applications that allow the user to enter and manage an asset inventory and subsequently generate work orders concerning these assets on an as needed basis. The basic mode of user interaction is in tabular form, although most packages either integrate or link to third party GIS to visualize assets on maps.

As these packages can be purchased 'off-the-shelf', they cover a wide range of user needs for a variety of industries. This results in an extensive user interface which requires substantial training to efficiently navigate. Software licensing costs combined with initial configuration, data loading and consulting fees are significant. Depending on the size of the user's utility service area and the variety of operations and procedures, many of the software's functionalities are not likely to be used as they apply to other industries only.

Large agencies may be able to implement such a system in a cost-effective manner. However, it is evident that the small to medium size agencies have difficulty implementing a solution for their needs as these off-the-shelf, desktop-based asset management systems often turn out to be relatively costly, both financially and in manpower. Moreover, an installed system can often be under utilized because of its complexity or neglect (outdated software).

Small agencies would rather allocate their resources and especially human resources into making critical-path decisions, planning for future capacity, customer service, and system maintenance and not in the training and operating asset management software. This scenario is especially poignant for agencies that have experienced regular staff turnovers, shortage in field staff, and the notable costs in training new recruits.

Web Enabled AIMS

With the increase of internet technologies and connection speed, an alternative option to asset information management has presented itself in the past few years. An emerging number of web-based asset management providers allow agencies to submit their asset data and have them integrated and served in a secured web application that can be accessed for a monthly subscription fee. Functionality is generally more limited in scope, but sufficient for most small agencies' needs. Implementation cost is lower, while interfaces are more user friendly in nature, limiting the need for extensive training and expert personnel. However, the main drawbacks to this type of asset information management are that some control of the data is transferred to the provider, and as the web service is focused on a wide variety of agencies, the available functionality is not optimized to the specific agency's needs.

Hybrid AIMS

Besides the desktop and web packages discuss above, there is a third option, which is a hybrid desktop/web solution. Users access asset information and management functionality through a "light-weight", optimized, user friendly web browser interface, while core GIS-based utility systems data are maintained in a desktop environment by one designated agency staff. This option may be the most streamlined solution, as it allows an unlimited number of users, serves functionality customized to a specific agency's needs, and requires minimal or no training to operate. Implementation cost is relatively low, can be spread over different phases, and varies based on required functionality and size of the utility system.

No asset management system is perfect. However, out of the three platform options (desktop, web, or hybrid), the hybrid system comes close to meeting all requirements listed in the Section title Methodology. A major advantage of the hybrid system is that it is extremely flexible and scalable in nature. As it is constructed from separate components in the back end, the user interface or front end can be expanded and customized on an as needed basis. This allows an AIMS to only provide functionality that is actually needed by an agency, and delivers information and automation to enhance existing operation procedures and management decision making. The web and desktop options individually are not as flexible, forcing agencies to adapt existing procedures to fit the workflows that the asset management system imposes. This has proved to be a hurdle in acceptance of a system by agency staff, as deeply engrained work methods are hard to change.

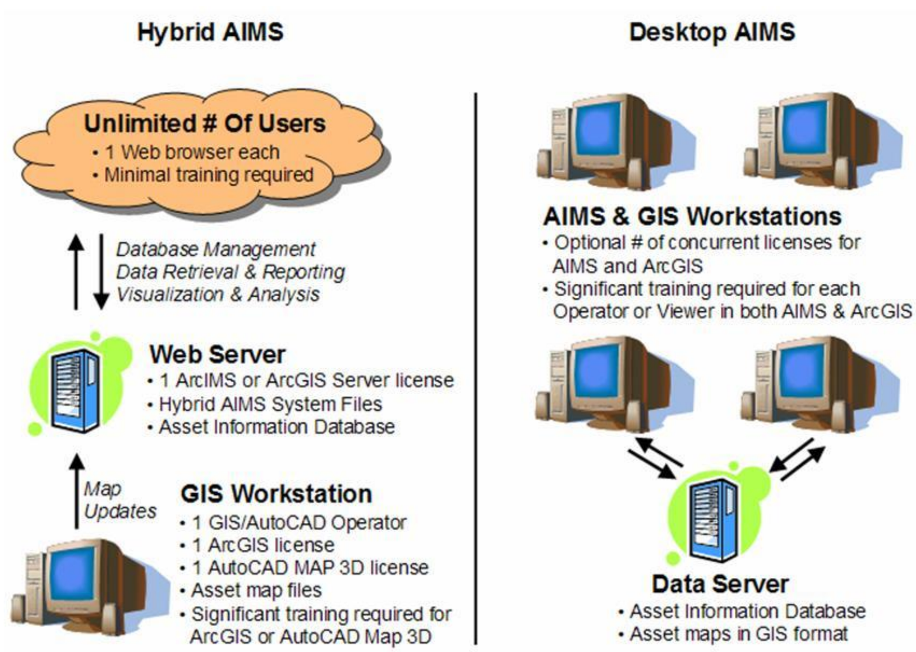
The hybrid system architecture is also the most compatible with the Total Assets and Operations Management concept and can be visualized by using a hub-and-spoke model (Figure 2). The hub represents the hybrid system interface, or AIMS. The spokes represent database links to data maintained by different departments in an agency. While each department is responsible for the quality and maintenance of their own data, the hub integrates selected data sets that are suitable for sharing between departments.

