ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)

ENTERPRISE

Demonstrate and Evaluate Communications to Support Rural ITS – Phase 1

PROJECT SUMMARY REPORT

Prepared by

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Acknowledgements

This document was prepared for the ENTERPRISE Transportation Pooled Fund TPF-5(231) program. With agencies from North America and Europe, the main purpose of ENTERPRISE is to use the pooled resources of its members, private sector partners and the United States federal government to develop, evaluate and deploy Intelligent Transportation Systems (ITS).

Project Champion

Bob Koeberlein, Idaho Transportation Department, was the ENTERPRISE project champion for this effort. The project champion serves as the overall lead for the project.

Members of the ENTERPRISE Pooled Fund

Arizona Department of Transportation

Federal Highway Administration

Georgia Department of Transportation

Idaho Transportation Department

Illinois Department of Transportation

Iowa Department of Transportation

Kansas Department of Transportation

Maricopa County, Arizona

Michigan Department of Transportation

Minnesota Department of Transportation

Oklahoma Department of Transportation

Ministry of Transportation of Ontario

Pennsylvania Department of Transportation

Dutch Ministry of Transport (Rijkswaterstaat)

Texas Department of Transportation

Transport Canada

Washington State Department of Transportation

Table of Contents

1. Introduction

Wireless communication has changed dramatically since the late 1800s when the first wireless communication began via the photophone and radio transmissions. Significant progress has been made over the past decade in improving the breadth and quality of cellular coverage, yet challenges still remain with using such communication in rural areas to support Intelligent Transportation System (ITS) devices. Satellite service can be an alternative with greater potential coverage but also greater cost than cellular communication. Radio communication is yet another alternative but with limitations such as line of sight.

In addition to not having a clear understanding of which communications to use with ITS in rural areas, ENTERPRISE members also expressed concerns about high costs and low reliability of various communication options. These issues can be even more challenging during disaster situations when information needs to be exchanged across rural areas and traditional networks may be unavailable.

The ENTERPRISE FY2014 Work Plan included a project "Demonstrate and Evaluate Rural Communications to Support Rural ITS" that outlined an initiative to identify, demonstrate, and evaluate one or more emerging communication technologies that could be used by transportation agencies to communicate with ITS devices in rural areas. Per direction from the ENTERPRISE Board, the project was separated into two phases in order to properly assess issues and potential solutions before coordinating a deployment and evaluation.

- Phase 1: Gather information about issues and potential solutions for communications to ITS devices in rural areas and develop a scope of work for Phase 2.
- Phase 2: Conduct the agreed upon scope developed in Phase 1, such as coordinating a demonstration of rural communications mechanisms and conducting an evaluation.

Phase 1, documented in this report, first gathered information about issues and potential solutions for communications to ITS devices in rural areas. A literature scan was conducted to determine whether adequate published literature exists to support transportation agencies in their selection of wireless communication for ITS devices, particularly in rural areas. This scan of published resources did not yield a substantive set of resources that could provide adequate guidance for understanding which communication to use with ITS devices in rural areas. Therefore, interviews were conducted with personnel from selected ENTERPRISE member agencies to gather information about challenges, as well as solutions implemented, for rural communications. The interviews yielded valuable information about a number of rural communications options and solutions, key issues, including potential options for the Phase 2 scope of work. At the April 2015 in-person ENTERPRISE Board meeting, three options for the Phase 2 demonstration/evaluation were identified. A survey of ENTERPRISE board members was then conducted to rate the options and to guide the Board's decision. The Phase 2 scope of work, detailed in section 4 of this report, reflects priorities determined by the ENTERPRISE Board to be accomplished during the remainder of the "Demonstrate and Evaluate Rural Communications to Support Rural ITS" project.

2. Communication Options for ITS Devices

Transportation agencies that operate ITS field devices must provide two-way communications in order to exchange data with devices such as Dynamic Message Signs (DMS), Road Weather Information Systems (RWIS), CCTV cameras, Warning Systems, HAR transmitters, among others.

