Communications and Power Improvements for Rural ITS Field Devices (Showcase Evaluation #10)

Final Report

by

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GLOSSARY OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
CCTV	Closed-circuit Television Camera
CDPD	Cellular Digital Packet Data
COATS	California Oregon Advanced Transportation Systems
DMS	Dynamic Message Signs
DOT	Department of Transportation
FCC	Federal Communication Commission
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
ISDN	Integrated Services Digital Network
ITS	Intelligent Transportation Systems
LAN	Local Area Network
LMDS	Local Multipoint Distribution Service
LMRS	Land Mobile Radio System
POTS	Plain-old Telephone System
RF	Radio Frequency
RWIS	Road Weather Information System
SOC	Satellite Operation Center
SOCCS	Satellite Operation Center Command System
SOFC	Solid Oxide Fuel Cell
3G	Third generation
TOC	Traffic Operation Centers
TOCC	Transportation and Operation Communication Centers
TMC	Transportation Management Center
VMS	Variable Message Signs
WLL	Wireless Local Loop

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EXECUTIVE SUMMARY

Many rural areas lack an integrated communications or power infrastructure that can support the deployment of intelligent transportation systems (ITS). As a part of the California Oregon Advanced Transportation Systems (COATS) Showcase project, the Western Transportation Institute at Montana State University conducted a study to document case studies of innovative solutions for addressing the communications and power needs of ITS field devices deployed in a rural environment. This project report provides the most recent information on current technologies and strategies utilized by transportation agencies throughout the country to supply communications and power to ITS field devices at remote sites.

A Project Evaluation Team was assembled to assist in the study. The team, composed of representatives from the California and Oregon Departments of Transportation (Caltrans and ODOT, respectively) and the Federal Highway Administration (FHWA), provided valuable advice and recommendations in conducting the project.

This report consists of three chapters. The first chapter reviews literature regarding applicable communications and power alternatives that have been evaluated or deployed in rural areas. There are more options available to mitigate the communications problem than power source alternatives. Solar power is being considered as a primary energy source to empower devices at both urban and rural areas. Other sources of energy such as wind generators and propane fuel cells are, however, being explored to complement or replace solar power, especially by states that suffer through long winters and harsh environment.

Chapter 2 provides a summary of an online survey conducted among all 50 States' Departments of Transportation (DOT's). The survey consisted of three basic questions regarding each state's experiences in the deployment of video and non-video (high and low bandwidths) applications and alternative power sources in rural areas. Twenty-six responses were received from 23 state agencies for a 44 percent response rate. Responses were entered into a database to allow queries to be conducted on each individual question.

Upon reviewing the survey report, the Project Evaluation Team suggested that the reported video (high bandwidth) and non-video (low bandwidth) communications applications are generally standard approaches. Thus, no communication applications were selected for further investigation. With the power source alternatives, however, the team recommended gathering additional information from the participating state DOT's that had indicated using or experimenting with the wind powered and thermal electric generators and propane fuel cells.

Chapter 3 reports on the follow-up inquiries that were sent to the agencies with selected power source alternatives. Having few moving parts, wind generators were reported as very reliable power sources. Not much information was provided on propone fuel cells. ODOT indicated using thermal electric generators, which use a propane fuel source and a thermopile to generate electricity. The generator has no moving parts and therefore is fairly low maintenance. Alaska DOT is currently experimenting with Solid Oxide Fuel Cells (SOFC) to provide power to remote weather stations. The cells were reported to be highly efficient and durable.

Coordinated efforts on national and/or state levels appear to enhance the coverage and technology of the wireless communications means. The State of California, for example, through the Department of General Services has a contract that provides telecommunications services for all state agencies. The contract includes voice and data services, ability to purchase telecommunications equipment, technical support, and a planned consolidated billing system. Similar efforts might be found helpful in improving the current shortfalls of communications needs in rural areas.

The lack of power sources in rural areas is also an issue when deploying ITS in rural locations. Wind generators and propane fuel cells are two alternative power sources that some states are currently using or experimenting with to complement or replace the solar energy. Wind generators are known for their efficiencies and low maintainability. Although, propane fuel cells are still at their experimental stage, they are being considered as another promising source of energy for rural areas.

1. LITERATURE REVIEW

1.1. Introduction

Rural accident fatality rates are much higher than in urban areas (1). Rural traffic accidents account for 28 percent of the total national crashes, but account for 56 percent of the total number of fatalities. Agencies are challenged to deploy ITS elements to improve transportation safety and mobility in their jurisdictions, yet many rural areas often lack an integrated communications and power infrastructure that could support such deployment.

Rural ITS applications include: traveler safety and information, emergency services, public transit and mobility, infrastructure operations, and commercial vehicle operations (2). Many of the communication technologies and power sources used in urban settings are not applicable or cost effective to address these applications. This chapter reviews the applicable communications and power alternatives that have been evaluated or deployed in rural areas.

1.2. Rural Communications and Power Challenges

Cellular and satellite are the primary methods of communications, but are not available or applicable in every situation (3). Cellular coverage in rural areas is not as intense as urban areas, but has been increasing over the years. Cellular sites cover 90 percent of the U.S. population and 70 percent of the country's land mass. The development of cellular systems in rural areas has largely depended on the local demand (4).

