

Application of Advanced ITS Interfacing That Improves Maintenance Operational Effectiveness and Winter Safety in Rural Areas

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In 1995, the state departments of transportation of Iowa, Michigan, and Minnesota formed a consortium to define and develop the next-generation highway maintenance vehicle that would utilize the latest maintenance operational technologies and interface with ITS. Focus groups revealed that while all maintenance operations could benefit from creating this new generation vehicle, ice and snow operations were the most complex and would benefit greatly from improvements in state-of-the-art vehicle navigation systems, onboard computer applications, and enhanced safety systems. This advanced technology highway maintenance vehicle functions as both operational truck and a mobile data-gathering platform. Sensors mounted on the vehicle record air and roadway surface temperature, roadway surface condition, and roadway surface friction characteristics. This information is Global Positioning Systems (GPS) correlated and used in maintenance operational decision making. The information will eventually be interfaced with the ITS technology in the Traffic Management and Information Service Provider Centers Subsystems of the National ITS Architecture. The advanced technology highway maintenance vehicle performs an important role in the U.S. Federal Highway Administration's "Weather Information for Surface Transportation ITS Field Operational Test" being conducted by the FORETELL consortium.

BACKGROUND

The mission of a department of transportation is to provide its customers reliable transportation facilities that perform to their level of service expectations and to accomplish this in the most efficient and effective manner possible. This mission is particularly challenging to snow belt states during the perils of a winter season. Just-in-time goods deliveries, a key ingredient in any state's economic vitality, places an ever-increasing importance on reliable year-round transportation. These increasing transportation demands are coming at a time when most states are being asked to downsize their maintenance operations work force. The application of advanced snow and ice control technologies and their integration with ITS offer excellent potential for increasing operational efficiency and effectiveness as well as improving winter mobility and driver safety.

In recognition of the potential that exists when utilizing advanced methods and ITS technologies for highway maintenance activities, a

four-phase study, shown in Figure 1, was initiated to define the desired vehicle and equipment capabilities for the next generation highway vehicle, develop and evaluate prototype vehicles, conduct benefit/cost analysis, and produce maintenance vehicles for fleet applications. The initial focus is on maintenance operations that are under public observation the most. Agency operations and ITS surveys have shown that safety and winter mobility rank high in customers concerns and expectations. Winter snow and ice control operations therefore are receiving first consideration for technology applications in developing the next generation highway maintenance vehicle.

Foundation Statements:

1. "The solutions must be selected and recommended based on a benefit/cost analysis and a reasonably short time to implementation".
2. "The application of solutions must be described in terms that related to improving service to customers ."

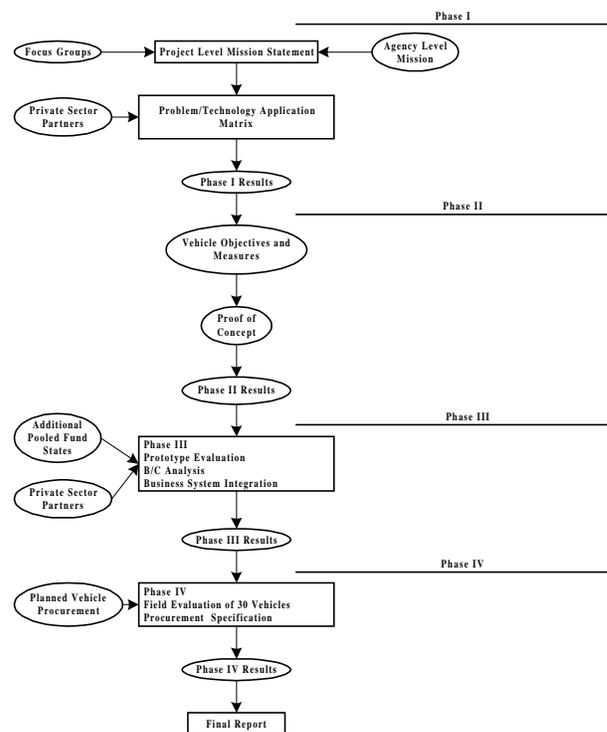


FIGURE 1 Four-phase study flowchart

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FOUR-PHASE RESEARCH IN PROCESS

Phase I

The objective of Phase I was to develop the functionality the concept vehicle will provide and to enlist private sector partners to provide the functionality. This phase began with a literature review of materials related to winter highway maintenance activities. One hundred and five articles were collected which pertained to state-of-the-art equipment, technologies, and research related to winter highway maintenance activities.

