




Dream Snowplow Takes Shape

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The voice of the customer can get muffled by stacks of technical reports, cost-effectiveness studies, and airtight contracts. So in October 1995, when a consortium from three progressive Snow Belt states set out to develop a new generation of winter maintenance vehicles, they put the paperwork aside and listened.

They listened to a plow truck driver still shaken by a crash with a motorist.

They listened to a manager charged with reducing salt use while accommodating more and more commuters.

They listened to a state trooper who had watched helplessly as an accident victim was hit more than once on an icy road because there was no way to quickly improve traction at the crash site.

Project Overview

Listening sessions were an integral part of a consortium project to put state-of-the-art technology to work in meeting the challenges faced by highway agencies responsible for combating snow and ice: to simultaneously increase productivity, safety, quality, and environmental sensitivity. The consortium includes representatives of the transportation departments of Iowa, Michigan, and Minnesota (with Iowa taking the lead role); the Center for Transportation Research and Education (CTRE) at Iowa State University; and private vendors. Multistate involvement, says Lee Smithson, deputy director of the Iowa DOT's Maintenance Division, is a big plus on a project of this size. "In this way, the states can share the costs and especially the expertise," he points out. "We're amazed at the things the other states come up with, and they're amazed at the things we come up with."

The members ultimately formulated a direct, three-phase plan for the project:

■ Phase 1—Listen to what the key players (including vendors) have to say about challenges

and solutions, and develop prototype requirements accordingly.

■ Phase 2—Build and evaluate one prototype vehicle in each state.

■ Phase 3—Using the evaluation results, modify the design, and build fleets of 10 vehicles in each state for further evaluation. Full production could follow.

Early in 1997, the prototypes rolled out of the fabricators' shops just in time for the season's last snowstorms, equipped much as the key players had envisioned. The basic trucks were standard issue. Even the technology was off the shelf, having been developed for other uses. However, the new vehicle brought the various components together for the first time for snow and ice control.

The project partners shared the costs, with the DOTs providing the trucks out of their regular fleet orders and fabricators already under state contracts providing the integration and assembly. Each state worked with a separate team of equipment vendors that donated the add-on advanced technology. If only one vendor supplied a particular product, that vendor donated one unit to each state.

Development of Requirements

During Phase 1, listening to plow drivers in focus groups (two in Iowa, two in Minnesota, and one in Michigan) helped the project steering committee understand the most pressing vehicle requirements. Duane Smith, CTRE's principal investigator for the project, says they expect fewer-than-normal engineering and manufacturing changes in the final production phase thanks to this direct input from the vehicle users.

In the focus groups, the facilitators encouraged innovative solutions. Notes Smith, "The facilitators didn't want to hear, 'We want heads-up displays in the cabs.' They wanted to hear, 'We need to know the ground speed without taking our eyes

off the road.' All we know is what we've used or heard about. This method allowed us to expand our horizons."

Among all five focus groups, a list of about 650 desirable features was compiled. That list included on-board access to weather forecasts, fewer hand-operated controls, the ability to carry multiple types of materials, adequate horsepower, a backing sensor, and means of making the vehicle more visible to the public. With this list in hand, the steering committee then heard the vendor perspective during workshops conducted in Detroit (April 1996) and St. Paul (July 1996). What available technology would meet the users' stated needs? What stumbling blocks existed? Were vendors willing to make a financial commitment to the project?

One by one the vendors discussed the desired features. In general, they appreciated the chance to hear what the end users of their products had to say about the ideal winter maintenance vehicle. And by the end of the last workshop, 14 private firms had the confidence, enthusiasm, and resources to support the project both conceptually and financially.

Prototype Snowplow

Vendor interest in providing a particular feature was a major factor in choosing which capabilities to include in the prototype snowplow. The vendors also attempted to strike a balance between those features that are mostly management tools (such as mobile pavement temperature sensing) and those that would make the operator's job easier (such as an engine power booster). Other considerations were whether the technology was fully developed and whether a need had been established for the capability to provide a certain type of data. A detailed display of the Iowa prototype and its various components is provided on the following pages.

A number of features considered for the prototype were deferred for use in the fleet vehicles or the full-production vehicles, or possibly for future use. Among the features planned for inclusion on fleet production units are the following:

- Material distribution rate display
- Chemical sensor to trace what is on the road
- Differential GPS for more accurate location information
- Real-time transmission to the shop, via cell phone, of data such as pavement temperature and

friction information (currently displayed in the cab and recorded for transfer to the shop computer)

Planned for use in the final production phase is transmission of data to the shop via digital radio, using the existing DOT infrastructure.