Satellite communication is not as limited in coverage as cellular. Satellite is able to send transmissions in many areas where cellular is not available. Though the availability to link satellite communication is better than cellular, the communication is not typically continuous. The lack of continuous communication limits the satellite applications.

Fiber optic is another communications medium that is being used in some rural applications for communication when the device is close to a town that has the network available. There is immense expense in extending fiber optic cable to remote locations – a base cost of $10 per foot for microtrenching that may increase substantially depending upon local topography.

The lack of power sources in rural areas is also an issue when deploying ITS in rural locations. In some instances it may be miles to the nearest power source and it is not cost effective to link to the source. Different technologies have been used to empower rural ITS technologies, including solar, wind, and fuel cells. In some environments these options may not be feasible. For example, Alaska experiences long time periods with little or no sun light, limiting the use of solar energy ().

It is evident that some rural ITS applications need unique communications and power devices. The following sections describe some of the applicable systems used in rural areas.

1.3. Communications Technologies

A number of different communication technologies are now available, including: cellular, satellite, fiber optics, standard phone lines, broadband, and analog/digital microwave. Since rural areas normally do not have access to landline communications, wireless communication is often used. Not all communication technologies are feasible for all projects. Factors being considered when choosing a communication technology are: cost, availability, amount of data being transmitted, and frequency of data transmission.

1.3.1. Cellular

One of the most popular communication technologies in the past years has been cellular. Many ITS applications, both in rural and urban areas, utilize cellular technology for communication. A common use of cellular services in rural areas is communication with mobile or fixed variable message signs (VMS).

Colorado DOT (CDOT) installed a large number of VMSs along rural areas of Interstates 25 and 70 to convey weather conditions, incident management information, and real-time route guidance during roadway delays (5). Traffic Operation Centers (TOCs) throughout Colorado transmit information to the VMSs by means of cellular-based technology. Due to the rural environment of most VMSs, cellular communication was the only option. CDOT is currently installing direct hard-wired fiber-optic lines for future communications. The fiber-optic lines will allow for more responsive and instantaneous connections.

Arizona DOT has also implemented VMSs in key locations throughout Arizona (6). Arizona has been challenged with issues of power and telephone service. Most of the signs are remotely controlled by dial-up landline modems. If no landline is available, and the cost is prohibitive, cellular telephones are used.

Cellular technology can also be used for other applications. Many states have installed emergency call boxes in rural areas. Many of these emergency call boxes are cellular-based. CDOT installed cellular emergency call boxes in key locations to help provide faster response to emergencies ().

Another possible application for cellular communication is transmission of data from rural areas to TOC or other users. Due to Alaska’s unique environment, the Alaska Department of Transportation and Public Facilities (ADOT) has investigated different communication technologies to use for the transmission of data for the Road Weather Information System (RWIS) (7). The RWIS stations in Alaska provide valuable information on weather conditions to multiple agencies in Alaska. ADOT is currently investigating whether cellular technology is able to transmit RWIS data to users. Other communication technologies being considered are: cable modems, IP telephone system, Land Mobile Radio System (LMRS), satellite communication, and spread spectrum radios.

Third generation (3G) wireless technologies, a fairly new cellular technology, have been developed for global coverage for speech and low-to-medium byte rate data services (). High byte rate services will be available in a limited coverage area. Prospective rural ITS devices include slow-scan or real-time video transmission.

1.3.2. Satellite

The different satellite systems available for data transmission include GEO systems, the Little LEO system, and the Big LEO system. Using satellite technology in rural areas is valuable when in extreme remote areas (). Mountainous areas sometimes have no form of communication available.

To test satellite technology for rural ITS, satellite transmission was used to collect data from a permanent traffic monitoring station near the town of Walkill in New York, located in the Catskill Mountains (8). The site in Walkill used a telemetry system to transmit data. A wireless transmitter periodically communicated with the traffic-monitoring device to download data and/or other information as desired by the user. The user then downloaded the data off of the designated server for a monthly fee of $30 to $40.

Major drawbacks with satellite technology are the long transmission delay and non-continuous communication, which limits satellite technology to certain ITS devices.

1.3.3. Broadband Radio Frequency

Broadband refers to communication technologies that use larger portions of radio frequency (RF) (9). There are two main unlicensed spectrums used in ITS technologies: 2.4 GHz and 5.8 GHz. Broadband communication can range from two to 30 miles, depending on technology and environment. Broadband technologies have been used for remote traffic controller data communications (). They have also been used for video surveillance and vehicle detection (). Caltrans uses wireless cameras for surveillance of the San Francesco Bay Bridge. The video is transmitted eight miles to the Caltrans building.

Many companies provide wireless technologies that are applicable for rural ITS devices. Technology determination depends on data transmission speed and amount, and range of transmission. States such as Alaska have considered using broadband to communicate with RWIS stations. Many other states use broadband RF to transmit data to/from work zones, RWIS stations, or CCTV surveillance.