The ideal capabilities of a winter maintenance vehicle were identified through focus group activities. Five focus groups were formed. The focus groups included representation from equipment operators and managers, mechanics, resident and central maintenance office engineers, area supervisors, law enforcement agencies, and emergency responders. Focus group meetings were held in the three consortium states generating more than 600 ideas. These ideas were later combined and organized into a list of 181 desired capabilities for the highway maintenance concept vehicle. The final prototype design for the three prototype vehicles provided the following desired capabilities that resulted from the focus group activities:

- Sense roadway surface temperatures
- Sense roadway surface friction conditions
- Record and download vehicle activities
- Improve fuel economy
- Provide adequate horsepower for the vehicle
- Carry and distribute multiple types of materials
- Provide removable salt/salt brine dispensing system
- Provide back-up sensors/monitors

Private sector equipment and technology providers were introduced to the study and asked to join in the effort. These private partners committed to providing equipment and expertise for the duration of the study. Phase I is complete and a more detailed discussion can be found in *Concept Highway Maintenance Vehicle, Final Report Phase One*, dated April 1997, Iowa State University, Ames, Iowa. The report is also on the Iowa State University's Center for Transportation Research and Education web site at <<http://www.ctre.iastate.edu/Research/conceptv/conceptv.htm>>.

Phase II

The objectives of Phase II were to build three prototype concept vehicles, integrating the subsystems into a working system, conduct proof of concept, and prepare for field evaluations of three prototype vehicles in Phase III. The mission of a department of transportation is to provide its customers reliable transportation facilities that perform to their level of service expectations and to accomplish this in the most efficient and effective manner possible. This mission is particularly challenging to snow belt states during the perils of a winter season. Just-in-time goods deliveries, a key ingredient in any state's economic vitality, places an ever-increasing importance on reliable year-round transportation. These increasing transportation demands are coming at a time when most states are being asked to downsize their maintenance operations work force. The application of advanced snow and ice control technologies and their integration with ITS offer excellent potential for increasing operational efficiency and effectiveness as well as improving winter mobility and

driver safety. Proof of concept was conducted for each of the functional areas integrated into the prototype vehicles. Proof of concept for Phase II was defined as conducting "end-to-end" processing, observing the success of the "end-to-end" processing, and observing if the data was reasonable. Proof of concept is not a rigorous statistically valid field test. A data collection and observation plan was developed to conduct proof of concept while operating the prototype vehicles during the winter of 1998-1999.

In addition, telephone interviews were conducted with the prototype vehicle operators to ascertain equipment performance. The interviews and documentation of equipment performance led to guidelines for the desired equipment capabilities for the Phase III prototype vehicle. Phase II is complete and the final report, *Concept Highway Maintenance Vehicle, Final Report Phase II*, is on the Iowa State University's Center for Transportation Research and Education web site at <<http://www.ctre.iastate.edu/Research/conceptv/conceptv.htm>>.

Phase III

The general objectives of Phase III to be achieved in 1999-2000 are to perform proof of concept on newly discovered technologies, establish the functionality of each technology to be implemented, conduct a benefit/cost analysis for each technology, estimate the time to implementation, conduct field evaluation, produce data flow and decision process maps to integrate the concept vehicle functionality in management and ITS systems and develop draft vehicle specifications for each consortium state.

Phase III will answer these questions:

- Which technologies should be implemented?
- What are the benefit/costs of each technology?
- What is the expected time to implementation?

Sensing roadway surface conditions is being attempted by Norsemeter of Norway using a device called Saltar. The Saltar design is an outgrowth of the evaluation done in Phase II and has been tested at Wallops Island, Virginia and North Bay, Ontario. Both tests are sponsored by NASA and attended by several manufactures of surface friction measuring devices. The Saltar device did function as expected. The report will be placed on the concept vehicle web page.

Benefit-cost analysis is currently being conducted on the pavement surface temperature measuring technology. Benefits will be based on estimating the difference between materials distributed knowing the pavement surface temperature at the vehicle's location and materials distributed based on the pavement temperature measured at a remote road weather information system (RWIS) site. Data are being collected based on interviews with field staff and collected from databases generated by the vehicle and the RWIS site. Analysis is currently underway.

Phase III also includes conducting proof of concept evaluation on a pavement surface freezing point sensing system. The system, supplied by Enator of Sweden, is currently undergoing benching testing conducted by CTRE.

Phase IV

The objectives of Phase IV are to:

- Equip ten vehicles per state with selected advanced technologies.
- Conduct field evaluation.