To the average AIMS user, the system architecture is transparent. The user experiences AIMS by opening a web browser and selecting a web link in the agency's intranet to activate the application. The look and feel of the AIMS interface is customized to the agency's work methods, but generally compares to other interactive web sites like internet banking, shopping and multimedia applications.

A typical hybrid system implementation consists of the following components (Figure 4):

- A web server that hosts the AIMS application modules
- A desktop computer with GIS and database applications for core asset inventory maintenance
- Any number of computers with a web browser to access the AIMS application

Figure 4: Comparison of system components between hybrid and desktop AIMS



Hybrid AIMS application modules consist of *standard web language scripts*, including HTML, Javascript, Visual Basic, and Microsoft .NET technology. They can be configured to optimize every aspect of the AIMS interface, including buttons, menus, and graphical elements. The scripts integrate and harness functionality from GIS components (ArcIMS, Autodesk MapGuide), enterprise database applications (SQL Server, Oracle, MS Access) and spreadsheet applications (MS Excel). Depending on the number of departments and data sets that are integrated in the hub, the scripts also link databases between different departments, and directly back to the central database in the hub, which contains the asset inventory. For instance, billing information is hosted by the accounting department, service call history is hosted by the customer service department, and all of these data are displayed in one coherent report by a mouse click on a parcel map.

Certain maintenance aspects of the asset inventory are better off being handled by a designated GIS and database administrator. For instance, graphical edits to the utility system map, or bulk database updates are more efficiently performed in a desktop environment than in a web browser. The administrator can either be a designated agency staff, or a consultant on an as needed basis. The utility system map can either be maintained in a GIS, CAD or combined environment, depending on the involvement of planners and engineers.

In the hybrid system, the administrator is the only person that needs to be trained to expert level in mapping, database administration and general asset management procedures. The administrator serves as the provider of AIMS modules and content, enabling the rest of the agency to benefit from a user friendly environment while managing asset information. This is in contrast to desktop-based asset management systems, where the few trained professionals are the funnel for asset information needed by the rest of the agency, resulting in longer response times and time consuming communications between agency decision makers and asset management system operators.

The biggest advantage of a hybrid system however, is the user experience through the AIMS interface. A user can create reports, analyze a utility system, visualize aspects of common utility system management tasks in maps, tables and graphs, and manage asset information without enduring many hours of GIS and database training. Examples of AIMS functionality and interface layouts are displayed in the next chapter, which describes a case study of a hybrid AIMS implementation for the Carmichael Water District, a medium-sized water utility service provider in Sacramento County, California.

CASE STUDY: CARMICHAEL WATER DISTRICT’S HYBRID AIMS IMPLEMENTATION

Background

Organized in 1916, the Carmichael Water District (‘District’) is located in the central portion of Sacramento County in California, northeast of the City of Sacramento and north of the lower American River. The area served by the District encompasses approximately eight square miles and serves a population of approximately 39,000. The District is predominately residential in character, with interspersed commercial areas. The District currently employs 28 employees with the responsibility of providing administration, water treatment, field operations, maintenance services, conservation and public education services to service the District's approximate 11,000 connections.

