FRONTIER:
Demonstration and Evaluation of Intelligent Transportation Systems for the Rural Highway Environment Pooled Fund Study

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1. EXECUTIVE SUMMARY

1.1. Introduction

1.1.1. Background

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) promoted research, demonstration and implementation of Intelligent Transportation Systems (ITS) technology. To date, projects have primarily focused on applications of this technology in urban environments to address problems such as congestion, mobility and incident management. The nation's "real" rural highway system (two-lane highways) – which comprises over 80 percent of road mileage in the U.S. and accounts for approximately 40 percent of all vehicle-miles traveled each year – has largely been ignored with respect to ITS.

The primary objective of this research effort was to prove that advanced technologies can be successfully transferred to rural environments. The obvious approach in this proof is to deploy, on a small scale, appropriate Intelligent Transportation Systems **(**ITS) technologies in rural areas and document the resulting benefits. Potential benefits from this effort align with the national ITS goals of improved safety, efficiency and convenience in travel. In addition, the lessons learned from this effort can further encourage support of and investment in rural ITS applications.

1.1.2. Project Selection Process

Participants in this project included representatives from eight State Departments of transportation: Montana, Idaho, Utah, Washington, Oregon, California, Wyoming, and Texas. These representatives comprised the Technical Advisory Committee (TAC). The TAC members provided guidance to the Western Transportation Institute (WTI) for the research, demonstration, and evaluation phases of the project, and were actively involved in the project selection process, which occurred in 1999.

Following a national and state specific review of efforts to quantify rural ITS benefits, WTI and the TAC developed demonstration project criteria reflecting gaps in existing rural ITS research. State Departments of Transportation were invited to submit projects for consideration, which were rated on criteria such as "rural focus," "uniqueness of effort," "cost realism," "quality of site selection," and "feasibility." The two projects selected for demonstration were:

- A **Rural Travel Time Estimation Project** in Oregon. This project was designed to provide travelers with real-time information about trip duration on a highly traveled rural highway in coastal Oregon.
- A **High Water Level Sensor Project** in Texas. The objective of this project was to provide critical real-time warning of roadway flooding conditions.

1.2. Rural Travel Time Estimation Project

Travelers routinely complain about lack of real-time information regarding trip duration on the highway. Detection of and response to incidents has been an ever-growing concern, and notification of the traveling public about incidents and, more importantly, expected delay/travel time is essential. To address these needs, the FRONTIER Project TAC selected a rural travel time estimation system for deployment and demonstration in Oregon to inform motorists and maintenance workers of possible delays or incidents.

The Rural Travel Time Estimation project used vehicle identification technologies to provide travel-time estimates for two contiguous highway segments near the Oregon coast. This stretch of highway is a significant rural travel corridor in the region and also connects two large tourist attractions: a casino on one end and Lincoln City, a popular coastal destination, at the other end. Congestion and incidents are a common occurrence on this corridor due to several factors, including a high percentage of slow moving trucks and campers/mobile homes, passing opportunities that are few and far between, mountainous terrain and speed zones.

Prior to system selection, WTI reviewed similar travel time estimation systems to learn from those experiences. Then, a general system engineering process was followed: applicable technologies were reviewed then a vendor was selected through a competitive open bid process.

The resulting system uses infra-red technology to read license plates for travel time measurement. The cameras along the corridor are calibrated to recognize the license plates of passing vehicles. The license plate numbers are privacy-protected numbers with encryption, and time-stamped tags are sent via telephone communications network to a central server. The server matches the timestamped tags collected at different checkpoints to identify vehicles that have passed between two or more locations. Using the matched vehicles passage times and the distances between observations, the system estimates the travel time between segments.

If the vision was fully and permanently deployed, the FRONTIER Rural Travel Time system could eventually provide travel information to motorists via portable variable message signs (VMS) along the corridor, ODOT's statewide traveler information system TripCheck (www.tripcheck.com), and the statewide traveler information 511 system. Motorists could then choose alternative routes and make travel decisions based on the travel time estimates.

The travel time system was installed in early 2001. It worked well initially (in March and April of 2001), but then developed a series of malfunctions (software issues, equipment failures) that prevented further data collection. The system was not fully functional again until the summer of 2004. WTI and Portland State University collaborated to collect data in the summer and fall of 2004, then began work on data analysis and evaluation. For the evaluation, researchers analyzed data collected by the system, including vehicle matches, travel time, travel speeds, and incident detection. To validate the accuracy, a comparative analysis was conducted with data from probe vehicles.

Two main conclusions can be deduced from the evaluation of the travel time system. First, the results of the preliminary analyses and the comparative travel time studies showed that when working, the system produced accurate travel time results. The system is capable of detecting and matching vehicles, measuring travel time statistics, measuring travel speed data, and documenting travel delays caused by incidents. The capabilities of the system were validated by the results of the field validation, which indicated that the system can reliably predict travel times within a minute, which is robust considering the length of the corridor (25 miles).

