CHAPTER 5: TRUCKS, PLOWS, SPREADERS

Each DOT in the consortium states agreed to provide its own snow plow truck to be configured as a prototype winter maintenance vehicle for that state. Each basic vehicle provided by the states is a 50,000-pound gross vehicle weight (GVW) truck with tandem rear axles. Iowa’s and Minnesota’s trucks have dump bodies, while Michigan’s truck has a chassis-mounted liquid tank and granular bin.

Equipment vendors equipped each prototype vehicle with three plows: a front plow, a side plow (wing), and an underbody plow (scraper). The front plow is capable of rotating side to side, with down pressure supplied by gravity. The wing plows are retractable and are mounted on the passenger side of the vehicles. Gravity supplies the wing plow’s down pressure. The wing plow on the Iowa prototype vehicle is capable of raising to a benching height of 60 inches, and lowering for bench plowing. The underbody plows, or ice blades, allow the equipment operator to apply down pressure hydraulically, rotate the plow’s angle from side to side (limited to right movement only on Iowa’s vehicle due to the placement of the friction meter), and adjust its vertical angle forward and backward.

All three trucks are equipped with liquid tanks and granular V-box spreaders, and each is capable of performing anti-icing, prewetting, and deicing functions. Anti-icing refers to the application of material (e.g., salt brine, liquid calcium chloride, or calcium magnesium acetate) to the road surface early in a storm or during plowing operations to prevent the formation of a snow/ice-to-pavement bond. Prewetting refers to the application of a liquid to granular material, like salt, before or as the granular material is applied to the road surface. This accelerates the ice melting process and prevents salt from bouncing off the roadway surface. Deicing refers to the application of chemicals and abrasives on the road surface to remove snow, ice, or frost already bonded to the pavement. Equipment operators can use each spreader’s “blast” mode feature to apply more chemicals and abrasives at locations that characteristically become icy. These locations include city street intersections, the ends of interstate highway exit ramps, or the bottoms of hills. The equipment operators use their own discretion with the blast mode.

OBJECTIVE

Conduct proof of concept for incorporating state-of-the-art plows, chemical/abrasive spreader systems, and in-cab controls and displays on snowplow trucks.

MEASUREMENT

Each state DOT in the consortium provides one snowplow truck. On each snowplow truck, three plows, a chemical and abrasive spreader system, and in-cab controls and displays are successfully installed, and they function as expected.

DISCUSSION
Each state provided a snowplow truck and plows on which add-on technologies were installed. Different private sector partners provided the material applicators for each of the three prototype vehicles, which were configured to meet the needs of each state. Because of the differences in trucks, the in-cab displays were also configured differently in each state’s vehicle. Each prototype maintenance vehicle is therefore unique. Specific details are discussed in the sections of this chapter for each state’s vehicle.

Iowa Prototype Vehicle

**Truck**

O’Halloran International, Incorporated, located in Altoona, Iowa, supplied Iowa’s base truck, a 1996 International Navistar 4900, model number NAV 4900. Monroe Truck Equipment (Monroe), located in Monroe, Wisconsin, was the fabricator and installed the snow plows and the chemical and abrasive spreaders. Monroe also installed and conducted initial testing of Iowa’s prototype vehicle’s technological components.

**Plows**

Monroe supplied three plows and one spreader for Iowa’s prototype vehicle. The front plow is an MTE MV-96-84-50-304-SS model. The wing plow is a heavy-duty benching wing with 11-foot moldboard and a benching height of 60 inches. The model number is MTE HDBW-11. The eight-foot moldboard underbody plow’s (scraper) model number is MTE TS961B.

Iowa DOT mechanics encountered challenges when mounting the switches to determine plow positions. The initial hydraulic pressure switch installed in the hydraulic lines for the wing plow was unreliable, and mechanics replaced it with a magnetic proximity switch. The magnetic proximity switch, which senses when the wing plow is next to the cab (“plow up”), proved reliable. A second challenge was the underbody plow sensors. Initially, only one pressure switch was installed in the hydraulic line for one of the hydraulic cylinders. However, because two hydraulic cylinders are used to provide independent left- and right-down pressure, Iowa DOT mechanics later installed one pressure switch for each underbody plow hydraulic cylinder, solving the problem.

Two side-by-side underbody plow gauges were located in the prototype vehicle’s cab, as show in Figure 5-1. The underbody plow gauges are the two on the right with black lettering against white backgrounds.
Figure 5-1 Gauges, Iowa vehicle

**Spreader**

The slip-in, single skid-mounted, 900-gallon liquid tank and 5.2 cubic yard Monroe Brute MSV heavy duty V-box spreader are located inside the Iowa prototype vehicle’s dump box. The anti-icing and prewetting systems are controlled by the vehicle operator in the cab by a SYN/CON controller provided by Bristol Company. A Spreadrite controller provided by Component Technology dispenses granular materials.