District customers receive approximately 70-80 percent of their water from the American River and 20-30 percent from District groundwater wells. The District’s complex water distribution system inventory includes approximately 153 miles of water mains, 3,700 valves, 1,300 fire hydrants and three pressure zones. Water production facilities include a microfiltration treatment plant, water production wells and storage tanks. District wide customer meter installations are scheduled to be completed by 2017. The engineering consultant and AIMS specialist provided engineering and consulting support services for the District, including preparation of a comprehensive Master Plan (Kennedy/Jenks, 2003), projecting complete infrastructure replacement over a 100 year period. The Master Plan focuses on inventory of the infrastructure, estimate of remaining useful life and development of a financial plan to support the long term planned system maintenance to manage a system approaching 100 years of age.

Integral to the Master Plan is the continued data collection and measure of asset condition and value to provide for focused reinvestment in those elements in most need. Equally important is the desire to avoid premature replacement of assets. At the same time, compliance reporting requirements (GASB34) necessitate an upgrade of asset accounting methods used by the District.

Hybrid AIMS Implementation

The District chose to implement AIMS in phases to spread the cost over multiple budget cycles. The strategy was to rapidly develop and implement modules to make functional tools available in very short time within each budget cycle. During initial meetings, needs were assessed and prioritized through mapping of operation procedures in flowcharts.

This process mapping exercise resulted in the following prioritized list of AIMS module implementation:

1. Asset Inventory
2. Utility System Network Tracing
3. Asset Condition
4. Asset Value
5. Master Plan and Planned System Maintenance
6. Customer Service Administration

Maintenance management and generation of work orders are currently not part of the District's AIMS interface as they have an adequate application in use already. However, work orders can be visualized through AIMS in connection with customer parcels, as scripts are able to tap into the back-end database of this application. In future budget cycles, the District is planning to include a Facility Management module to access plans and manuals for treatment plants, production wells, tanks and pumps. AIMS will be accessed in the field through wireless Virtual Private Network connections to the office. Other plans for AIMS include meter reading route management and customer water usage reports and analysis.

The District is now hosting AIMS in their in-house web server, with all staff accessing the application through Microsoft Internet Explorer. The number of functions and levels of database access available for any given user is determined by the system administrator who assigns access levels, login and passwords to different staff depending on their duties. In the District's case, the system administrator role is performed by the Manager of Operations.

Distribution system maps are served using ESRI's ArcIMS, the asset information database is stored in Microsoft SQL Server, and graphs and tabular reports are on the fly created in browser windows ready for printing, or in PDF. Map based edits and bulk database updates are outsourced and performed by the engineering consultant and AIMS specialist on an as needed basis. The following are more details of the six features in the Hybrid AIMS implementation.

