AUGUST 1997

CTRE

en route

"CHANGE IS THE ONLY CONSTANT"

CTRE en Route highlights transportation research, education, and outreach at the Center for Transportation Research and Education at Iowa State University. It is published on line at http://www.ctre.iastate.edu/

DIVISION HIGHLIGHTS: ADVANCED TRANSPORTATION TECHNOLOGIES

SNOW PLOWING GOES HIGH TECH

Public partners: Federal Highway Administration, Iowa Department of Transportation, Michigan Department of Transportation, Minnesota Department of Transportation, and the Center for Transportation Research and Education (CTRE) at Iowa State University

Private partners: Bristol Company, Fosseen Manufacturing, Global Sensor Systems, Monroe Truck Equipment, Norsmeter Company, O'Halloran International Inc., Roadware Corporation, Rockwell International, Sprague Company, Tri-State Signing, and Tyler Ice

Snow Plow: Background

For highway agencies in the Snowbelt, the special problems posed by snow- and ice-covered roadways make it especially difficult to satisfy the public's demand for uninterrupted mobility. And tight staffing budgets sometimes mean that lone equipment operators are single-handedly driving the snow plow truck and managing its ancillary equipment. Operators and highway agencies are always looking for ways to modify the snow plow truck to make it more efficient, safer, and easier to operate.

Together with university and private sector partners, three Snowbelt state departments of transportation—in Iowa, Michigan, and Minnesota—have embarked on a project to design, assemble, and test an advanced-technology vehicle for winter highway maintenance. CTRE at Iowa State University is the project manager. Eleven private vendors from Canada, Norway, and the United States provided technologies for a prototype truck for each participating state. The prototypes have been assembled and will be tested in the three states during the 1997–98 winter.

Snow Plow: Special Technologies

For the prototype vehicles, each of the three DOTs provided a new, 25-ton snow plow truck equipped with underbody blade, front and wing plows, spreader box for salt/sand, and state-of-the-art material application systems. The application systems differ from truck to truck, according to the preferences of each state DOT. Minnesota's truck has a slip-in, removable Tyler V-Blend salt/sand V-box inside the dump body. A divided spreader box allows operators to distribute any desired ratio of the two materials. The systems are controlled by the operator in the cab with a Tyler Quantum Control. Michigan's truck employs a Monroe Duz More chassis-mounted V-box and permanent liquid tank. The anti-icing and prewetting systems are run from the cab by a Raven controller. Iowa's truck has a slip-in, single-skid-mounted liquid tank/Monroe Brute MSV heavy-duty V-box spreader inside the dump box. The anti-icing and prewetting systems automatically reduce the amount of dry material when liquid operations commence. The operator uses a SYN/CON controller, provided by Bristol Company, in Iowa's cab.

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INSIDE

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IOWA STATE UNIVERSITY

"At a later phase in the project, an automated system will be added to the vehicle to adjust material application levels based on pavement friction and temperature and other data."

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After configuring the basic vehicle components, the project team added special technologies to increase each truck's performance. The technologies selected for the prototype vehicles during the first phase were primarily those that meet high-priority needs identified by truck end-users and that can be obtained, basically "off the shelf," through participating vendor partners.

- **On-board computer.** Rockwell International's PlowMaster was installed in the cab. The PlowMaster stores data collected by various components of the vehicle on a standard PCMCIA card. These data (surface temperature, material distribution, roadway surface friction, and engine status) are immediately available to the truck operator via a display in the cab. The PCMCIA card can be removed from the PlowMaster to transfer data to a personal computer, or the base station (e.g., the state DOT) can download the data via the base station's radio system.
- **Friction meter.** The Norsemeter uses an automobile tire to measure the friction of the road surface. The tire is automatically skidded on the roadway surface at timed intervals (and at the operator's discretion), and a friction value is recorded by the Norsemeter. The meter can record values at tire "slippage"—or, to save wear on the tire so it lasts longer, at 80 percent of slippage—and sends the friction data to the PlowMaster. The operator can then adjust the amount and kind of deicing material being applied to the roadway based on actual measurements of friction rather than on guesswork. (At a later phase in the project, an automated system will be added to the vehicle to adjust material application levels based on pavement friction and temperature and other data.)
- **Temperature sensors.** A Sprague RoadWatch Warning System monitors the temperature of the pavement surface and the air. Infrared sensors mounted on the driver's side-view mirror collect temperature data and transmit them to the PlowMaster and the cab display. Carefully monitoring the pavement temperature helps operators decide when to employ anti-icing techniques. If anti-icing materials are applied too soon (when the pavement is still far above freezing), they are wasted. If materials are applied too late (after the pavement has reached freezing), snow and ice will already have begun accumulating on the roadway and the operator will need to switch to deicing strategies. But, as Strategic Highway Research Program tests have demonstrated, anti-icing materials applied just as the pavement surface temperature reaches freezing can often help keep a roadway clean, relatively dry, and safe using less material than do traditional deicing techniques.
- **On-board global positioning systems (GPS) receiver.** A Rockwell International GPS receiver is mounted above the cab. As the truck moves down the highway, the receiver records the vehicle's location every five seconds and sends the data to the PlowMaster. The truck operator can also trigger the receiver to collect position information (time and location) for landmarks like crossroads and for emergencies like stranded vehicles or accidents.