Bristol Company, located in Broomfield, Colorado, supplied the SYN/CON onboard controller system in the cab for deicing and prewetting system control. This controller can store up to eight settings for liquid and granular material, each with six subsettings for prewetting material applications. These settings and subsettings allow for custom chemical and abrasive material applications that respond to level-of-service requirements and storm conditions.

Component Technology, located in Des Moines, Iowa, supplied the Spreadrite GL-400 modular spreader control system, which automatically adjusts material application rates to compensate for changing travel speeds. After a material application rate has been selected, the GL-400 uses a vehicle speed sensor to automatically adjust the feeder drive and maintain a uniform spread rate. This setup allows the equipment operator to concentrate on operating the vehicle safely, not on changing the material output rate. The GL-400 also has a manual mode option, which allows the equipment operator to manually control the material application rate, and a manual “blast” mode that overrides the selected material application rate for short time
periods. The variable speed material applicators worked well; operators responding to CTRE’s user survey appreciated the ease of vehicle operation made possible by the spreaders.

*Inside the Cab*

Through experimentation, Iowa DOT mechanics determined their optimum configuration for displays and controls in the prototype vehicle’s cab. The first challenge was locating the PlowMaster and friction meter displays. They were first installed on a pedestal behind the driver’s right elbow, where they were difficult for operators to view when they were driving the vehicle. See Figure 5-2.

![Initial placement of PlowMaster and friction meter displays, Iowa vehicle](image)

**Figure 5-2 Initial placement of PlowMaster and friction meter displays, Iowa vehicle**

To make the displays easier for the drivers to see, Iowa DOT mechanics mounted them in another location to the front and right of the driver, on the dash. However, this location blocked some of the controls and vents on the dash.

Iowa DOT mechanics next built a wrap-around dash extension of sheet metal to free up the dash and provide even easier accessibility to the PlowMaster and friction meter displays. See Figure 5-3. This final location was conceived by DOT mechanics after they observed a similar dashboard setup in over-the-road semis. DOT mechanics can easily remove and re-mount the dashboard extension because the original dashboard bolt holes are used.
The PlowMaster display is mounted behind the snowplow blade levers. (Eventually, friction meter information was incorporated into the PlowMaster display, and the friction meter display removed from the cab.) To the immediate left of the PlowMaster display are two gauges, the air filter restriction indicator (on top), and Sprague’s temperature sensor system (on bottom).

Figure 5-3 Final placement of displays and technology gauges, Iowa vehicle

Immediately below the PlowMaster display is the control for the Fosseen engine booster system. The control area includes an alcohol pump pressure gauge and an on/off switch for the injection system. A green light indicates when the alcohol tank is empty. The gauge reads 15-20 psi (normally 17 psi) when the alcohol system is not injecting alcohol engine, and increases to 60 psi when the alcohol injection system is active.

To the immediate right of the alcohol injection system’s control area are two hydraulic pressure gauges for the underbody plow. Since the underbody plow has independent left- and right-down pressure cylinders, two gauges are used. This configuration enables the equipment operator to observe the hydraulic pressure of each cylinder. Refer to Figure 5-4.

Iowa DOT mechanics also encountered challenges installing the friction meter computer. This computer was first located upright behind the passenger seat, which provided minimal legroom for the passenger. To overcome this, DOT mechanics removed the passenger seat’s suspension base, built a custom-made cabinet/box suspension combination, and placed it underneath the passenger seat. The cabinet has a “drawer” for easy access to the computer unit.
Figure 5-4 Material applicator controls, Iowa vehicle

Michigan Prototype Vehicle

Truck

Navistar International Corporation, located in Fort Wayne, Indiana, supplied the Michigan snowplow truck. The truck is a 1996 International Navistar 2574, model number NAV 2574. Monroe functioned as the fabricator and provided initial installation of the prototype truck’s technological components.

Plows

Monroe supplied all three plows for Michigan’s prototype vehicle. The front plow is an MTE DSM-120-86-48/304-MICH model. The wing plow is a model MTE RMJW-10. The underbody plow’s (scraper) model number is MTE 050-9012-0000-MICH.

Spreader

Michigan’s vehicle has a 6.5 cubic yard Monroe Duz Mor chassis-mounted, self-unloading V-box with a spinner spreader and permanent 900-gallon liquid tank mounted in front of he V-box. The anti-icing and pre-wetting systems use a Raven de-ice system controller in the cab.

Raven Industries, Incorporated, located in Sioux Falls, South Dakota, supplied a DCS 700 de-ice system controller for the anti-icing and pre-wetting system. The DCS 700 consists of a computer-based control console, a speed sensor, two control valves, flow meter, granular rate sensor, and cable controls. The console mounts directly in the cab of the vehicle for operator use. The speed sensor is mounted on the vehicle. The motorized control valves, flow meter, and
granular rate sensor are mounted to the vehicle framework. The equipment operator sets the
target application rate for each product, and the DCS 700 uses the speed sensor to automatically
maintain uniform material flow relative to vehicle speed and gear selection. A manual “blast”
mode can be selected to allow the equipment operator to override the material application rate
for short periods of time. The DCS 700 also monitors distance and speed, and totals all materials
spread, to help analyze material output amounts and rates. As in Iowa, the operators greatly
appreciated the convenience of the speed-regulated material application system.