These ITS devices require various levels of bandwidth to exchange data such as text displays, voice, camera images, and full motion video from a Department of Transportation (DOT) operations center (e.g. Traffic Management Center) to an ITS device, or vice versa. Bandwidth needs include:

- Low Bandwidth (10s of Kbits/second) - needed for devices such as DMS, HAR, Warning Systems, CCTV cameras that provide still images, and RWIS data
- High Bandwidth (100s of Kbits/second) - needed for devices such as CCTV that provide full motion video

ITS device communication options for rural areas range from land-line to wireless mechanisms, and can be either be owned and operated by the agency or can be obtained through commercial service providers:

Examples of Land-Line Mechanisms:

- Fiber optics
- Telephone (T-1, copper, DSL, etc.)
- Cable

Examples of Wireless Mechanisms (Commercial Carriers):

- Cellular
- Satellite
- Two-way mobile data

Wireless Mechanisms (Owned and Operated by a Public Agency):

- Land mobile data radios
- Microwave systems
- Other “combination” systems that link multiple communications types

In order to better understand rural communications mechanisms used by ENTERPRISE transportation agencies and issues with communicating to ITS devices in rural areas, interviews were conducted with personnel from five ENTERPRISE member agencies, to collect relevant information. Interview summaries can be found in Section 3 of this report.

3. Rural Communications - Types and Challenges

Interviews were conducted with personnel from five ENTERPRISE agencies, to collect information about the mechanisms they use for communications to ITS devices in rural settings and challenges experienced. Interview summaries for the following agencies are shown in the corresponding tables, as noted:

- Idaho Transportation Department (Table 1)
- Iowa Department of Transportation (Table 2)
- Kansas Department of Transportation (Table 3)
- Pennsylvania Department of Transportation (Table 4)
- Washington State DOT (Table 5)

Table 1: Summary of Idaho Transportation Department Interview

Idaho Transportation Department (ITD) Interview with Bob Koeberlein on 4/3/15
Communication Types Used in Rural Areas
• Cellular - primary • Fiber used where available • Some copper, using dial-up modems • Lease bandwidth from a "wide area network" operated by a regional telecom consortium (this network connects all major cities in the state) • Mountaintop microwave system is used as a backup
Challenges
• Lack of coverage in some locations • Inadequate bandwidth for video transfer using cellular • Cellular network is vulnerable during regional or national emergencies

Table 2: Summary of Iowa DOT Interview

Iowa Department of Transportation (IA DOT) Interview with Tim Simodynes and Tony Taylor on 4/2/15
Communication Types Used in Rural Areas

• Cellular - primary
  - Coverage is good across the state
  - It is generally reliable
  - Works well for most devices, with the exception that it does not work well for streaming live video; cellular only transfers snapshot images from CCTV cameras
• Occasionally use microwave communication from an ITS device to a nearby maintenance garage which then ties into fiber communication network

Challenges

• The major challenge is with streaming live video from rural traffic cameras to the Traffic Management Center (TMC) with cellular communications.
• It is possible to dial into a cell modem, but need to minimize bandwidth use.
• Exploring the use of commercially available products that manipulate video data to stream over cellular (e.g. compress video data to use less bandwith)
  - Products to be tested: Qvision and Live View
  - Plan to install three trailer-mounted cameras on a project in Davenport, Iowa during the 2015 construction season. One will be connected to ITS network via directional wireless radio, one will use Qvision's service on a cellular modem, and one will use Live View's service on a cellular modem. There is a need to evaluate capabilities and test the products with TransSuite (IA DOT's Active Traffic Management System software.) This deployment could serve as a test bed for an ENTERPRISE Phase 2 evaluation of Qvision and Live View.