During the 1997–98 winter tests, these technologies will relay friction, temperature, and position data to the truck operator, via the on-board computer, and to the operator's base station. This real-time information will take much of the guesswork out of operators' road maintenance decisions and will help agencies respond

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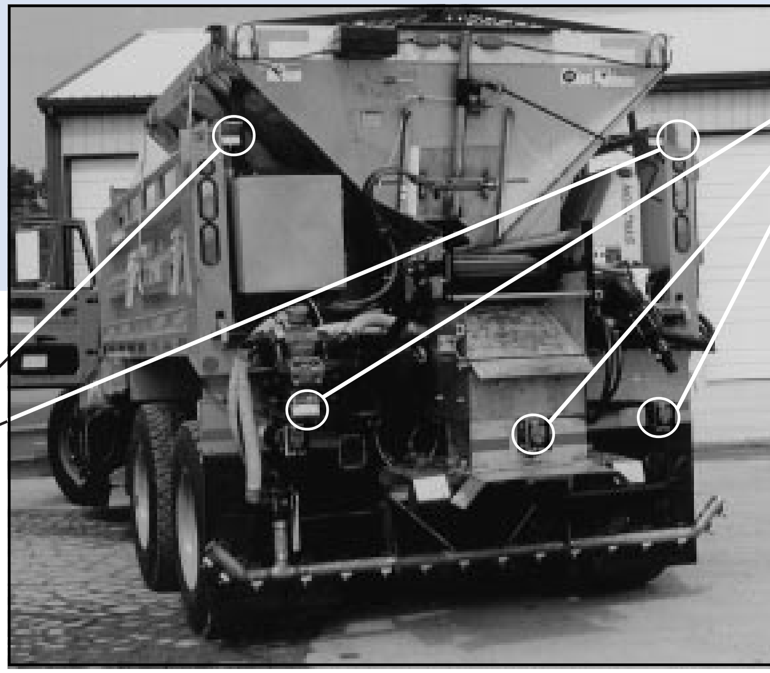
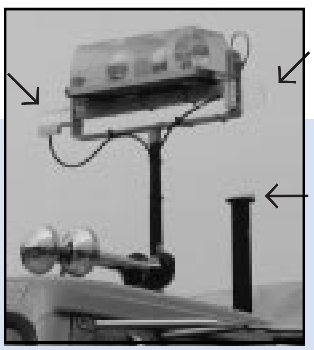
high-intensity warning lights:
Tri-State Signing
New Hampton, Iowa



reverse obstacle sensors:
Global Sensor Systems
Ontario, Canada

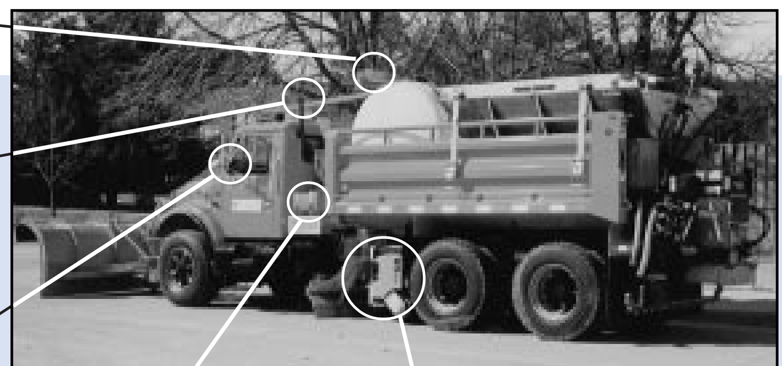
Iowa's prototype truck

O'Halloran International Inc., Des Moines, Iowa (truck vendor); Bristol Company, Broomfield, Colorado (material applicator)