Anticipated for the future are the following:

- Heads-up displays (to be considered when the cost is lower)
- Automated underbody plow operation (to be considered when the technology is fully developed)
- Voice-activated controls (to be considered when refined sufficiently, for example, to correctly interpret background noise)

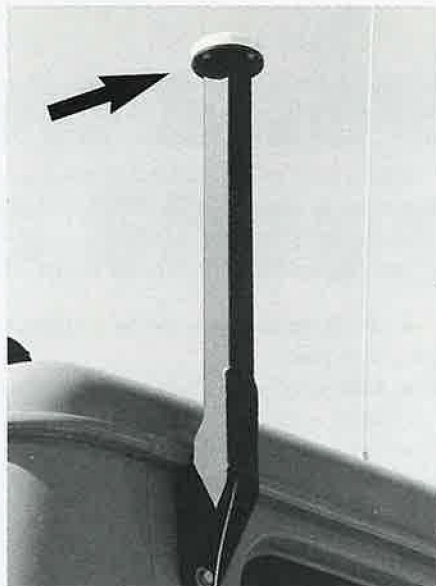
Evaluation Process

Evaluation will take place in two phases: testing of the individual prototype vehicles and testing of the entire fleets as they function as a group. Objective tests will establish the validity of the data and the reliability of the equipment, as well as whether the winter conditions are a factor in performance. Subjective data in the form of operator feedback are also being collected. After each storm, a telephone interview is conducted with the vehicle operators. To minimize the burden on the operators, they are asked six standard questions designed to quickly elicit the most relevant information:

- Which element of the new technology worked the best?
- Which element of the new technology worked the worst? Did this relatively poor performance have any negative impact on the operation of other vehicle components?
- Was the Plowmaster display easy to read while you were driving?
- How did the added technology on the prototype vehicle affect your comfort and attention to the road as compared with conventional maintenance trucks? (Was the added technology a detriment or enhancement to the attention you could give the road?)
- Did you have any other problems while driving the truck?
- What suggestions for improvement do you have?

Comments received to date indicate that the operators like the variable-speed material applicators and the user-friendliness of the Plowmaster computer. A number of challenges were presented

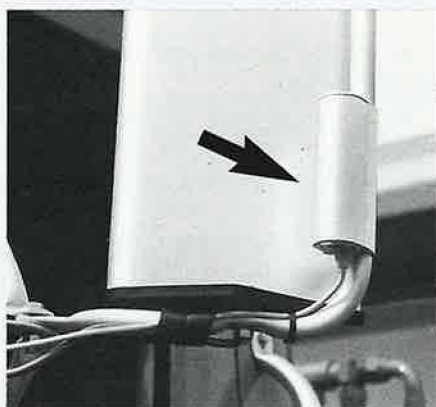
Global Positioning System antenna (Rockwell International, Cedar Rapids, Iowa) was provided for all three prototype vehicles. By fleet production time, it will be possible to send data from sensors and equipment, including vehicle location, to the shop in real time every 5 seconds.



Data recording readout inside the cab (Plowmaster, Rockwell International, Cedar Rapids, Iowa) was provided for all three prototype vehicles. The system records data from sensors, which are transferred to a personal computer at the shop for later analysis.



Air/pavement temperature sensor system (Roadwatch system, Sprague Company, Canby, Oregon) is used to transmit air and pavement temperatures from infrared sensors to the snowplow cab (and, by fleet production time, in real time to the shop). Combining these data with GPS tracking data (creating a "thermal trace") makes it possible to fine-tune chemical use because it allows more accurate prediction of both the time at which the pavement temperature will drop below freezing and the time at which the pavement temperature will reach its lowest point.



In addition, notes Lee Smithson, these data could have other applications. "A television station preparing a 6 a.m. newscast could someday go to the Internet and find out that the DOT has had 34 trucks out since 2 a.m., and the temperature is dropping rapidly enough that the pavement could be slippery by commute time. Instead of trying to get a busy garage supervisor on the phone, the station could just query the database and receive the current information."

GENERAL DESCRIPTION OF

The basic truck is an IH 4900 Series, 50,000-lb gross vehicle weight rating (GVWR), with tandem axles, dump body, and front-wing and underbody plows from O'Halloran International, Inc., in Des Moines. Installation of plows, sander, and controls was performed by Monroe Truck Equipment,



Power booster (Fosseen Manufacturing, Radcliffe, Iowa) automatically injects an ethanol fuel additive whenever the engine needs more power. A control box mounted in the cab allows the driver to adjust the demand level at which the system engages, such as plowing uphill or moving into freeway traffic. More fuel-efficient than full-time use of a more powerful engine, the power booster, first developed for transit buses, can increase horsepower by 20 percent.

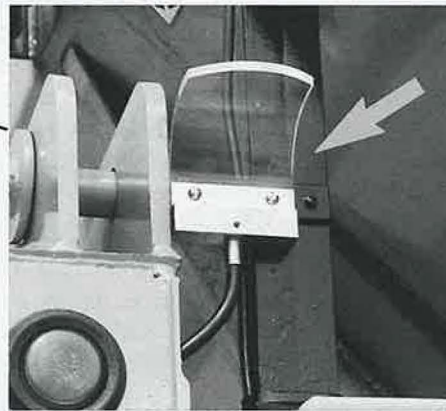
IOWA PROTOTYPE SNOWPLOW

Monroe, Wisconsin. Data from sensors and equipment (for example, vehicle location, air and pavement temperature, and pavement friction) are displayed in the cab, are recorded digitally, and by fleet production time will be sent to the shop in real time.