Table 3: Summary of Kansas DOT Interview

Kansas Department of Transportation (KDOT) Interview with Leslie Fowler on 4/8/15
Communication Types Used In Rural Areas
• Fiber communication is the much preferred approach (but access to fiber is limited in rural areas) • Cellular is used for Dynamic Message Signs (DMS) and CCTV camera images
Challenges
• Access to fiber is limited • Occasionally need to travel to sites to reboot DMS • Would prefer to control devices from a web-based Active Traffic Management System (ATMS) • Would be beneficial to transfer full motion video over cellular

Table 4: Summary of Pennsylvania DOT Interview

Pennsylvania Department of Transportation (PennDOT) Interviewed Doug Tomlinson on 4/1/15
Communication Types Used in Rural Areas
• PennDOT does not use a standard approach statewide for determining communications to ITS devices in rural areas. - First consider what coverage is available, such as fiber or telephone (T-1), then determine if wireless is needed - Work closely with Information Technology (IT) personnel to make decisions about how to provide communications to rural ITS devices; especially rely on IT to help with issues such as security. • Cellular Service: - No real issues with cellular (where it is available) - Recently transitioned to 4G - Verizon allocated a portion of bandwidth for PennDOT, which provides increased security and reliability
Challenges
• Access to power for ITS devices in rural areas • Topography - Cellular coverage is limited - Coverage is often needed beyond where fiber coverage exists

Table 5: Summary of Washington State DOT Interview

Washington State Department of Transportation (WS DOT) Interviewed Tim McDowell and Bill Legg on 3/30/15
Communication Types Used
WSDOT has implemented a state-owned, custom-built wireless network that consists of the following three mechanisms: • Core Microwave Infrastructure - Provides high-capacity (155 Megabits/second) communications, using "hub-and-spoke" approach with point to point connections • Medium Capacity Mobile Data System - Medium capacity (64 Kilabits/second) - Works well for transferring text to Dynamic Message Signs (DMS), snapshot images, and Road Weather Information Systems (RWIS) data • "Last Mile" Links - Low capacity, but works for pan-tilt-zoom (PTZ) cameras Cellular (where available) is used in some locations if coverage from the custom-built network is not available. The following benefits of implementing a custom-built network were noted: • Enables Coverage in Mountain Pass Areas - Cellular coverage does not exist in many areas within the mountainous terrain - Because these mountainous areas experience significant snowfall, WSDOT needs access to these locations in order to report road conditions • Communications are Portable - The mobile data system operates from WSDOT vehicles, allowing vehicles to collect road data and transfer it as it is collected so that it may be used to provide traveler information • Avoid Ongoing Service Costs - There is an initial investment for infrastructure, but then the agency avoids ongoing service charges such as a monthly cellular service fee - Capital funds (e.g. grant funding) are typically easier to obtain than operational funds, making the initial infrastructure investment more easily secured
Challenges
• Mountainous Environment - Lack of cellular coverage in sparsely populated areas - Line of site required for microwave communications; many base stations required when using this approach • Access to Power - Often difficult to access commercial power in rural areas • Tribal Lands - Unable to install infrastructure on tribal lands

4. Determination of Phase 2 Scope

During the April 2015 ENTERPRISE in-person board meeting in Phoenix, AZ, the interview summaries from Section 3 of this report were presented to Board members. Upon consideration of the needs and challenges presented, a number of options for the Phase 2 of this project "Demonstrate and Evaluate Rural Communications to Support Rural ITS" were discussed.

Per this discussion, the following options were suggested for the Phase 2 scope of work:

- Demonstrate and evaluate one or more satellite communications technologies in a rural setting;
- Demonstrate and evaluate one or more commercially available products (e.g. Qvision, Live View) for transferring video data over cellular in a rural setting; and
- Research and explore potential solutions to automatically poll (i.e. "ping") ITS devices in the field from a remote location, checking for malfunctions, power outages, and communications outages.

It was determined that a survey would be sent to ENTERPRISE members, to rate the options above and to suggest any additional Phase 2 scope options for consideration.