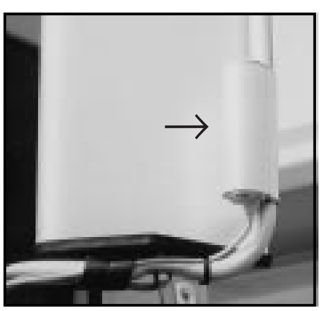
high-intensity warning lights:
Tri-State Signing
New Hamption, Iowa

global positioning system:
Rockwell International
Cedar Rapids, Iowa

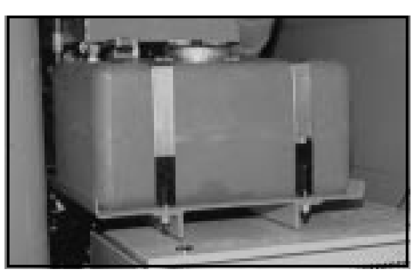


pavement friction measuring device:
Roadware Corporation
Ontario Canada
and
Norsemeter Company
Rud, Norway

air/pavement temperature sensor:
Sprague Company
Canby, Oregon



engine power booster, alternative tank:
Fosseen Manufacturing
Radcliffe, Iowa



SNOW PLOW . . . FROM PAGE 4

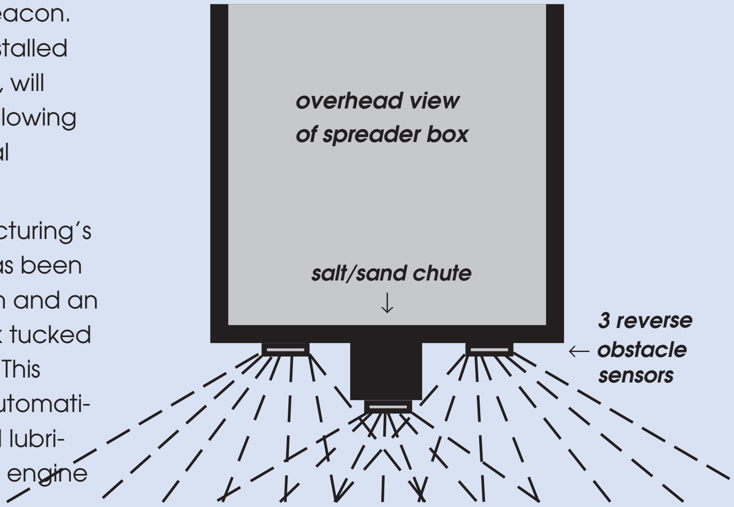
quickly to stranded vehicles and other emergencies. The on-board display is currently being designed to be tested in each of the three prototype vehicles. The goal is for the hard data to be translated and displayed in terms that are immediately meaningful to the operator.

In later phases of the project the on-board computer will automatically and continually fine-tune the truck's application of sand, salt brine, and chemicals according to current road conditions. Eventually, the real-time road condition data (friction, temperature) may also be made available to the public so travelers can make informed decisions about changing routes or postponing trips.

"Heavy, slow-moving snow plow trucks themselves can present a hazard to motorists in a snowstorm, but each prototype truck is specially equipped to reduce the danger."

High-tech safety features were also added to the prototype vehicles. Heavy, slow-moving snow plow trucks themselves can present a hazard to motorists in a snowstorm, but each prototype truck is specially equipped to reduce the danger.

- **High intensity, fiber optic warning lights** by Federal Signal. A single light motor mounted in the cab distributes light signals through fiber optic cables to the external lens, originating four solid or flashing warning lights to supplement the existing strobes and revolving beacon. Light from the fiber optic lens, installed on and above the cab and box, will penetrate greater distances in blowing snow and fog than will traditional warning lights.
- **Power booster.** Fosseen Manufacturing's Hydrofire fuel injection system has been incorporated into the fuel system and an eight-gallon alternative fuel tank tucked into free space behind the cab. This unique engine power booster automatically introduces a water/alcohol lubricant blend fuel additive into the engine injectors for extra horsepower when needed. For example, the booster will help the truck accelerate quickly when entering traffic, reducing the need for motorists to brake on slippery roads.
- **Reverse sensors.** Global Sensor Systems Inc.'s Search-Eye sensor system detects the presence of objects behind the vehicle. If an object is detected while the vehicle is in reverse, the system automatically applies the brakes to avoid collisions with objects in the operator's blind spots or that are obscured by snow. The Search-Eye system consists of three sensors mounted at different locations along the rear of the vehicle and wired to the braking system. Three sensors are necessary to compensate for the salt/sand chute's interference with each sensor's cone of vision. Without the additional input from other sensors, the system would see the chute as an separate object and would apply the brakes every time the operator tried to back up. (See the overhead representation of the three cones of vision, adjusted to miss the chute, below.)