1.3.4. Fiber Optics

When available, fiber optics may be used as an alternative communication for large data amounts. Data transmission with fiber optic lines is typically over long distances, but can also be used for short-range communication. Georgia DOT (GDOT) installed an automated fog warning system on part of Interstate 75 (10). The warning system includes 19 fog sensors, five sets of traffic loops for each direction, four CMSs, and CCTV cameras in front of each CMS. The sensor data are transmitted to an on-site computer by a fiber optic communications network. Warnings and speed advisories can be automatically posted on the CMSs by the computer, and the TMC in Atlanta is automatically notified. Telephone lines are used to transmit data to the

TMC. CCTVs are also connected to modem phone lines so that each sign can be viewed to confirm messages.

1.3.5. Digital/Analog Microwave

Microwave systems in rural areas have been used to transmit high capacity data over long distances (). Microwave systems have been used for communications where wireline transmission is not available or too costly.

New microwave technology, Local Multipoint Distribution Service (LMDS), is now available. LMDS uses the 28 GHz spectrum and is designed to transmit interactive voice, video, and data signals within small cells of two to ten miles diameter (). LMDS appears to be a good alternative to fiber and coax data communication in rural areas, but requires licensing by the Federal Communication Commission (FCC). LMDS, used along with Wireless Local Loop (WLL), provides a good telecommunication alternative for rural areas.

1.3.6. Multiple Technologies

Minnesota DOT (Mn/DOT) has established Transportation and Operation Communication Centers (TOCCs) to help gather and deliver transportation information for rural or smaller urban areas (11). Some of the TOCCs control various roadside ITS devices, cameras, VMSs, and vehicle detection. Communication technologies used by the TOCCs to communicate with the ITS devices include telephone service, wireless telephone service, twisted pair copper, fiber optics, and local cable providers. Mn/DOT also is upgrading the analog microwave network to a digital microwave network.

Having utilized the Internet successfully to distribute traffic data (i.e. vehicle speeds in a corridor and camera images) to the public, Caltrans modified the existing code of the Satellite Operation Center Command System (SOCCS) software to also control field devices such as Closed Circuit TV (CCTV) systems and changeable message signs (CMS) from anywhere within Caltrans' network (12). This implementation has brought immediate benefits to California's rural districts by providing command and control capability to Satellite Operation Centers (SOCs) and Transportation Management Center (TMCs), eliminating standalone field device control systems and the ability to use existing networked workstations already deployed in a TMC.

1.4. Power Sources

Solar energy is the most common power source currently being used to empower rural ITS technologies. Other alternative sources being explored by the agencies include wind and fuel cells power generators.

1.4.1. Solar

Using solar energy for power has been a concept for over a hundred years. Advances in technology have allowed solar energy to become less expensive and more appropriate for commercial use. Solar panels are commonly used to provide power in remote areas. Energy received by the panels is stored in a battery. The satellite system, for example, in Walkill, New York requires 12V DC power charged with solar panels mounted on top of the cabinet (8). This energy generated and stored in batteries can then power electronic devices overnight or during times of extended cloud cover.

With Alaska's extreme environment, power supply is a challenge. ADOT has considered self-contained power modules for RWIS sites where other forms of power are unavailable (7). The power modules consist of a room with a generator, AC/DC control panels, a battery bank, and RWIS controls. The battery bank provides power for all electrical devices. The generator recharges the batteries either by demand, or by a voltage regulator. A solar panel on the roof is also used during summer months to recharge the batteries.

1.4.2. Wind

Similar to solar energy, wind has been used for many years to help power machines. Due to technology advances, wind turbines have become a popular form of energy generation in the past few years. New technology is allowing small wind turbines to be placed on rural ITS devices to provide power or back up power to solar or conventional power supplies. The North Dakota and Wyoming DOT's reported using wind generators as alternative power sources to empower the states' RWIS and supplement solar power applications, respectively.

1.4.3. Propane Fuel Cells

ADOT has considered several alternatives to power their RWIS stations, including a propane generator and fuel cell technology. The propane generator engine operates at 2,600 RPM, and consumes 0.37 pounds of propane per hour at 500 watts (7). The propane generator is expected to cost $570 for six months. The fuel cell consists of two 500-watt fuel cells and three 150-pound hydrogen tanks. The hydrogen tanks need to be changed on a regular basis, increasing the cost and limiting its installation in extreme rural areas. The University of Alaska is evaluating propane as a hydrogen source for solid oxide fuel cells to use in an avalanche detection study.

1.5. Concluding Remarks

Many rural areas lack an integrated communications or power infrastructure that can support the deployment of ITS technologies. There are more options available to mitigate the communications problem than there are power source alternatives. Solar power is being considered as a primary energy source to empower devices in both urban and rural areas. Other sources of energy are, however, being explored to complement or replace solar power, especially by states that suffer through long winters and have a harsh environment.

2. PRELIMINARY SURVEY OVERVIEW

2.1. Overview

To learn more about other state transportation agencies' practices for addressing the communications and power needs of rural ITS field devices, WTI conducted an online survey. The survey consisted of three questions regarding each state's experiences in the deployment of video and non-video (high and low bandwidths) applications and alternative power sources in rural areas. Copies of the survey and the cover letter are included in Appendix A.