INTERFACING WITH ITS

National ITS Architecture

The Iowa Department of Transportation envisions the concept vehicle functionality fitting into the National ITS Architecture Subsystem and Communications architecture very smoothly. Figure 2 illustrates the placement of the functionality.

Road and Weather Model Interface

As part of the "Weather Information for Surface Transportation ITS Field Operational Test," the Iowa prototype maintenance vehicle provided air and pavement temperatures to the FORETELL Consortium to assist in the calibration of a new road and weather forecast model. The vehicle operates as a mobile environmental sensor station gathering real-time pavement thermal profiles and air temperature data for input to the FORETELL microscale models. This interface is

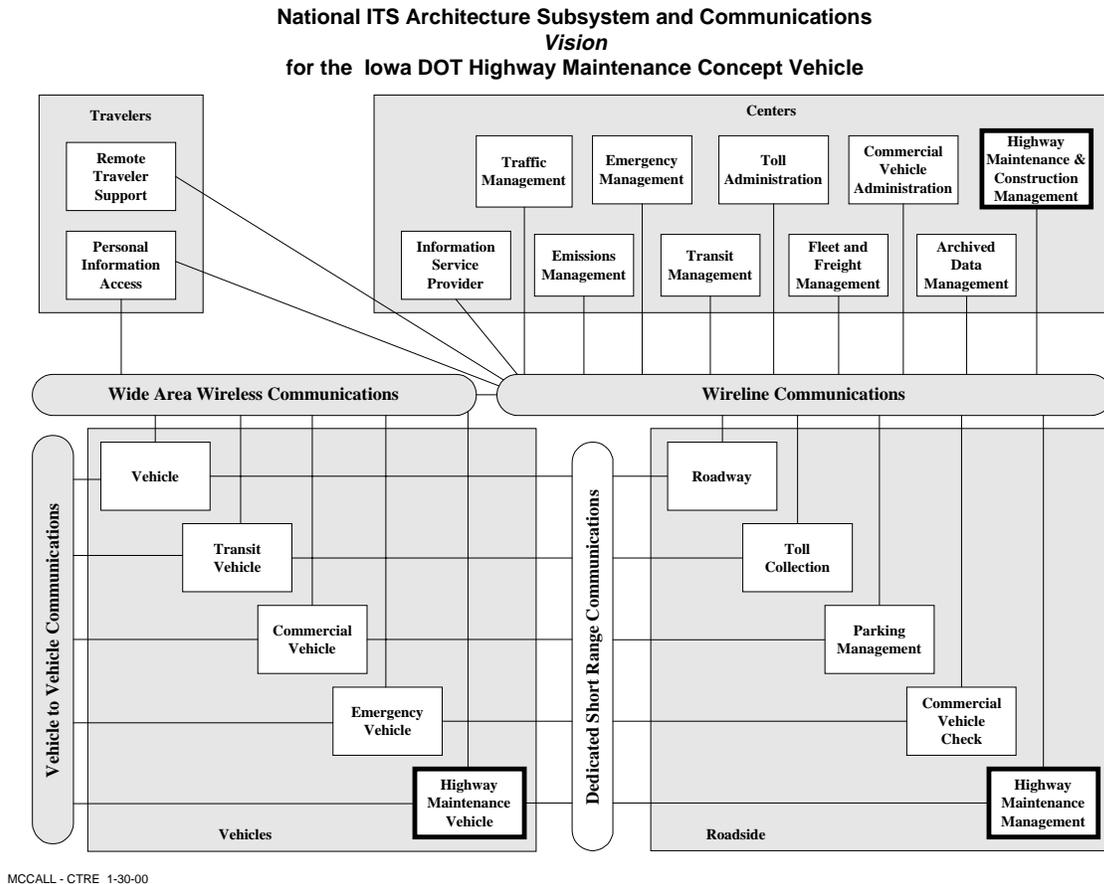


FIGURE 2 National ITS architecture subsystem and communications vision for the Iowa DOT highway maintenance concept vehicle

depicted in Figure 3. It is envisioned that the ten advanced technology maintenance vehicles in Phase IV of this research will serve as FORETELL's mobile platforms using NTCIP 'ESS' protocol standards to radio air temperatures, wind speeds, pavement data and maintenance operations reports in real time to FORETELL ITS service centers. These ITS service centers will provide the interface between ITS, and ITS users, allowing progressive deployment of weather, roadway, and other ITS applications throughout the service center area.