The second conclusion that must be drawn from this evaluation is that the potential capabilities of this system were overshadowed by operational and maintenance concerns. Because the system (and therefore its data) was viewed as unreliable, ODOT was reluctant to use or disseminate any of the system information to the public. Therefore, the system's potential as a public information tool has yet to be evaluated. Further research on travel time estimation systems is recommended to produce longer-term data on technical reliability, as well as to incorporate the data into traveler information systems.

1.3. High Water Level Sensor and Warning System

Weather and its related impacts are a significant issue to the safety of travelers and the operations of the transportation systems in rural America. Flooding and rapidly rising water have a significant impact on many transportation systems, and as such TxDOT was interested in this second FRONTIER demonstration project.

The second TAC selected project was the Highway Water Level Sensor System. The site for this project is located in Wise County, Texas on a two lane, undivided approach to a structure crossing the West Fork of the Trinity River.

Prior to system development, WTI conducted research on previous efforts to deploy similar high water warning system technologies. To guide deployment, TxDOT developed a concept of operations, then technologies were determined and a pre- qualified vendor was selected for system implementation.

This project placed infrared water level sensors at critical locations on each approach to the site. The sensors were placed to provide the first warning, or alert mode, when water was within two feet of reaching the roadway surface, as well as second warning, or alarm mode, when water reached the roadway surface. The sensors are interconnected to two advanced signing installations with LED flashers, which display the message “Possible Flooding/Water over Road/When Flashing” during alert mode, or “Do Not Enter/High Water” during alarm mode. The central computer also employs a pager notification system to ensure appropriate personnel are aware of the changing conditions, especially outside normal business hours when office personnel may not be monitoring the base station.

The high water system installation (which began in 2001) had several problems, including a lightening strike that took out several system components. However, the vendor and TxDOT had the system fully operational again in 2002. The next issue became an ongoing drought in Texas, which hindered the potential for any flood events. The first flood event during which data collection could take place occurred during the summer of 2004.

A flood event in June 2004 resulted in a successful activation of the warning system. In December 2004, the system also accurately detected ice on the road, and the ice detection light was activated. The accuracy of the weather data was also validated by a comparative analysis with a nearby NOAA weather station. Surveys and interviews conducted with maintenance personnel indicate that they are impressed with initial performance of the system, and are interested in installing additional systems at other locations.

1.4. Conclusions

This study basically consisted of rural deployments of two different ITS applications. The license plate reading based travel time system, at the time of deployment, was the only one of its kind in the U.S. The initial research showed that there were only a few vendors capable of building and maintaining the system. The travel time system had maintenance issues for the duration of the study, and was only fully operational for several months over a three year period.

Rural districts generally lack the manpower and other institutional resources to provide ongoing, high maintenance support to new technologies.

Conversely, the high water warning system was an application that was applied successfully in the urban environment in Texas and other states. Thus, this deployment involved taking a tested system and applying it in a new environment. The system was reliable and functioned well.

The two distinctly different results from these two projects suggest perhaps that the main hypothesis was basically correct, but incomplete. Advanced technologies can be successfully transferred to rural environments, *if rural conditions, challenges, and resources are adequately addressed in advance.* Urban ITS applications can not be *directly* transferred to the rural environment; they must be adapted to account for such factors as:

- remote locations
- significantly lower AADT
- technological infrastructure
- available staffing resources and expertise
- available fiscal resources to support testing and deployment delays

The FRONTIER project has helped to identify key factors that must exist to ensure successful deployment of ITS technologies in a rural environment. The lessons learned will contribute to the development of criteria for future rural deployments. This project in fact underscores the need for increased ITS research specifically aimed at rural challenges and deployed in rural environments.

1.5. Next Steps and Future Research

As a next step, the Technical Advisory Committee should develop an action plan for disseminating the information that was learned as part of this effort, in order to raise awareness of the need for rural ITS and its potential benefits. This heightened awareness, in turn, will likely provide a greater opportunity for increased focus on rural issues and targeted funding for rural efforts.

Based on the evaluation results of this effort, there are several additional areas that would make interesting and useful studies to DOT's in the rural environment. Future research ideas include:

- What is appropriate level (i.e., spacing) of detection for the rural environment?
- What percentage of rural ITS deployments are completed within the project's original schedule and budget? How many ITS projects are actually deployed, fully-functional, on time, in any environment?
- What impact do software and communications issues have on successful and useful deployment in the rural environment?
- What should be the requirements for testing new technologies before deployment in rural environments? Should only proven technologies be deployed in rural environments?
- What is the reliability of ITS devices in any environment? Is there a difference in reliability between urban and rural environments?