The survey was distributed through David Ekern, associate director of the American Association of State Highway and Transportation Officials (AASHTO), to AASHTO's 52 member agencies (including the District of Columbia and Puerto Rico). The survey reached about 110 individuals in two Subcommittees of the Standing Committee on Highways: the Subcommittee on System Operations and Management and the Subcommittee on Advanced Transportation Systems (ATS). These subcommittees deal mostly with ITS issues.

Twenty-six responses (including four from different district/offices within the Virginia DOT) were received from 23 state agencies for a 44 percent response rate. Responses were entered into a database to allow queries to be conducted on each individual question. Responses, grouped under each question, are listed in detail in Appendix B.

This chapter provides a summary of the survey responses. Under the Project Evaluation Team's direction, the information was used to identify promising communications technology and alternative power sources.

2.2. Question 1: Video Communications Technology

Question 1 inquired whether the state agencies employ video (high bandwidth) communications technology. Out of 26 responses, 19 agencies (73 percent) indicated employing such technology. CCTV was reported as a primary application of the technology.

Ada County Highway District in Idaho indicated using fiber optic communications for its network of CCTV cameras in the Boise area. Louisiana DOT stated deploying CCTV cameras on its urban freeway segments for traffic monitoring and video detection. Maryland State Highway Administration's CCTV cameras, deployed at more than 60 locations, are providing visual information on traffic congestion, incidents and roadway conditions during inclement weather to more than 40 multi-jurisdictional command centers in the three-state region. Utah DOT generates CCTV images for the public to access on its state traffic information website, CommuterLink.

Minnesota employs the technology in its Twin Cities Traffic Management Center and in TOCCs in a few other cities. Missouri DOT indicated applying the technology in video surveillance for urban freeway and arterial traffic management. California DOT (Caltrans) applies the video streaming at 56 Kbs (using satellite), and at 11 Mbs using the 802.11b standard. North Dakota extensively uses the technology for signal activation, traffic counts, vehicle classification, and surveillance at its Road Weather Information Systems (RWIS) sites. California, Louisiana, Rhode Island Transportation Management Center, South Carolina, and Tennessee DOT's stated having some leased T1 services as mediums for video. Oregon DOT uses a Pelco Codec to compress video and move more than one video stream on a T1.

2.3. Question 2: Non-video Communications Technology

Almost all respondents (25 agencies) indicated employing the non-video communications technology. Dynamic message signs (DMS), highway advisory radio (HAR), and RWIS are the primary applications of the technology indicated being used among most responding agencies. Indiana DOT communicates with its DMSs and HARs via modem. Louisiana connects its HARs via cellular dialup and DMSs via normal landline dialup services. Maryland uses ISDN to communicate with its DMSs. Caltrans uses cell phone and leased telephone lines to control CMS and HAR systems. The ISDN was being used because it is advantageous from a cost perspective, not because it is necessary to have the higher bandwidth.

Mn/DOT's non-video technology includes communication with traffic signal systems, traffic monitoring devices (loops and other non-intrusive devices), remotely activated bridge de-icing systems, RWIS, two-way radio connection with maintenance vehicles and state patrol vehicles, and state patrol vehicles equipped with Mobile Data Computers. Other applications listed by the responding agencies are listed as:

- Traffic data collection via radio polling
- RTMS radar vehicle detectors via a 900 MHz spread spectrum radio
- Fog detectors
- Web cameras
- Flashing beacon control
- Electronic toll collection
- Communicating between TMCs and field elements

Smart Traffic Center of the Virginia DOT indicated using dial up connections to reach its DMSs located in rural areas. Getting power and phone lines to the areas has been very expensive for the center.

2.4. Question 3: Alternative Power Sources

Twenty-one responding agencies (81 percent) indicated using alternative power sources to empower ITS field devices. The most typical alternative power source used by respondents was solar, normally backed up with battery packs. In addition to solar power, California, North Dakota and Virginia DOT's indicated using wind generators. Caltrans indicated using wind generation and air-alkaline batteries to provide power to their Roadside Radio Repeaters, and radio equipment at mountaintops. Washington DOT stated employing propane fuel cell and solar as power sources. Oregon DOT uses thermal electric generators to power remote sites. Wyoming is currently evaluating wind power to supplement solar power applications. Louisiana indicated using solar power to regenerate battery power for RTMS detectors. The maintenance, however, has proven to be problematic.

The aforementioned alternative power sources are being used to empower portable signal systems, variable message signs (VMS), video cameras, RWIS, and DMS.

2.5. Additional Comments

Communications has been identified as a key element in Minnesota's ITS Strategic Plan. Reiterated by the Minnesota Guidestar Board, expansion of wireless communications is seen as essential in the ability to bring the benefits of ITS to the rural areas where many of the most serious crash and fatalities issues are. Virginia DOT shares this concern, and is presently investigating the use of wireless LAN on two sections of Interstate 81.

Upon the selection of promising communications technology and alternative power sources, the associated agencies were contacted a second time for further information (detailed in Chapter 3).

