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MIDWEST TRANSPORTATION CONSORTIUM

IOWA STATE UNIVERSITY

RESEARCH PROJECT TITLE
Web-based Implementation of a Winter Maintenance Decision Support System Using GIS and Remote Sensing

FINAL REPORT DATE
May 2005

SPONSOR
Research and Special Programs Administration, U.S. Department of Transportation (MTC Project 2003-05)

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KEY WORDS
remote sensing—geographic information systems—expert system—snowplow—decision support system—snow—winter maintenance

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Web-based Winter Maintenance Decision Support System

tech transfer summary

Objectives

- Integrate geo-spatial analytical techniques, existing snow removal asset management systems (SRAMS), and web-based spatial decision support systems to implement a web-based winter maintenance decision support system (WMDSS) to help stakeholders optimize snow removal assets
- Allow transportation personnel to (1) access and visualize Iowa DOT geographical information system (GIS) inventory data for their locality in a web-based GIS environment; (2) view remote sensing data and extract up-to-date transportation infrastructure data; (3) use web-based GIS tools to manage, analyze, and edit infrastructure data, including both spatial editing and attribute editing; (4) use such data, edited to support local use, in existing SRAMS.

Problem Statement

Adequate snow and ice control is critical to traffic safety, maintaining city commerce, and allowing residents access to schools and medical facilities. Currently, most methods of snow removal management are manual, from choosing routes and assigning vehicles and personnel to determining the materials and amounts for each route. Various factors, such as the lead time for inventory orders, the reorder point, and stock levels, must also be monitored to keep the necessary snow removal materials in stock. Existing methods are often based on a set of static rules that are costly and inefficient for snow plowing and resource allocation during constantly changing winter weather conditions. The small margin of error during heavy storms and the lengthy reaction time of human-based methods can prove hazardous.

Existing snow removal methods do not provide visual feedback about routing and resource allocation. Visual feedback would not only help optimize current assignments, but also allow a review of the allocations for better planning in the future. Also, existing methods do not use integrated weather information to alert snow removal crews and provide scenario-based decision support. Researchers have explored using geospatial technologies, such as GIS and decision science and support tools, to plan snow removal operations. However, while most of these winter maintenance tools can address many information needs, these tools are seldom placed in the hands of interested stakeholders. Most tools are not constructed with a nontechnical user in mind and lack an easily understood interface. The unavailability of suitable data sets and inefficient methods technology transfer methods also hinder such tools.

Research Description

This project integrated geospatial analytical techniques (GIS and remote sensing), existing SRAMS, and spatial decision support systems to implement a web-based WMDSS that enhances the capacity of stakeholders to

Continued on next page

Research Description continued

evaluate and manage snow removal assets optimally. To extract up-to-date road infrastructures, hyperspectral data were gathered from the high-resolution Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and classified with the Spectral Angle Mapper (SAM), Mixture-tuned Matched Filtering (MTMF) and Mixture-Tuned Matched Filtering combined with Classification and Regression Tree (MTMF-CART).

The web-based WMDSS was then designed by integrating the ArcIMS ActiveX Connector with ArcIMS RouteServer Extension and web technologies such as ASP, XML, RSS, etc. The WMDSS used the gathered infrastructural data to provide intelligent expert decision support for prioritized route creation, inventory management, resource allocation, and a provision for embedded weather information. The developed system not only manages and allocates resources, but also provides expert advice to assist complex decision making such as routing, optimal resource allocation, and live weather information monitoring. See Figure 1.

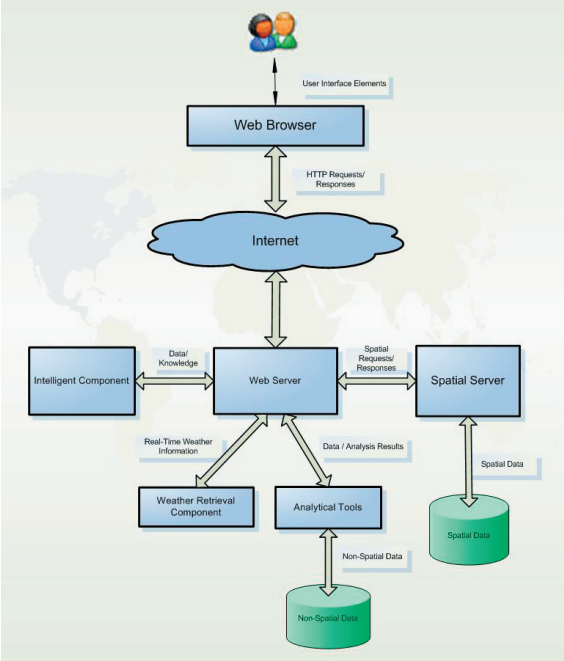

Figure 1. WMDSS architecture

Key Findings

- With an uncluttered, menu-driven interface divided neatly into areas, WMDSS can help nontechnical users manage and assign snow removal resources.
- Live or forecasted weather information from a weather feed webpage, and stored weather conditions, can suggest material assignments, determine resource allocation, generate alerts, and develop scenario-based solutions.
- Existing snowplowing routes can be viewed, or expert knowledge in the form of embedded business rules can help create new routes by estimating plowing time and the number of runs necessary to clear a roadway
- Depending on priority and total snowplow time for each route, vehicles can be assigned to snowplow the routes.
- Encoded expert knowledge and system-based weather conditions help users assign and analyze inventory.
- Users can assign drivers to routes and vehicles based on driver experience and vehicle operation costs.
- Users can view all current assignments in one screen, including current vehicle and driver assignments, weather conditions, and material estimates. See Figure 2.
- A detailed help system, assists users with all the possible actions that can be performed (e.g., creating routes and assigning vehicles).

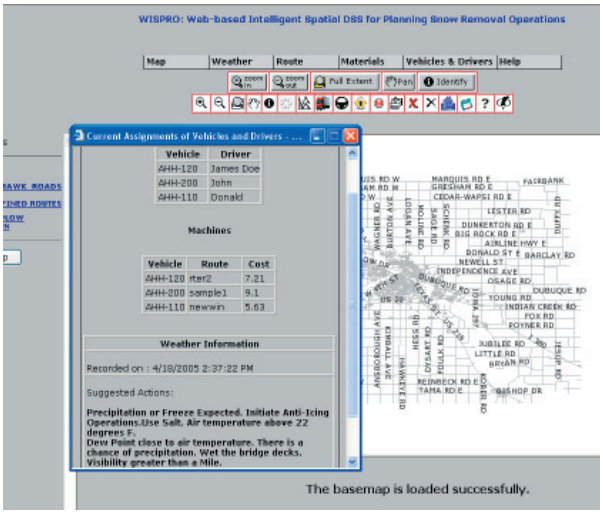

Figure 2. Summary of assignments in the WMDSS interface

Implementation Benefits

An accessible and available web-based WMDSS enhances the capacity of city/county planners, resource managers, transportation personnel, and policy makers to evaluate different procedures for optimally managing snow removal assets.

Implementation Readiness

The technology from this project was transferred to the end user in different ways. The project's results were widely published in refereed journals and conference proceedings and presented in workshops and conferences. A detailed tutorial has also been made available. In addition, a hands-on workshop was given that showcased WMDSS for end users. The project team will continue to transfer the technology through distributing user manuals, meeting with end users and other winter maintenance personnel, and developing an educational interactive website.