Snow Plow: Design Process

A unique aspect of this project has been the active involvement of the eventual vehicle "consumers" in the vehicle's design—a bottom-up approach. At five focus group meetings in the three states, snow plow operators, mechanics, and highway maintenance supervisors—the vehicle end users—identified approximately 600 features they would like in the ideal snow plow truck. Participants were encouraged to dream, and their wishes ranged from hovercraft units that don't touch the roadway, to systems for monitoring operators' vital signs, to automatic washing systems to prevent vehicle corrosion.

The features identified at the five meetings were later incorporated into a database and categorized (administrative, pre-operative, post-operative, and at-rest features; features pertaining to infrastructure and roadway systems). Similar features were combined, leaving a total of 183 desired features that, prioritized, would serve as the basis for the prototype vehicle requirements.

Snow Plow: Private Sector Partners

Another critical aspect of this project was the involvement of vendors from the private sector. The contributions of vendors not only made the prototype vehicles possible but also opened avenues for eventual private production of additional vehicles.

To solicit the involvement of private enterprise, the Iowa, Michigan, and Minnesota DOTs developed a list of technology vendors in their states that might be interested in the project, and the ITS America membership directory was culled for additional prospects. Over 200 potential partners, including maintenance engineers and research engineers from all the Snowbelt state DOTs, were invited to a workshop in which the project was introduced, progress to date described, and commitments of technology, equipment, vehicle assembly, staff time, and/or funds solicited.

Of the 49 people who attended the workshop, held in Detroit in April 1996, 10 vendors initially committed to the project (additional vendors have since asked to participate). These vendors agreed to supply off-the-shelf technology that could be used on the prototype vehicles. Some vendors of unique technologies agreed to supply products for all three prototype trucks. (See the photos on page 5 for a complete list of participating vendors.)

In July 1996 the vendor partners met in St. Paul with the three participating DOTs to set up a team for each state, prioritize the list of desired truck features, develop a list of specifications, and establish development schedules and budgets.

Snow Plow: What's Next

The prototype vehicles were ready for some initial testing and evaluation in late winter 1996–97. Summer 1997 activities involve incorporating new or improved versions of technologies, testing the functionality of the vehicles in non-winter roadway maintenance activities (edge rutting, pavement patching, etc.), soliciting additional information from vendors, and evaluating the appropriateness of the technologies. A plan is being developed for correlating data from the prototype vehicles with the transportation management systems of the three participating state DOTs.

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"Ten vendors initially committed to the project, and others have since asked to participate."

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The bottom-up design approach is being supplemented by top-down consideration from DOT management personnel. In subsequent phases of the project they will consider how state DOTs can use data provided by the prototype vehicles in maintenance management systems and what the data architecture should be to ensure compatibility with DOT systems. They will also determine the logical data transfer points from the vehicles to the DOTs' business processes.

During the winter of 1997–98 the prototype vehicles (with some modifications) will be thoroughly tested and evaluated in snow and ice conditions. Some of the new technologies have never been subjected to the harsh environment of snow and ice removal. One goal of the prototypes is to identify technology or equipment failures caused by the environment and make modifications to ensure future reliability. The research team will document the validity and repeatability of the data captured by the moving vehicle. Vehicle operators will be surveyed in simple telephone interviews to discover "Did the enhancements on this vehicle make a difference in your job assignment?" A report covering the testing and evaluation of the prototype vehicles will be issued in 1998.

In the final phase of the project the project team proposes to develop a fleet of 10 vehicles in each of the three states to be tested and evaluated.

Snow Plow: Bottom Line

The initial literature review and design phase of the project was funded by the three state DOTs, and the project partners are securing funds for the second phase of the project: modifying, testing, and evaluating the prototype vehicles. A lump sum has been secured from the Federal Highway Administration's regional and national Priority Technology Program; the balance will be covered under a pooled-fund study. Invitations to participate in the pooled-fund study will be sent to all Snowbelt state DOTs this summer. Funding for the final phase, assembling and testing a small fleet in the three partner states, will depend on the evaluations of the prototype vehicles.

It would be prohibitively expensive for most highway agencies to duplicate the prototype vehicles. But the partners believe that by developing, testing, and modifying enhanced winter maintenance vehicles, they are leading the way for private industry to produce them at competitive prices. end

Many project partners gathered at the Iowa DOT in May 1997 for a news conference to introduce the prototype vehicle to the public (from left):
Wilfrid Nixon, University of Northern Iowa
John Whitnell, O'Halloran International
Greg Tomsic, Rockwell International
Tom Maze, CTRE
Bob Kayser, O'Halloran International
Craig Cole, Rockwell International
Dave Stone and Duane Fosseen, Fosseen Manufacturing
Jim O'Halloran, O'Halloran International
Leland Smithson, Iowa DOT
Tim Simodynes, CTRE