3. CASE STUDIES

3.1. Overview

The preliminary survey conducted among the state transportation agencies was to identify case studies of innovative solutions for addressing the communications and power needs of rural ITS field devices. Upon reviewing the survey report, the Project Evaluation Team suggested that the reported video (high bandwidth) and non-video (low bandwidth) communications applications are generally standard approaches (e.g., CCTV, HAR, DMS, RWIS, and traffic surveillance). Thus, no communication applications were selected for further investigation. With the power source alternatives, however, the team recommended gathering additional information from the participating state DOT's that had indicated using or experimenting with wind power, thermal electric generators and propane fuel cells.

The North Dakota, Virginia, and Wyoming DOT's indicated using wind-powered generators to empower their RWIS stations and supplement solar powered applications. Wind generation was among the power supply sources that Caltrans indicated using to empower their mountaintops' Roadside Radio Repeaters and radio equipment. Thermal electric generators were indicated being used to power remote sites in Oregon. The Washington DOT was the only agency that indicated using propane fuel cells as an alternative power source.

Follow-up inquiries (via emails and phone calls) were sent to California, North Dakota, Oregon, Virginia, Washington, and Wyoming DOTs. They were asked to provide more information on how these generators are working, what products are being used, cost, any lessons learned, and any other information that might be useful to other state DOTs.

3.2. Wind Generators

The North Dakota, Virginia, and Wyoming DOTs provided additional information on their wind generators. North Dakota indicated using the Southwest wind power Airfoil 3 model. They are being used at three of their 17 RWIS sites throughout the state to supplement their solar powered generators. The generator has three 46-inch diameter blades that generate 400 watts of power under a 26 mph wind speed. It is a 12-volt model with a built-in regulator. With only two moving parts, the generator is almost maintenance free. During the summer time the blades are removed. The cost is $500 per unit. More information on this particular wind generator can be obtained from www.southwestpv.com.

The Virginia DOT indicated using wind generators to power a weather station on Interstate 77. This site has been utilized to provide power for a weather array as well as providing power for a wireless repeater site for the new weather and visibility system that covers the 32-mile corridor of Interstate 77 with a total of 14 detection sites. This system is in the testing/acceptance phase and is operating as expected. The complete installation cost about $60,000 and the work was done by three of the department's signal technicians. The power plant consists of ten 800-amp hour batteries as the storage medium, a solar array of four 2 × 4 foot panels, and a Whisper 9000 wind generator that is rated at 900 watts output. The battery cabinet contains a voltage regulator allowing the charge rate setting to be specified in volts per cell in the batteries. Total power generated is about 1,500 watts, which is more than what the station requires. The described power source has been pretty reliable. The only trouble reported in nearly six years, other than a one-time replacement of the regulator, was one gunshot to one of the solar panels.

Wyoming DOT indicated using the AIR403 wind generator (Southwest Wind and Sun) to supplement solar power applications. They have about five installed at this time; two of the sites have a solar panel to provide back up for the wind power. The wind generators have been installed for about three years. There had been one breakdown with a bad regulator and two stolen ones. The equipment was then mounted atop a 30-foot mast to stop the thefts.

3.3. Propane Fuel Cells

Fuel cells are electrochemical devices that combine hydrogen with oxygen to produce electricity, heat and water. The Washington DOT staff person who had indicated using propane fuel cells as an alternative power source was unable to provide any additional information about their experience in this area.

The Oregon DOT indicated using thermal electric generators, which use a propane fuel source and a thermopile to generate electricity. It has no moving parts and therefore is fairly low maintenance. The generators come in various sizes from 15 watts to around 500 watts. The generator costs about $5,000. Complete installation with the propane tank, control panel, etc. is probably close to $20,000. The operating costs are higher than for a utility connection, but this provides reliable power for remote sites. Oregon only has a couple of these generators. No vandalism has been reported so far; vandalism has tended to be more of a problem with solar cells. More information on these thermal electric generators can be obtained through the vendor website: http://www.globalte.com/intro.htm.

Rime icing at high elevations in Alaska's coastal passes remains a formidable challenge. ADOT is currently negotiating a partnership with the University of Alaska at Fairbanks to deploy Solid Oxide Fuel Cell (SOFC) provide power to remote weather stations. SOFC operates on nearly 50 percent natural gas. It is highly efficient and durable.

4. FINAL REMARKS

One of the most significant challenges to deploying intelligent transportation systems (ITS) devices in rural areas is accommodating these devices' communications and power needs. Effective communications is seen as essential in the ability to bring the benefits of ITS to the rural areas where many of the most serious crash and fatalities issues are. Providing power is also a key element but it is found to be somewhat less problematic than the communication issues.

Coordinated efforts on national and/or state levels appear to enhance the coverage and technology of the wireless communications means. The State of California, for example, through the Department of General Services has a contract that provides telecommunications services for all State Agencies. The contract includes voice and data services, ability to purchase telecommunications equipment, technical support, and a planned consolidated billing system. Similar efforts might be found helpful in improving the current shortfalls of communications needs in rural areas.

The lack of power sources in rural areas is also an issue when deploying ITS in rural locations. Wind generators and propane fuel cells are two alternative power sources that some states are currently using or experimenting with to complement or replace the solar energy. Wind generators are known for their efficiency and low maintenance requirements. Although propane fuel cells are still at their experimental stage, they are being considered as another promising source of energy for rural areas.