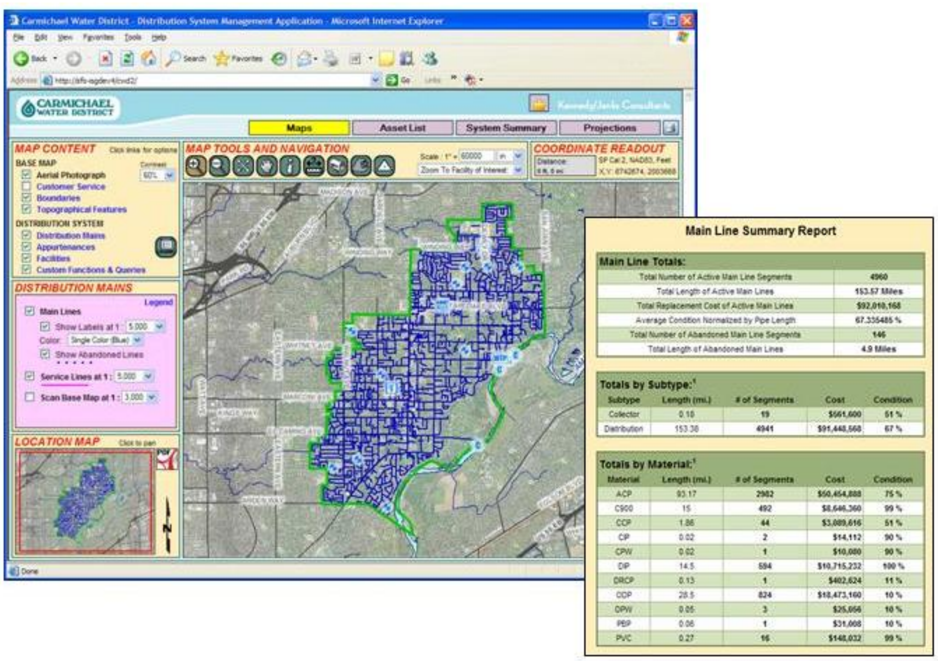
1. Asset Inventory

The first step in developing an AIMS is the compilation of the asset inventory. The District has been maintaining a map book in AutoCAD to represent the distribution system layout for use in field and office operations. Using the map book as a start, the engineering consultant and AIMS specialist created a single master AutoCAD drawing for the entire district, configured as a geometric network ready for hydraulic modeling and network tracing. The District needs to maintain this drawing in AutoCAD format (as opposed to GIS format), in order to effectively communicate information between District engineers, contractors and consultants.

Asset information such as material type, diameter, status and installation date, is stored in a SQL Server database, which is live linked to the assets in the CAD drawing through Autodesk's GIS solution, AutoCAD MAP 3D. The database structure is based on water utility industry standards as published in ESRI's web site (McKibben, 2002). The CAD maps and database are accessed by ESRI's ArcIMS and served in the hybrid AIMS interface for user interaction (Figure 5).

The interface provides basic GIS map navigation functionality that includes zooming and panning in a variety of ways. Distribution system assets are categorized in coherent groups including main lines, system valves, control valves, hydrants and facilities, and can be displayed on the map separately by toggling a switch. Asset information can be accessed by a mouse click on the map, or through tabular searches. Custom maps can be printed to PDF with specified District title block information. District-wide statistics can be accessed through a series of summary reports.

Figure 5: Utility system map and main line summary report



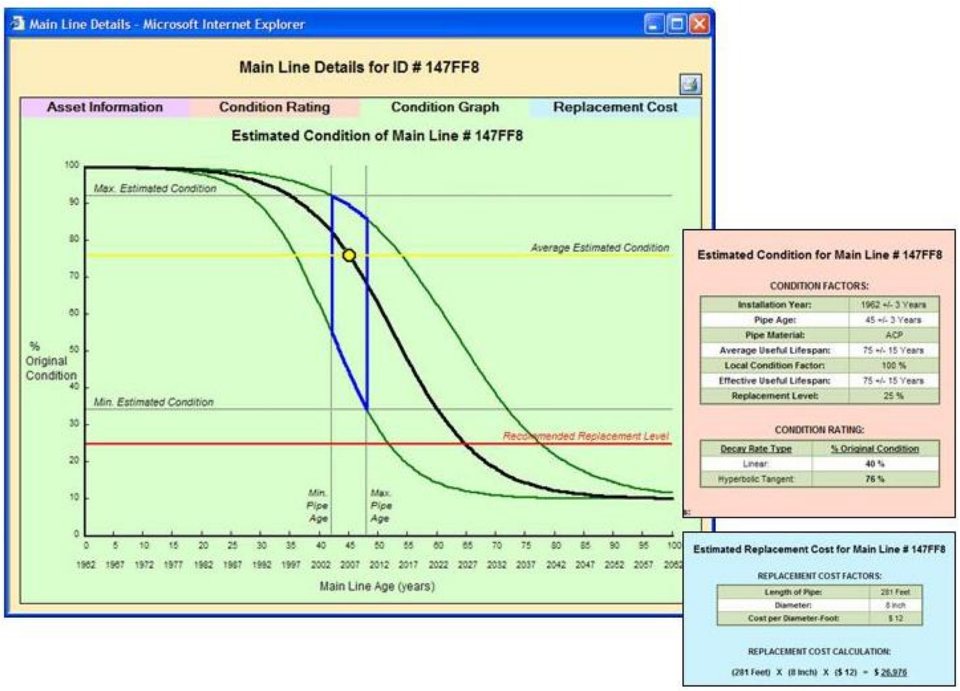
<u>2. Utility System Network Tracing</u>

During emergency situations (e.g. a water main break) or in preparation for Planned System Maintenance, the District needs to find the set of system valves to close in order to stop the flow of water through an asset due for repair or replacement. Additionally, the District needs to notify customers that there will be a disruption in service during repair work. Since the asset inventory map has been created as a geometric network, the distribution system can be modeled to provide these answers automatically. Through the system isolation function, a District user can select an asset on the map, upon which affected assets are highlighted and valve and customer lists are generated. Customer addresses are formatted in a PDF in standard Avery format for easy labeling.