4.1 Member Survey to Rate Options

The ENTERPRISE member survey to request input on preferences for the Phase 2 scope of work included the following basic questions:

1) Three scope options were suggested for Phase 2 during the April ENTERPRISE Board Meeting. Rate each option using the scale provided (no interest, low interest, medium interest, or high interest.) For each area of interest, provide input on the following: What would you like to learn from the project? What parameters should be evaluated?
    - Option 1: Demonstrate and evaluate one or more satellite communications technologies in a rural setting.
    - Option 2: Demonstrate and evaluate one or more commercially available products (e.g. Qvision, Live View) for transferring video data over cellular in a rural setting, including integration with ATMS software. (Note: Iowa DOT has initiated an effort to install three trailer-mounted cameras on a project in Davenport, Iowa. One will be connected to their ITS network via directional wireless radio, one will use Qvision's service on a cellular modem, and one will use Live View's service on a cellular modem. Tim Simodynes has offered that this could serve as a test bed for evaluation of the use of Qvision and Live View if members are interested.)
    - Option 3: Research and explore potential solutions to automatically poll (i.e. "ping") ITS devices in the field from a remote location, checking for malfunctions, power outages, and communications outages.
2) Please provide any other demonstration/evaluation options you would like to suggest for consideration.

Five ENTERPRISE agencies responded to the survey: Iowa DOT, Idaho Transportation Department, Minnesota DOT, Pennsylvania DOT, and Washington State DOT. Table 6 shows results from the survey.

Table 6: Results from ENTERPRISE Member Survey

Survey Results		
Ratings for Option 1: Demonstrate Satellite	**Ratings for Option 2: Demonstrate products to assist with video transfer**	**Ratings for Option 3: Explore solutions to remotely check operability of ITS devices**
No interest – 1 ***Low –2*** ***Med – 2*** High – 0	No interest – 0 ***Low – 1*** ***Med – 2*** ***High – 2***	***No interest – 1*** ***Low – 2*** ***Medium – 1*** ***High – 1***
What would you like to learn? What parameters should be evaluated?		
• Best practices, feasibility, cost, issues • Coverage, cost, bandwidth • Available bandwidth, service coverage area, line of sight (through foliage)	• Best practices, feasibility, cost, issues • Video quality and connection reliability • Quality of video transfer, integration with ATMS. • IADOT could be a testbed, for evaluating Qvision and Live View	• Is this different than what would be done by command and control software (ATMS)? • Will I need a stand-alone website to interface with the ping results? • We have been using IPMonitor to do this for years
Provide any other demonstration/evaluation options you would like to suggest for consideration		
• We have struggled with wireless in a rural environment (challenging terrain, trees, etc.) • Wide-Area Wireless Technology - like deploying our own LTE network (similar to MTO). • Tracking mobile equipment locations remotely (e.g. sharing with District staff where their DMS are). Our cell modems have GPS capabilities but it hasn't been reliable and often returns a location of 0,0.		

4.2 Emphasis and Tasks for Phase 2

Based upon responses received from the survey of ENTERPRISE Board members, budget available, and concurrence at the July ENTERPRISE Board webinar, the following emphasis and tasks will comprise the Phase 2 scope of work:

Task 1: Evaluate Products for Streaming Full Motion Video over Cellular

- Coordinate with Iowa DOT to document the test deployments that include three trailer-mounted cameras in rural areas:
  - 1 camera connected to the ITS network via directional wireless radio
  - 1 camera using Qvision on a cell modem
  - 1 camera using Live View on a cell modem
- Develop evaluation criteria and an assessment plan, investigating factors such as:
  - Feasibility, cost, video quality (resolution and frame rate), video compression (MPEG4, H.264, etc.), connection reliability, integration with ATMS, and best practices for use of each approach deployed
- Collect available data and input from Iowa DOT and conduct the evaluation
- Document findings in a final report

Task 2: Explore Potential Solutions for Checking Operability Status of ITS Devices Remotely

- Conduct a survey and/or interviews, to document current DOT practices
  - Systems or software used, devices connected to, functions performed, accuracy, reliability, cost, issues experienced
  - If a system is not used for remotely checking operability of ITS devices, what needs exist?
- Research tools and systems commonly used in utilities industry, such as those used to check for operability of gas lines, water systems, and electrical systems, to learn whether similar systems might be applicable to ITS devices.
- Explore the viability of potential solutions, such as updates to ATMS software, off-the-shelf products, or other options
- Document findings in a final report