APPENDIX A: SURVEY FORM

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Communications and Power Improvements for Rural ITS Field Devices

Survey

The California and Oregon Departments of Transportation are interested in learning about the other state transportation agencies' practices for addressing the communications and power needs of rural intelligent transportation systems (ITS) field devices. This survey is a part of the rural California/Oregon Advanced Transportation Systems (COATS) evaluation project being conducted by the Western Transportation Institute (WTI) at Montana State University.

Your agency's responses to the survey will help both agencies to develop guidelines for future deployment of ITS devices in rural environments. WTI will prepare a report based on the survey results, and copies will be provided to respondents who request one (see below). Thank you in advance for your assistance in this important project.

Please distribute the survey to the appropriate staff member(s) to complete. This survey would probably be best completed by personnel in your organization's Traffic Management's Office, or equivalent.

Please submit the completed survey by **December 23, 2002**. Please feel free to contact me if you have any questions or concerns.

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Question 1

Do you employ video (high bandwidth) communications technology? Yes o No o

If yes, please list the applications.

Question 2

Do you employ non-video (low bandwidth) communications technology? Yes o No o

If yes, please list the applications.

Question 3

Do you use alternative power sources (solar, fuel cell, wind-powered, etc.) to empower ITS field devices? Yes o No o

If yes, please identify the sources and typical applications.

Comments

Please provide your comments.

APPENDIX B: SURVEY RESPONSES

Question 1. Do you employ video (high bandwidth) communications technology?

State	*Organization*	*Response*	*Remarks*
AL	Alabama DOT	Yes	Closed-circuit television (CCTV) cameras, ATC
CA	California DOT	Yes	Full NTSC video using spread spectrum, FEMA licensed frequencies, microwave radio and fiber optics. Video streaming at 56 Kbs (using satellite), and at 11 Mbs using the 802.11b standard. Using leased telephone lines (ISDN, T1) for video teleconferencing.
ID	Idaho DOT	Yes	Ada County Highway District (ACHD) uses fiber optic communications for its network of CCTV in the Boise area (I-84, I-184, and arterial streets).
IN	Indiana DOT	Yes	At this time we are using wireless microwave communications to bring our video to our traffic management center in Northwest Indiana (suburban Chicago).
KS	Kansas DOT	Yes	We are using fiber optics and microwave to transmit video from 5 cameras around the KC Speedway into a command center. This is near the KC Metro area but the installation at this time is stand-alone with future plans to integrate into the KC Scout System. We are also installing fiber optics for the KC Scout System that will be operational late 2003.
LA	Louisiana DOT	Yes	CCTV cameras deployed on urban freeway segments for traffic monitoring & video detection. Technology includes running compressed video (MPEG 2) over a fiber ATM network & also wireless ethernet at 5.9 GHz. Also have some leased (T1) services for video.
MD	State Highway Administration	Yes	Video verification in the CHART ATMS is provided by pan and tilt CCTV cameras (currently at over 60 locations) which provide visual information on traffic congestion, incidents and roadway conditions during inclement weather to over 40 multi-jurisdictional command centers in the three-state region. Each camera uses 384 Kb/sec (1/4 T1) and is consolidated at regional ATM switches for transmission throughout the network.
MN	Minnesota DOT	Yes	Twin Cities Traffic Management Center and at out state Transportation Operations and Communication Centers (Duluth and Saint Cloud and soon in Rochester and Mankato) for traffic conditions and incident monitoring.
MO	Missouri DOT	Yes	ATM/SONET, IP/SONET, and analog video over fiber. Fiber optic systems include DOT owned, shared DOT/city ownership and public/private partnership. We have also experimented with low bandwidth video applications (dial-up and leased lines).

State	Organization	Response	Remarks
ND	North Dakota DOT	Yes	We have started using video for signal activation. This video will also be used for counts, classification, etc. Some of the larger cities in ND are also using this technology. We also use video for surveillance and at road weather information system (RWIS) sites.
OR	Oregon DOT	Yes	We use International Fiber Systems– VT4930WDM for locations where we have access to fiber. We have also used microwave and spread spectrum wireless options to transmit video short distances. We also use commercial T1 service. In these cases we use a Pelco Codec to compress video and move more than one video stream on a T1. The product is a PelcoNet 101T/R.
PA	Pennsylvania DOT	Yes	
RI	Rhode Island Transportation Management Center	Yes	T-1 Lines
SC	South Carolina DOT	Yes	Point to point and multiplexed fiber optic cable; DS 3 (15 mbs) leased line; T-1 leased line; wireless LAN for IP video.
TN	Tennessee DOT	Yes	Using T1 phone lines but in an urban area. None in rural areas.
UT	Utah DOT	Yes	We are generating CCTV images for the public to access on our State traffic information website Commuter Link. We also are using high bandwidth for our State LAN connections (i.e., Center to Center inter-ties).
VA	Virginia DOT	Yes	We are just testing some wireless applications.
VA	Virginia DOT - Staunton District	Yes	Use 802.11b wireless equipment from camera to high-speed internet access point (T1) belonging to local education centers. All cameras are digital with a web server.
WA	Washington DOT	Yes	Microwave, Sonnet Fiber, WSDOT LAN.
AZ	Arizona DOT	No	
NH	New Hampshire DOT	No	
NY	New York DOT	No	
VA	Virginia DOT	No	
VA	Virginia DOT	No	
WV	West Virginia Division of Highways	No	
WY	Wyoming DOT	No	

Question 2. Do you employ non-video (low bandwidth) communications technology?