<u>3. Asset Condition</u>

In order to reduce the number of occurrences of water main failure, the District needs to track the condition level of assets, and estimate their remaining useful life so they can be replaced or repaired before they fail. As a start, all main line segments were assigned an approximate installation year, from which an asset age can be calculated. For each type of main line material, an average useful life was estimated based on industry experience. Each asset can be individually assigned a local condition factor, depending on the environment or soil type that the main line is buried in. Taking into account all of these parameters, the condition level of every main line represented on the map can be visualized on a decay curve (Figure 6). Uncertainties in installation year and useful life estimates are represented by a boundary-enclosed area in the graph. When the estimated condition reaches 25% of its original condition, the asset will join a backlog list of scheduled preventative maintenance projects. Maps can be visualized to show main lines in different colors based on their estimated condition level, thus highlighting system hot spots of failure risk. Summary reports generate estimates of system wide condition levels, which is a good indicator of overall system health.

Figure 6: Condition rating and Costs calculations for individual assets



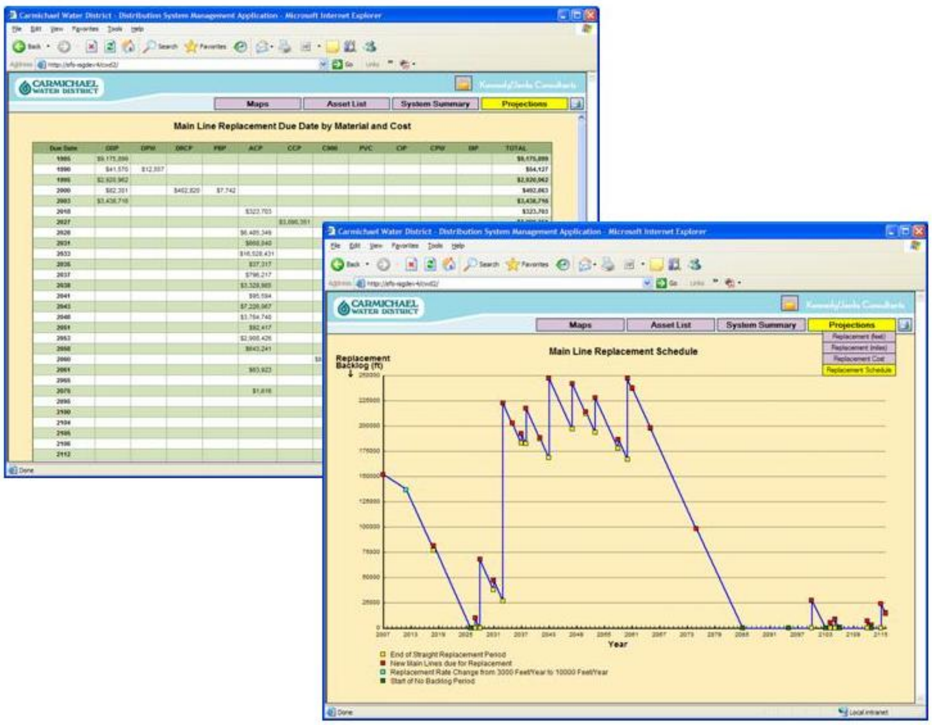
4. Asset Value

To help budgeting activities related to yearly maintenance costs, main line replacement cost is calculated for each segment based on the current market value of materials, design and construction costs, and consulting costs. District users can select main lines that are part of a Planned System Maintenance project, upon which a total estimated cost is presented. These cost calculations are also required in order to comply with the new Governmental Accounting Standards Board, Statement 34 (GASB34) regulations for the accounting method standards of infrastructure assets. The District's reports are aimed to comply through the Modified Approach, taking into account an up-to-date asset inventory, condition assessment and estimation of yearly maintenance budgets. The interface provides replacement cost calculations for individual assets through a mouse click on a map (Figure 4), and for system wide replacement cost, essentially showing the total value of the entire distribution system.