CONCLUSIONS

The four-phase research project to develop a new generation, advanced technology highway maintenance vehicle began in 1995. The vision was to develop a concept vehicle that would support equipment operators and fleet managers in making more informed and cost-effective decisions based on using emerging ITS technology. The approach was to bring technology applications from other industries to the concept vehicle. The customer was brought into the planning process at the very beginning and is one of the reasons the project has been successful in field-testing. Each of the three consortium states has built and operated an advanced technology highway

maintenance vehicle in its daily maintenance operations for three years. The advanced technology applications have withstood the severity of snow and ice control operations for two winters with only minor problems. Each vehicle and its advanced concept technologies have passed proof of concept tests. Each technology is now being evaluated to make sure what benefits have been realized and calculate their respective benefit/cost ratio. Emerging technologies are also being tested on the concept vehicle. First generation concept technologies are being redesigned to improve their reliability and reduce complexity and cost. For example, a roadway friction-measuring device has been redesigned to make it smaller, less complex, and more durable, and the cost has been reduced by 65%. Reduced cost is especially important because each state will need several hundred friction measuring units to adequately meet the need of rural ITS to accurately determine and predict the winter condition of road surfaces and its impact on braking and driving traction.

Field operators and managers feel the new technology has made their efforts more efficient and effective. The information these vehicles provide to the ITS community is an incidental benefit to the main snow and ice control mission and is used by both the department of transportation in their operations management and the ITS service centers.

As new technologies emerge, they will be evaluated and tested using the model developed for this research project.

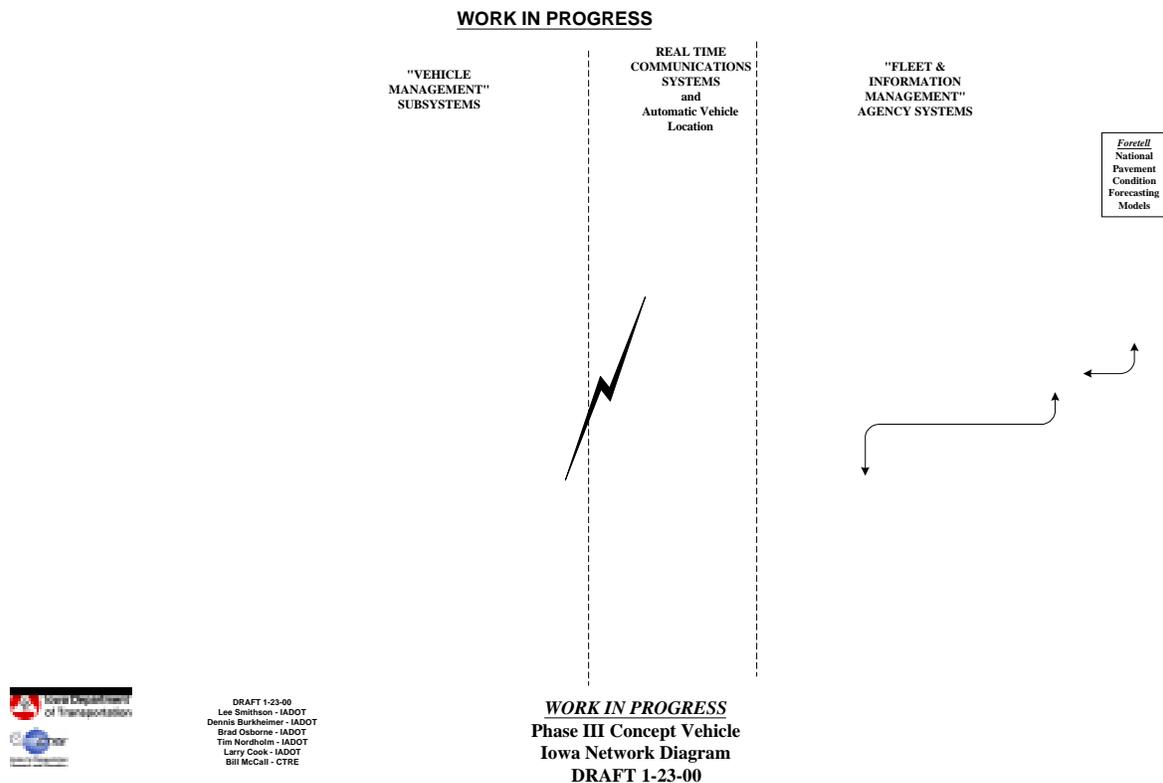


FIGURE 3 Work in progress, Phase III concept vehicle, Iowa network diagram