State	***Organization***	***Response***	***Remarks***
AL	Alabama DOT	Yes	Dynamic message signs (DMS)
CA	California DOT	Yes	Use 47 MHz, 450 MHz, 800 MHz, microwave radio equipment (analog and digital), and leased telephone lines (T1 and analog) for voice communications. 800 MHz radio equipment for irrigation systems control. Cell phone and leased telephone lines to control CMS and HAR systems. Wireless (CD/PD), leased telephone lines and fiber, for communications between our TMCs and the field elements. Wireless for PDAs (including Palm, Blackberry devices). Leased telephone lines (TI, T3, OC-3, OC-12), fiber optic, satellite and digital microwave radio for WAN and LAN applications. satellite for electronic toll collection (FASTRAK).
AZ	Arizona DOT	Yes	Use plain-old telephone system (POTS) for data and still frame photos. Also use analog cellular for data and still frame.
ID	Idaho DOT	Yes	Control of DMS via dial up modems. Data collection at traffic counting stations via dial up modem. Data collection for the road report via radio polling.
IN	Indiana DOT	Yes	We currently communicate with our dynamic message signs and highway advisory radio via modem in Indianapolis. However, we are constructing our wireless microwave backbone system here in Indy now. By summer of 2004 we should be communicating with these devices via microwave. Our Northwest Indiana (suburban Chicago) system is fully operational via wireless microwave.
KS	Kansas DOT	Yes	We are currently using cellular modems to transmit RWIS and variable message sign (VMS) information. The VMS are portable signs placed in a semi-permanent location.
LA	Louisiana DOT	Yes	RTMS radar vehicle detectors are communicated over a 900 MHz spread spectrum radio. Highway advisory radios are connected with cellular dial-up. DMS include normal land-line dial up service.
MD	State Highway Administration	Yes	We use ISDN to communicate with our DMS and POTS to dial-up to our portable DMS and Highway Advisory Radios (HAR). The ISDN is used because it is advantageous from a cost perspective, not because it is necessary to have the higher bandwidth.

State	***Organization***	***Response***	***Remarks***
MN	Minnesota DOT	Yes	Non-video communications includes communication with various traffic monitoring and control devices statewide. This includes traffic signal systems, traffic monitoring devices (loops and other non-intrusive devices), remotely actuated bridge de-icing systems, Road/Weather Information Systems, two way radio connection with maintenance vehicles and state patrol vehicles, data to state patrol vehicles equipped with Mobile Data Computers (soon about 70 percent) of the fleet and Automatic Vehicle Location equipment with maintenance and state patrol
MO	Missouri DOT	Yes	We are using low bandwidth communications for traffic signal interconnect, weather stations, traffic count stations, advanced warning devices, etc. Mediums include dial-up telephone, DOT owned twisted pair (analog FSK), Cellular Digital Packet Data (CDPD), analog and digital radio systems (licensed and unlicensed applications) and low bandwidth fiber (i.e. traffic signal interconnect).
ND	North Dakota DOT	Yes	We use this for gathering data for RWIS.
NH	New Hampshire DOT	Yes	
NY	New York DOT	Yes	Traffic monitoring, video detection
OR	Oregon DOT	Yes	We collect still-frame video and other data with a variety of methods. These include dial-up telephone, 56 k frame relay and wireless options. We use an Axis 2400 or Gyyra Tango II JPEG camera server for our still frame video capture.
PA	Pennsylvania DOT	Yes	
RI	Rhode Island Transportation Management Center	Yes	Standard telephone lines
SC	South Carolina DOT	Yes	Dial-up telephone leased line
TN	Tennessee DOT	Yes	Using fiber in a LAN in a rural area for communication between DMS, fog detectors, HAR and local control center. Between local control center and remote center (40 miles) using microwave.
UT	Utah DOT	Yes	We are using low bandwidth connections for basically all other ATMS devices (VMS, Traffic Monitoring Stations [TMS], RWIS/EES, HAR, Mobile Data Terminals, PDA's, AVL, Signals, WIM).
VA	Virginia DOT	Yes	Using dial up connection we have several DMS located in some rural areas, which have cost us great amounts to get power, and phone to them.

State	***Organization***	***Response***	***Remarks***
VA	Virginia DOT	Yes	Variable Message Signs (5), Weather Stations (3)
VA	Virginia DOT - Staunton District	Yes	Some use dial-up with digital camera.
WA	Washington DOT	Yes	Dial up phone - land line and cell (some used for video image transmission), 900 MHz.
WV	West Virginia Division of Highways	Yes	Communications systems with roadway sensors and relay communications within a fog detection system.
WY	Wyoming DOT	Yes	DMS Sign Control, RWIS Data Collection, Web Cameras, Traffic Monitoring Stations, Flashing Beacon Control
VA	Virginia DOT	No	

Question 3. Do you use alternative power sources to empower ITS field devices?