5. Master Plan and Planned System Maintenance

The District's 2003 Master Plan (Kennedy/Jenks, 2003) illustrated that there are some major challenges ahead to prepare for a large volume of Asbestos Cement piping all coming due for replacement between 2025 and 2035. Reports provided by AIMS related to asset inventory, condition and value are in agreement with this observation and can be visualized in tables and graphs (Figure 7). These types of reports are in essence a dynamically updated schedule for Planned System Maintenance and can be used for the planning of resources, both financially and in manpower. Additionally, the interface provides tools for scenario building by letting District users adjust main line replacement rates and seeing the effects on schedules and budgets.

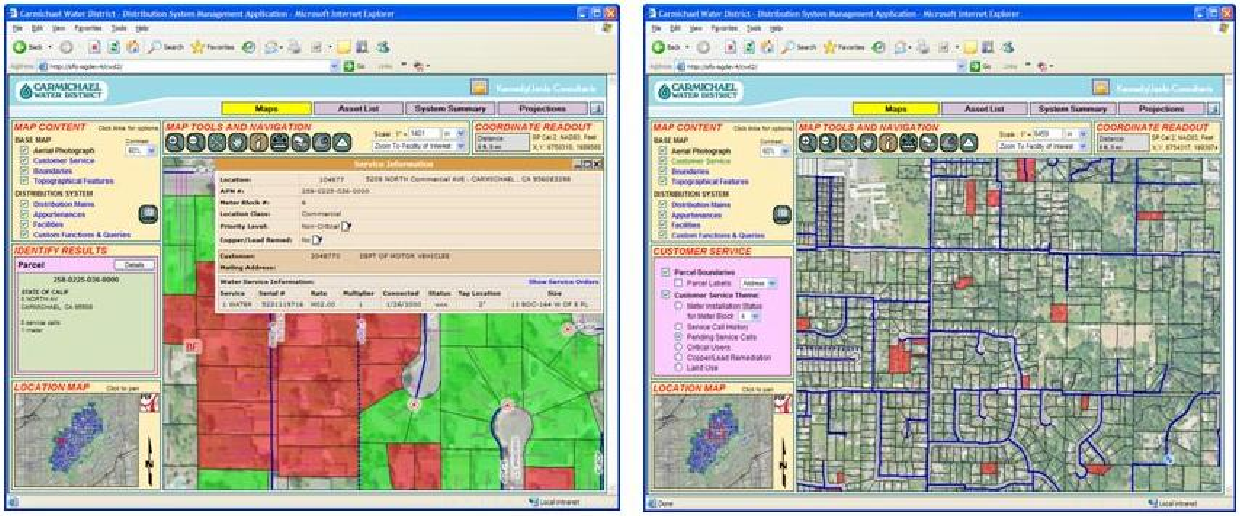
Figure 7: Main line replacement schedule graph and table listing by material type and cost.



6. Customer Service Administration

The District uses Microsoft Great Plains software for their customer service and billing information. However, some of the available output reports are not sufficient for the District's needs. Instead, AIMS accesses Great Plains' back-end SQL Server database, and creates reports and thematic maps that are customized to the District's needs. District users are able to mouse click on a parcel map and retrieve customer service information, meter installation data and tap location descriptions. Additionally, parcel maps can be visualized by work order history, pending work orders, meter installation status, priority water users and land use (Figure 8).

Figure 8: Customer Service map examples – meter installation and pending work orders



DISCUSSION

Results firmly emphasize an innovative approach of information handling with minimal "excess baggage." The solutions focus on the exact needs of the end users: water and wastewater management staff dedicated to systems planning and capital improvement of aged or under capacity systems. Too often, information handling becomes the sole responsibility of IT service staff, with enterprise information solutions that are outdated or carry unnecessary overhead such as dedicated database administrators, data entry staff, and GIS specialists. Present day information technology calls for data generation and maintenance at the operating department level where AIMS budgets are approved based on actual needs like equipment inventory, system upgrades, and regulatory compliance. Moreover, each department is responsible for its own budget; the information system costs should be directly attributable to that budget and not to the entire enterprise.

