DATA RULES

Designing IT systems for our cities

Consulting engineers are competing to bring our transportation, water and sewage management systems into the next century. Here's a look at how to win clients and get the job done, using information technology as a tool.

by Paul C. Marsh, P.Eng.

This recent watermain break in Sarnia turned into a flood after the line ran for eight hours because staff were unable to locate a valve buried under asphalt. As a result, a length of road base was damaged, spoiling previous work. Such problems can be prevented by computer systems that keep inventories of infrastructure and enable good record keeping. *Photo: Glenn Ogilvie, courtesy of* The Observer.

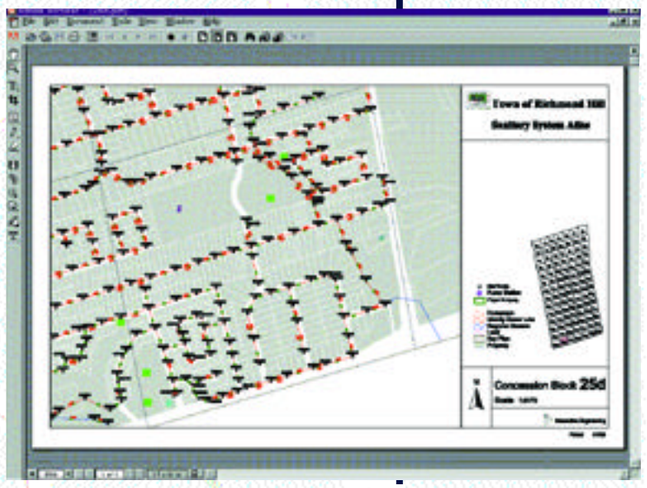
When it comes to infrastructure management and needs analysis, municipal clients expect us to deliver solutions to generalized problems, rather than specific problems. They're usually not looking for a one-time analysis of the performance of a process or system, although that does happen too. What's often expected is an "active" report that provides performance and/or needs analysis on an ongoing basis. This value-added analysis unties dependency on any one consultant. It clearly requires that some expertise be retained by the client for reproducing such analysis, which must be considered part of the consultant's "technology transfer" service.

For example, municipalities often do sewer needs studies once every five years. Using this type of dynamic reporting, however, a sewer needs study can be done every year, based on data collected by the client. This accomplishes two goals: direct system observation is done by the client organization's staff, and the dynamic analysis is comparatively less expensive than traditional consulting services. So the client has more flexibility to invest in options analysis, providing more in-depth information on the options for fixing given problems under investigation, like inflow and infiltration in sewers.

The new buzzword: system integration

Delivering an infrastructure management system in a format that meets client needs is challenging. You have to deal with new operating systems, software versions, and software standards in the rapidly changing field of information technology.

However, it's important to remember that clients are unlikely to "trash" their existing software because some new system does a better job. There is often function overlap in the new system, or there is a shared data set required for full operation of another department's application.



An online view of Richmond Hill's sanitary sewer system, part of the town's infrastructure database and management system.

System integration is the watchword for today's engineering environment. Operating a duplicated data set in two separate systems effectively requires specific technology and processes to synchronize the data within the two systems. Duplicating data entry is not an option, because the probability for human error is too great.

Common obstacles in infrastructure management

In our consulting practice, we typically face a scenario in which a client's existing systems and applications are not performing as expected and/or have never been fully or properly implemented. The client says: "Tell me what to do to make this infrastructure needs analysis and management software work."

The statement "make this work" presumes the client has a vision of how infra-

Richmond Hill's engineering projects go digital

The Town of Richmond Hill has been working for the past four years to set up a management system to track existing infrastructure. Since Richmond Hill is one of Canada's fastest growing municipalities, the need to keep infrastructure up to date is a concern. Reviews of proposed developments require continual reference to existing infrastructure to ensure that new development will not cause infrastructure capacity problems "downstream" in existing developed areas.

Data standards in action

The use of digital technology is a must for infrastructure management. A relational database management system (RDBMS) was created for Richmond Hill's inventory of infrastructure, using the new Municipal Infrastructure Data Standard (MIDS). (See sidebar on p. 34.)

Geographics software from Bentley Microsystems is the primary data management tool for graphic manipulation of the RDBMS. This geographic information system (GIS) acts as a spatial reference for editing the database of infrastructure components. The RDBMS stores location references, like streets, addresses and coordinates taken from the municipality's global positioning system and total station surveys, as well as topological relationship information, such as node and link model representations.

The objective is the continuous updating of infrastructure data, as new construction takes place. In the past, engineering consultants hired to manage new construction have always prepared "as constructed" plans to provide records for the municipality. This was primarily accomplished with computer software, such as AutoCAD or Microstation. When a final submission was made, the town would digitize the plan prepared with AutoCAD by a consultant.

In the future, this wasted effort will be avoided with the submission of "as constructed" data in AutoCAD form. The submission will be in two parts: an AutoCAD file and a Microsoft Access database of attributes, such as material, pipe class, diameter, etc., for each of the infrastructure components submitted in the AutoCAD file. These two submissions will be processed into the primary infrastructure database and added to the GIS.

