Checking priorities

Colo. city tests optimized snowplow routing solution

When it comes to snowplowing operations, most public-works agencies historically have applied an ad-hoc approach, defined by geography and relying on individual drivers to navigate through a route based on the driver's perception of efficiency.

In 2012, the city of Centennial, Colo., and CH2M Hill became among the first in the U.S. to use optimized snowplow routing solutions to enhance transportation efficiencies. The results have been nothing short of phenomenal, resulting in a reduction of plowing time of up to 40%.

Centennial, with a population of approximately 103,000, and CH2M Hill, a Colorado-based consulting, design, design-build, operations, and program-management firm, have been engaged in a public-private partnership for public-works services, including snow-removal operations, for the past four years. It is believed to be the largest partnership of its kind in the U.S. The optimized routing project is among several innovations that

CH2M Hill has introduced to improve the overall efficiency in delivering public-works services while providing substantial savings to the city.

The goal of efficiently moving people and products through a defined network of streets has been an engineering problem going back centuries. The challenge has been to move resources efficiently through a transportation network without redundancy and duplication of effort. Transportation networks, regardless of their design, have a multiplicity of options for vehicle navigation through the network. The permutations for routing become exponentially exacerbated when one adds multiple resources and hierarchical routing.

10 for 10

Combinatorial routing problems were first represented by the Konigsberg Bridge Problem. Leonhard Euler solved this problem with the development of graph theory, which became the linchpin of modern capacitated arc routing problem solutions. The engineering problem associated with snowplow routing is the Chinese Postman Problem, an arc routing problem that seeks the shortest route along a network of roads where each road is covered only once. The Chinese Postman Problem has been adapted for a variety of transportation-related problems, including snow-removal operations. The research and application of arc routing problem solutions to snowplow operations has been focused in Europe, Canada, China and Japan

The snowplow route system for Centennial assigned 10 trucks to 10 routes. The routes are divided into Priority One (arterial roads) and Priority Two (collector roads) routes. The initial research into optimizing the routes involved evaluating existing routes and allocation of resources. A histogram was created that showed the allocation of Priority One and Priority Two routes for each plow truck. The result was very unbalanced. Some trucks had 30 miles of total road and others had more than 60 miles. Additionally, the Priority One and Priority Two routes were unbalanced between the trucks. The result of this misallocation of resources between the plow trucks was ad-hoc redistribution of resources by operators and supervisors during a snow event.

CH2M Hill engaged C2Logix Inc. to apply mathematical algorithms for route optimization. The process for optimizing the routes is highly iterative. The software defines the shortest distance through the network with the number of resources allocated to the effort.

The Centennial project defined 10 trucks to cover the network for snow-removal operations. One of the challenges with snowplow operations has been hierarchical routing. Priority One routes are better served with echelon-plowing techniques, which manages snow removal by placing trucks in sequence on the route.

The routes were optimized by equalizing the amount of Priority One and Priority Two routes for all 10 trucks. The process involved two distinct networks. Priority One routes were divided into five routes with two trucks each for echelon plowing. Priority Two routes were divided into 10 routes with one truck per route.

The Priority One network was serviced first, and the trucks broke apart and plowed the Priority Two networks independently. The process optimized the path through the network based on elapsed time to complete the route. The software developed an average time for the five teams to complete the Priority One network. Each team was evaluated for time, and routes were adjusted to bring each team as close as possible to the average elapsed time for the group. The balancing of the routes is more art than science, and a skilled specialist reviews the routes for the best spatial fit in the overall network. The same process was engaged for the Priority Two network with 10 single trucks instead of five teams. The routes were continually modeled and refined until all were balanced and optimized.

Technical development of the routes is the preliminary work for route optimization. The heart of organizational performance is leading people effectively through process change. CH2M Hill engaged the people who manage the drivers as well as the drivers themselves in the final development of the routes. After the routes were created, supervisors drove them and brought back their comments. The route edits were applied to the software, and the routes were modeled and balanced again. The next level of review was with the drivers. Drivers were asked to drive the new routes and offer their comments for improvement. CH2M Hill included as many driver comments as possible and reconfigured the routes again. Inclusion of supervisors and drivers was critical both to the overall performance of the routes and organizational buy-in.

An additional innovation was the use of guided driver devices to map and direct the drivers through the new routes. CH2M Hill engineers programmed the routes with software designed for route development for guided driver devices. The entire route system was transferred to guided driver devices.

Drivers selected their route from a menu and the devices directed them to the route and initiated the route sequencing. This enhancement allowed drivers to focus on snowplowing operations and also assisted them in maintaining route orientation during night driving and heavy snowfall scenarios. Relief

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drivers were able to perform at the same level as experienced drivers because route memorization and familiarity were no longer a requirement for success. The drivers maintained the optimized snowplow routing solution with the aid of the Garmin devices.

Plowing right through

The increase in efficiency was tremendous. The city of Centennial uses automatic vehicle location/global positioning system (AVL/GPS) to track and monitor performance of plowing operations. The time for completing snowplow routes is recorded for each storm with AVL/GPS. The time for completing the Priority One and Priority Two system, under the traditional operating philosophy, during a 12-in. snow event on Dec. 21, 2011, was eight hours. The time under the optimized snowplow route methodology during a 15-in. snow event on Feb. 2, 2012, was 5.5 hours. A 4-in. snow event was managed in 4.5 hours on Feb. 23, 2012. Snowplowing operations experienced an increase in efficiency of 28% on the first implementation and more than 40% on smaller events.

Route optimization has transferable benefits to other public-works operations. In Eldorado, N.M., a CH2M Hill water and sanitation project has utilized route optimization for meter reading. Savings were even greater than the snow-route optimization. The process for developing the routes was very similar and involved engaging staff and routing specialists to create a collaborative approach. The final product produced the following savings:

- Reduced miles driven by 48%, or an average of 3,873 miles per year;
- Decreased fuel costs by an estimated 66%;
- Cut labor hours by nearly 50%;
- Lowered CO_2 emissions by 48%, or 2.2 metric tons; and
- Cut the read cycle by one day.

In summary, route optimization produced a high rate of return on investment. Savings were immediate and sustained. Operational efficiencies can be used to reduce resource requirement or increase service delivery. Many organizations use the increased resource capacity to attack maintenance backlogs that have grown from previous reductions in force or budget. An additional benefit is the collaboration of all members of the work force to propel the organization forward and achieve a collective solution. **R&B**

Information for this article provided by CH2M Hill.

For more information about this topic, check out the Maintenance Channel at www.roadsbridges.com.