The first challenge involving the Michigan prototype maintenance vehicle was to find spray
nozzles that would meet Michigan’s standard procurement specifications—120 gallons per lane
mile (for two lanes) at 60 mph, or 240 gallons per mile (gpm). Monroe’s solution was a three-
tiered system that activates three different booms per lane at various speeds and at the
specification application rates. Raven Industries—Monroe’s ground speed material applicator
supplier—and Monroe developed a switching circuit to activate the system for the specified flow
rates and associated vehicle speeds.

After the challenge involving material application rates was successfully met, another
challenge arose—installing three-inch diameter pipes, hoses, fittings, and a liquid de-icer pump,
to meet Michigan’s standard procurement specifications for liquid material flow rates. The
original 12-volt direct current ball valves selected by Monroe were replaced because of the room
required to accommodate the hose barbs and the size of the components. Monroe selected an
American National Standards Institute (ANSI) butterfly valve, which shortened the valve lengths
and provided easier serviceability access. Monroe used stainless steel piping and welded elbows,
flanges, and tees to complete the spray bar assemblies. This setup provided unrestricted liquid
material flow and a smaller configuration.

Another challenge was meeting the Michigan DOT’s performance specifications for the
granular material spreader. A wider conveyor and relatively light Michigan DOT application
rate specifications required a slow-moving conveyor. Monroe preferred a faster moving belt
with a lower gate/door opening, which would allow the hydraulic components to perform better.
Monroe provided an adapter opening to improve spreader performance, resulting in more
uniform distribution of material within Michigan’s specifications.

Inside the Cab

Through experimentation, Michigan DOT mechanics determined their optimum
configuration for displays and controls in the prototype vehicle’s cab. See Figure 5-5 for a
picture of the Michigan prototype vehicle cab controls.
Minneapolis Prototype Vehicle

**Truck**

Boyer Ford, located in Minneapolis, Minnesota, supplied Minnesota’s base truck. The truck was a 1996 Ford L9000. Tyler Ice, a division of Tyler Industries, Incorporated, located in Benson, Minnesota, functioned as the fabricator for, and provided initial installation of, the prototype truck’s technological components.

**Plows**

The Minnesota DOT purchased all three plows themselves and mounted them in-shop. The underbody plow on the Minnesota prototype vehicle is not capable of changing its vertical angle.

**Spreaders**

A slip-in Tyler V-blend, dual chamber V-box is located inside the dump body. It is a divided spreader box, allowing operators to distribute a ratio of two granular materials. In addition, the vehicle has a 900-gallon liquid tank.

The anti-icing, deicing, and prewetting functions are controlled in the cab using a Tyler Industries Quantum Controller, and a Tyler Industries LDS-1000 Anti-Ice System. These systems enable the equipment operator to specify and maintain predetermined material application rates. In addition, the Quantum Controller uses a speed sensor to automatically maintain uniform material flow relative to the vehicle speed and gear selection. A manual
“blast” mode can be selected to allow the equipment operator to override the material application rate for a short time. As in Iowa and Michigan, the operators appreciated the convenience of the semi-automated spreader system.

**Inside the Cab**

Tyler Ice’s challenge with the Minnesota vehicle’s cab controls was to find enough space for the extra displays and controls—anti-icing control and pressure gauges, the Tyler Quantum controller, the friction meter computer, and the hydraulic controls for the plows. To accommodate all the controls and make them easily accessible to operators, Tyler built a customized console-type mounting, with the controls wrapped around the driver’s seat as shown in Figure 5-6. The computer for the friction meter was installed on the floor, in front of the engine cover, making for a crowded cab. Figure 5-7 shows the PlowMaster display, and Figure 5-8 shows material applicator readouts.

![Figure 5-6 Cab controls, Minnesota vehicle](image-url)
Figure 5-7 PlowMaster display, Minnesota vehicle

Figure 5-8 Material applicator controls, Minnesota vehicle
OBSERVATIONS

Proof of concept was successful for this stage of the project. Each state DOT in the consortium provided one snowplow truck equipped with plows, winter chemical and abrasive spreader systems, and in-cab displays and operator controls. Fabrication and installation activities during Phase II proved the feasibility of making a significant amount of technology and information available to the operator in the cab. Each vehicle is unique, but all three provide similar plowing and spreading capabilities. Generally, installation of all the PlowMaster display, operator controls, and gauges in the cabs made cab conditions quite crowded, but each state modified the in-cab installations to provide safe and efficient operating conditions for drivers. In Phase III, as more of the add-on systems are automated and coordinated through the PlowMaster (e.g., the material application systems), the in-cab configurations may be revised.