Putting it all together

Two key pieces of technology converged to make this possible: AutoCAD and Microsoft Access, which are widely accessible file formats, but lack any structure for engineering infrastructure information. Along with the MIDS, the Tri-Committee on the Utilization of Computers in Public Works (www.tricom.org) has developed a Graphic Data Standard for Infrastructure Data, which provides the specifications necessary for organizing the AutoCAD data. Attribute data (pipe diameter, material, valve types, etc.) are organized using the MIDS.

The Tri-Committee is a not-for-profit agency that develops standards for public works professionals. It has provided these two standards to the infrastructure industry as non-proprietary, vendor independent specifications for the organization of data structures for engineering systems. The standards are examples of how existing information technology standards, relational databases and AutoCAD files can be used to organize engineering-related information effectively.

The new Municipal Infrastructure Data Standard

The Municipal Infrastructure Data Standard (MIDS) is an infrastructure management tool, which provides a framework for the digital storage and management of infrastructure-related data. It was developed by the Tri-Committee for the Utilization of Computers in Public Works, a non-profit corporation providing software and data standards to public works professionals. MIDS provides specifications by which a relational database management system (RDBMS) can be built and loaded with a municipality's infrastructure data.

For example, for municipal clients, our firm has connected infrastructure databases to AutoCAD, Microstation, GIS programs and a web server to provide users with "basic" data information retrieval. This type of system provides:

- analysis capabilities using GIS software, including routing analysis;
- hypertext links among MIDS data, which provides a simple, easy-to-search infrastructure data repository; and
- website software that provides a regulated change request process for altering MIDS data content. This creates a record of the request, an approval process, and an audit trail of the changes made and not made.

The overall goal is better data for future decisions. The technology provides a platform for improving the knowledge used to provide infrastructure services to communities.

A copy of the MIDS can be downloaded from www.ogra.org/mids/model.htm.

structure management should work. However, this may not be a "good," "realistic" or "desirable" vision to work toward. The client may also not have a firm understanding of the system's history.

Clients tend to focus on the "technology" as the broken part, believing that, if it is replaced, the problem will be solved. In reality, it may not be a "technology problem," but rather a problem related to the use of the technology (i.e. staff weren't trained to use the new system, the database wasn't set up properly, etc.). Rather than address an implementation problem, the client may believe that it's easier to buy a new technology solution.

The data fundamental to making infrastructure management work may not even exist. If it does exist, it may be too ill formed for successful deployment. This places a consultant in the unenviable position of being the bearer of bad tidings. What's the solution? As a rule, request a data audit in advance of project initiation, to avoid trying to make a silk purse out of a sow's ear.

Going beyond "expert" opinions

When tackling the problems described above, it helps to remember that delivering engineering services in today's knowledge-based "digital" age will require more than a traditional "expert" engineering opinion. The traditional approach of presenting conclusions based on field investigations, coupled with "expert" opinion, is insufficient for most engineering information consumers today. Decision makers want to hear a "business case" presented in a clear understandable fashion that supports a particular recommendation. Too often, recommendations are presented based on opinion or policy analysis, instead of actual data analysis.

Today, clients want to have a clear problem statement under investigation, coupled with a business case analysis for the conclusions being drawn and the recommendations provided. This is more than an option comparison analysis using standard economic approaches: It requires some value-based analysis of the problem statement itself. The prime directive for an engineer is "question the problem statement," then look for solutions.

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Consumers of engineering services want to take delivery of process enhancements, or reports that continue to provide analysis every time the report is run against a database of timely data. This is dynamic information instead of static information, which enables a client to access information about an ongoing project continuously. For example, a dynamic system might send an email warning of a change in some condition that is being monitored.

To provide recommendations for process changes, you will need to have a special relationship with a client based on trust. If organizational change or alterations in process activities are required to solve a given problem, these recommendations must be presented in a manner that can be implemented by an organization without facing undue hardship. This is especially true in unionized work environments.

A software vendor will recommend technology to solve a problem; an engineer will provide a solution that may involve technology, but will definitely be based on analysis of the problem.

The quest for standardization

When I started my engineering career, advanced analysis was most often done with a calculator that had formula functions (computers used punched cards then), and the only other equipment I needed were my eyes. Now my everyday activities require flowcharting software, some expertise in CAD software, geographic information system software, math software, programming in several languages, website management, database design and analysis, plus lugging an eight-pound portable computer around. Although I am a civil engineer, I need these tools to solve engineering problems for my clients.

It's clear that the way engineering work is done will continue to change, as information technology changes. Making these changes work better for engineers will not happen without our efforts.

It's necessary for engineers to add engineering knowledge and value to general information technology standards, which will make them useful for engineering purposes (see "Richmond Hill's engineering projects go digital," on p. 33). In other words, we need to create engineering information standards based on today's information technology standards. The challenge is for present and future engineers to leave a legacy of engineering documentation that builds on existing practices to provide a better methodology of delivering projects to clients. ◆

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