Slide-in V-box (Monroe Trucking Equipment, Monroe, Wisconsin) allows dry material to slide out better than with a tailgate spreader/dump box. This mechanism also eliminates the problem of upraised dump boxes not fitting under bridges, street lights, and so on. The dry material hauling capability is 5 cubic yards.

Anti-icing and prewetting equipment (Bristol Company, Bloomfield, Colorado, and Monroe Truck Equipment, Monroe, Wisconsin) is removable so the vehicle can be used as a dump truck when not needed for snow and ice control. The system allows application of brine or other liquids and stores up to six settings for liquid/dry material combinations. (The equipment is linked to a ground speed sensor; a faster truck speed triggers a faster flow rate.) Large-capacity tanks (900 gallons) minimize the need for refilling.



High-intensity lights (Tri-State Lighting, Hampton, Iowa) were installed on the Iowa and Minnesota prototypes. Hooked up with fiberoptic cable, the lights are not affected by vibration, so they can be mounted in a wider range of locations. They could possibly be used to outline the wing plow, making the vehicle more visible to motorists who might attempt (illegally) to pass on the right. The high-intensity lights can be more visible through a snow cloud than a strobe light or the revolving lights currently used.



Reverse obstacle sensors (Global Sensor Systems, Paris, Ontario, Canada) detect obstacles behind the vehicle when the vehicle is in reverse and automatically apply the brakes. This feature is especially important because some motorists tend to drive close behind a snowplow, risking a crash in certain situations, such as when the driver must back up to reset a tripped plow.

Friction meter (manufactured by Norsemeter Company, Rud, Norway; distributed by Roadware Corporation, Ontario, Canada) provides a coefficient representing the slipperiness of the road. The friction coefficient is displayed in the cab and recorded on Plowmaster. This system was first developed to assess the slipperiness of wet/dry runway pavements at airports.

by the temperature sensors and the friction meter. Yet many of the operators pointed out that even when equipment malfunctioned, they could still operate the truck at or above the same level of service at which they operated conventional plows. This kind of operator feedback is essential if the vehicle is to have optimum utility and receive operator buy-in.

Expected Impact/Research Needs

In essence, the private vendors had already done the feasibility studies for the technological components they contributed. Beyond the individual components, a large-scale economic impact study was unnecessary. Although DOT personnel have spent a significant amount of time on the project, the contribution of the vehicle itself—a standard truck—was not a major financial investment.

In the future, the data gathered by the prototype snowplow will have uses beyond improving the ability to combat snow and ice. A future goal of the project is to make winter driving safer by

learning (a) how adverse driving conditions develop and (b) when the average driver responds to these conditions. When this information is available, winter maintenance activities can be focused intensively on those areas in which they can be the most effective.

A 2-year study that has been proposed by CTRE and the University of Iowa would correlate information gathered by the equipment on the snowplow truck (for example, friction, visibility, and treatments used) with data on accident rates and traffic volume/speed. This information would be used to create a predictive model of changes in driving behavior as winter weather conditions develop. Ultimately, a benefit-cost model would be developed to measure how well the new technologies (especially friction measurement) perform in winter conditions.

Such strides are within reach thanks to the involvement of CTRE. Says Smithson, "At the DOT, we don't have the staff to do projects like these anymore. The concept vehicle project would not be taking place at all without this unique partnership."

AASHTO's Snow and Ice Cooperative Program

KEN F. KOBETSKY

In 1994 the American Association of State Highway and Transportation Officials formed a Winter Maintenance Policy Coordinating Committee to provide guidance on improvement of snow and ice control among the member departments. AASHTO also invited cities and counties to join this effort. It was apparent from the experiences of the member departments and other local agencies that improved customer service in the area of snow and ice control could be achieved at significantly reduced costs. A great deal of the equipment and materials used for snow and ice control in the past was based on operational experience rather than research and development.

In April 1997, AASHTO held a national workshop on snow and ice control. This workshop was attended by more than 100 representatives of the research community, state and local operations, and industry. The objectives of the workshop were to identify ways of applying research findings, share operational successes and failures in improving customer service, and challenge industry in the development of new products and equipment for snow and ice control. Following the workshop, AASHTO's Standing Committee on Highways established a Snow and Ice Coop-

erative Program (SICOP) with the following mission, goals, and strategies.

Mission: Provide leadership, innovation, and results in order to improve the safety, service, environmental quality, reliability, and cost-effectiveness of winter highway operations.

Goals: Change culture, build capacity, close the gap between knowledge and practice, and advance technology.

Strategy: Identify needs, opportunities, and priorities; develop resources; build partnerships; coordinate programs; communicate; promote and inform; educate; plan and conduct projects; and ensure deployment.

Rodney Pletan of the Minnesota Department of Transportation is serving on loan to oversee SICOP. He is currently working to establish national programs in the areas of training, customer service, and material specifications. By late 1998, a training program is expected to be available for use by state, county, and local governments in enhancing the state of the art in snow and ice control.

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