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Model predictions: GIS helps public works manage assets

*Apr. 17, 2013***David Totman** | *American City and County*

An increasing number of local governments have recognized the advantage of including geographic information system (GIS) technology in their predictive modeling processes. Departments such as city and county law enforcement have been quick to integrate GIS into predictive modeling to analyze the potential for criminal activity in a specified area.

Public works departments also are starting to use GIS to enhance their predictive modeling methodology, particularly for asset management and maintenance.

There are three primary components used in predictive modeling for asset management. GIS is the first. GIS maintains what the asset is and where it is located. The second is a work/asset management system, which records the asset's historic information: its composition, installation details, age, past repairs, costs, etc. The third is the predictive model itself, which uses the data from the first two components for calculation and analytical purposes, as well as the subsequent plotting of asset condition degradation curves. Those plots help decision makers visualize the condition of an asset so that they can

take remedial action if necessary.

Reducing life cycle costs with predictive models

Pierce County, Wash., was an early adopter of GIS and predictive modeling integration. With 1,700 square miles, 1,300 square miles of which are unincorporated, the county is a mix of urban and rural areas. The county's Public Works Road Operations Division (PWROD) oversees management and upkeep of a road network of approximately 1,600 miles, including the roads' pavement condition, billboards, medians, gates, and vegetation.

The department also maintains related roadway assets, which include network drainage structures such as catch basins, manholes, conveyance pipes, culverts, dry well systems, fish-bearing pathways, and open channels. "All these features are included in our asset management system, which is managed by ArcGIS," says Michael Isun, engineer technician for PWROD. "We use GIS throughout our entire operation, from data collection and asset management to maintaining our predictive models and developing our annual budgets." The asset management system provides managers and senior technical staff with access to all county infrastructure information. A huge benefit is that Maintenance and Operations Program managers can get a quick status review on the overall health of an asset and take action when necessary. Work orders can be adjusted to trigger a repair or replacement based on the department's predictive models.

For budgeting purposes, the asset management system also maintains cost-per-function (CPF) calculations. The CPF determines the total cost of labor, materials, and equipment needed to repair or replace a particular asset.

The department's predictive models are maintained by ArcGIS and include its rating assessment information (RAI), which stipulates federal and state levels of maintenance standards for public works assets. The RAI contains a comprehensive collection of specifications ranging from the amount of sediment allowed in a catch basin to the Americans with Disabilities Act regulations for curb ramp slope.

"Over the last several years, we have collected hard data that has allowed us to significantly improve our predictive maintenance and deterioration models," Isun says.

Using the predictive models helps with both the budgeting and prioritization of remedial

maintenance work, as well as the reduction in life cycle costs for Pierce County's road assets, because the models make it easier to identify assets that potentially need repair or replacement. Those costs include all expenditures from creation to replacement or disposal of an asset. Typically, life cycle costs include planning, design, construction and acquisition, operations, maintenance, renewal and rehabilitation, depreciation, financing and replacement or disposal.

Level of service established first

"Our predictive maintenance models are simple but effective," says Matt George, GIS programmer engineer at Pierce County. "We begin by establishing level of service [LOS] targets for all asset categories and subcategories. Then, using very detailed criteria, we conduct on-site condition assessments that capture defect severity/extent, relevant attribute information, and that identify a specific remedy action. This data is used to generate and prioritize maintenance and operational work orders and to measure whether or not we are keeping up with LOS goals."

Street sweeping, shoulder mowing, landscape maintenance, and similar activities were among the first assets Pierce County set up on predictive maintenance cycles. It began with those activities because the maintenance needs are largely driven by season and/or a prioritization criterion (for example, grass and weeds grow in the spring; high traffic roads need more sweeping than lower traffic roads, and so on). To qualify the effectiveness of those predictive models, maintenance staff captured a condition reading prior to completing the work to determine the model's accuracy.

For most other road assets (pavements, shoulders, sidewalks, storm drainage, walls, etc.), the county conducts on-site condition assessments on cycles specific to the performance trends of each. For assets with more dynamic performance trends, such as gravel shoulders, overhead vegetation, and storm drain features, the county performs annual condition assessments. For assets with more gradual degradation curves (pavements/sidewalks, retention walls, etc.), assessments are conducted on biannual or longer cycles.

"As we have established a depth of baseline data, we are now able to identify trends/patterns that support transition to predictive maintenance cycles for more of our asset categories, which allows us to reduce the need for resource-intensive on-site assessments," George says. "We believe that predictive maintenance usually is a more cost-

effective approach to road maintenance, but managers should regularly measure and qualify the effectiveness of these programs with site assessments and with respect to risk and liability."

Predictive models for pavement management

GIS can be used to help manage pavement assets in public works operations. Even though the asphalt vendor often provides pavement degradation curves and many pavement management contractors have special vehicles that can collect real-time diagnostic data while driving the roads, the data from the GIS and work management system can be used to manually populate a pavement condition index (PCI), from which the curves are plotted. The goal from any of those methods is to generate degradation curves that show the projected condition of a city or county's pavement over a specified period of time depending on the level of maintenance.

Because the frequency of road maintenance is determined by the amount of money a city or county is able to allocate, the public works department must decide whether to spend less money every few years to maintain its roads or wait longer between repairs and spend more money. Both scenarios can be graphed and compared on the asset condition degradation curve.

The same predictive modeling procedures and the resultant degradation curve can be applied to other public works assets. For example, a steel pipe buried in soil will eventually rust. so collecting information related to the pipe and its installation will provide the data necessary to develop the predictive model.

One important factor in determining how long a pipe will last is the way in which it was installed — was a pipe bursting method used or was a trench dug? If a trench was dug, was the backfill engineered with good gravel and tamped in or was the existing soil used for fill and just shoved back into the trench? Is the surrounding soil filled with minerals and therefore potentially corrosive? If it was not properly installed, a pipe could possibly bend, crack, or weaken, and that would reduce its life span.

Another factor in predicting the eventual failure of a pipe is the crew that did the installation. Sometimes, premature construction failure across a city can be traced to a single crew. That could be a matter of improper training or poor inspection procedures

leading to installation problems. In addition to construction materials, installation procedures, and repair history, the work management system can also store information about the crew that installed the asset.

Maintaining public infrastructure is an ongoing process that requires both short- and long-term planning and appropriate budgets. Together, the GIS, asset management system, and predictive models provide an accurate snapshot of the condition of the entire infrastructure of a city or county at any specified time, which is a key factor in the planning and budgetary processes and in many cases can help reduce costs.

Even failure of an asset is a data point. As a result, every water main break, every pavement analysis, every electric conductor outage is an opportunity to collect data about why it failed, which allows the continued refinement of the predictive model, increasing both its accuracy and usability.

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