This study finds that for many utilities, sufficient tools are available for use as web-enabled AIMS, with minimal if any need for additional data hardware or infrastructure. Eliminating the need for expensive hardware or software solutions allows resources to be applied where they have the greatest benefit: in integrating legacy data from various existing ad hoc asset management systems into one easy to use, organization-wide web-based system. The study shows that in general, asset data exists in three forms: 1) anecdotal or institutional knowledge must be transliterated into validated quantitative information; 2) printed materials, which must be translated into workable computer formats; and 3) disparate sets of electronic information, which must be consolidated into a coherent accessible data repository. These forms of asset data can all be accessed using a web-enabled AIMS, resulting in cost-effective applications that are common for all users, with no multiple licensing of software and with a single repository of data.

CONCLUSION

Effective and easily maintained AIMs that provide the most benefits are single, common, and time consistent interfaces to integrated information, with productivity and cost advantages. The "hub and spokes" (Figure 2) is a practicable concept for an effective AIMS solution, where the central hub is a web based set of Internet data display tools acting as a centralized information center that displays condition assessment report (Figure 9) and up-to-date overflow reports (Figure 10). The spokes represent data paths to the information center which also contains online data entry forms to expedite daily record keeping. For example, the spokes could contain paths of data feed from spreadsheets, databases, CAD files, and GIS into the hub.

Figure 9 Online System Condition Summary Report

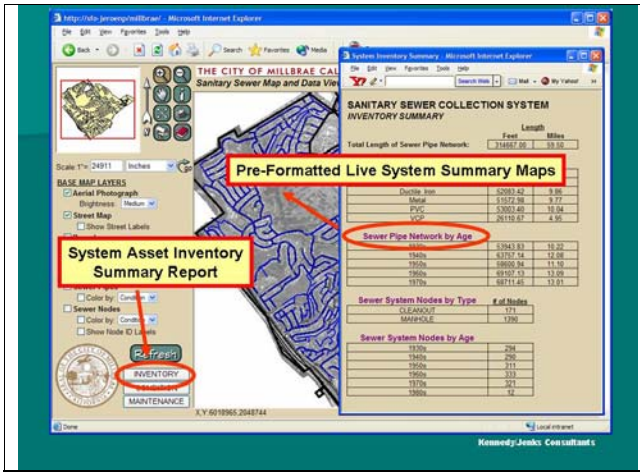
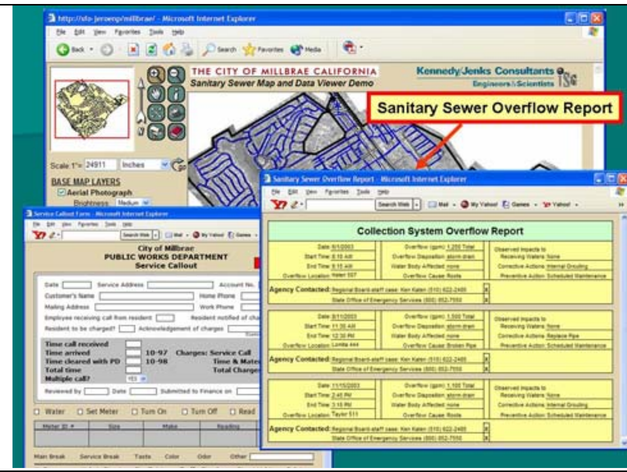


Figure 10 Online Collection System Overflow Report



(Source: Demonstration & Studies Web Site, Kennedy/Jenks Consultants 2003)

The hybrid desktop/web option (Figure 4) is the most advantageous for agencies of any size that want to maintain control of their data, implement asset information management in phases, and make asset information accessible to a wide variety of users within an agency. The hybrid system is user friendly, flexible and scalable, and integrates existing procedures, applications and databases – or 'haystacks' – into a single user interface, enabling users to find that one piece of information – the 'needle' – quickly and efficiently.

Complete and cost effective asset management solutions should include procedures to incorporate information from the various data sets managed by departments, integrating them into the hub for web-enabled management decision making. The end result is a seamless communication structure specific to the needs of a water or wastewater agency and that can expedite system planning and maintenance support. A well thought out AIMS also does not require significant investment in hardware and software upgrades. For example, the City of San Mateo, California implemented a computerized maintenance and management system (CMMS) for their collection system asset management by simply connecting existing AutoCAD drawings of system layout with a GIS for capital improvement planning and hydraulic modeling while using a Microsoft Windows Access database to manage system condition information, asset valuation data, and connection fees.

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