State	***Organization***	***Response***	***Remarks***
AZ	Arizona DOT	Yes	Use solar panels with battery for locations which are inaccessible by hard wire electricity due to cost or permitting land ownership issues.
CA	California DOT	Yes	We are using solar, wind generation and air-alkaline batteries to provide power to our Roadside Radio Repeaters, and radio equipment at mountaintops. We have looked at fuel cells, but do not have enough information or experience in order to implement them.
ID	Idaho DOT	Yes	Solar panels on portable signal systems used on construction projects.
IN	Indiana DOT	Yes	We do have some, but not all, devices powered with solar & battery back-up. The solar works quite well.
KS	Kansas DOT	Yes	Our cameras located around the KC Speedway area are powered by solar. The VMS located in District 3 also use solar power.
LA	Louisiana DOT	Yes	Solar used to regenerate battery power for RTMS detectors. This has proven to be problematic in maintaining.
MN	Minnesota DOT	Yes	We are testing some solar power with battery backup for remote devices.
MO	Missouri DOT	Yes	We use solar power at a few locations. Solar is chosen where utility power is not available or not cost effective.
ND	North Dakota DOT	Yes	We use solar panels and wind generators on our RWIS. Also, have solar on some of our ATR sites.
NH	New Hampshire DOT	Yes	Solar panels - to power traffic data collections devices, and WIM equipment.
NY	New York DOT	Yes	Solar to run DMS and RWIS
OR	Oregon DOT	Yes	We have used both solar cells and thermal electric generators to power remote sites.
PA	Pennsylvania DOT	Yes	Solar - Portable VMS
RI	Rhode Island Transportation Management Center	Yes	Solar VMS
SC	South Carolina DOT	Yes	Solar power. CCTV and RVD applications.
UT	Utah DOT	Yes	SOLAR: Interstate ramp merge beacons, HAR Beacons, RWIS, TMS (PAD's), Bryce Canyon N.P. CCTV, Portable VMS's

State	***Organization***	***Response***	***Remarks***
VA	Virginia DOT	Yes	We have used both solar and wind for a weather station on I-77.
VA	Virginia DOT - Staunton District	Yes	Solar powered Road-Weather Information sites (traffic detector, camera, environmental). No PTZ on cameras.
WA	Washington DOT	Yes	Propane fuel cell, solar
WV	West Virginia Division of Highways	Yes	We utilize a solar array to provide power at a remote fog detection location. This power is used primarily to provide communications.
WY	Wyoming DOT	Yes	Solar - This power source is used when commercial AC power is not available. Wind Power - This technology is currently be evaluated to supplement solar power applications. Solar power is used for Road Closure flashing beacons, HAR flashing
AL	Alabama DOT	No	
MD	State Highway Administration	No	But we want to!
TN	Tennessee. DOT	No	
VA	Virginia DOT	No	
VA	Virginia DOT	No	

Comments

State	*Organization*	*Comments*
AL	Alabama DOT	None
CA	California DOT	The State of California, through the Department of General Services has a contract that provides telecommunications services for all State Agencies. The contract, CNT-001 (formerly known as CALNET) includes voice and data services, ability to purchase telecommunications equipment, technical support, and a planned consolidated billing system. All State Agencies are required to procure telephone and data services from this contract. The contractors are SBC (Pacific Bell) and MCI.
AZ	Arizona DOT	None
ID	Idaho DOT	None
IN	Indiana DOT	None
KS	Kansas DOT	None
LA	Louisiana DOT	None
MD	State Highway Administration	None
MN	Minnesota DOT	Communications has been identified as a key element by the Minnesota Guidestar Board in its Implementation Plan based on the board's ITS Strategic Plan. Effective communications including expanded wireless communications is seen as essential in the ability to bring the benefits of ITS to the rural areas where many of the most serious crash and fatalities issues are. Providing power is also a key element but we find it to be somewhat less problematic than the communication issue in Minnesota.
MO	Missouri DOT	We are also exploring additional radio data applications for mobile and rural use. These are low bandwidth applications using the High-VHF, Low-VHF and HF radio bands. Please contact us if you need more information.
ND	North Dakota DOT	None
NH	New Hampshire DOT	None
NY	New York DOT	Other applications to follow in future.
OR	Oregon DOT	None
PA	Pennsylvania DOT	None
RI	Rhode Island Transportation Management Center	None

State	***Organization***	***Comments***
SC	South Carolina DOT	None
TN	Tennessee DOT	None
UT	Utah DOT	None
VA	Virginia DOT	None
VA	Virginia DOT	None
VA	Virginia DOT	Presently, exploring the use of wireless LAN for two sections of I-81. Working with Virginia Tech. Transportation Institute (VTTI) to develop and deploy project.
VA	Virginia DOT - Staunton District	In the future, all field devices (except overhead VMS) will try to use solar power for power. For comm., a wide variety of solutions will be used, but wireless is being investigated. All equipment will be digital IP addressable with user configurable addresses, not hard coded firmware. All software will be web-based accessible with browsers and log-on passwords.
WA	Washington DOT	Although your questions appear straightforward I was not sure if you wanted responses about bandwidth (a measure of the quantity of data that can be transmitted as we define it) vs. band (where on the frequency spectrum the application falls). An example that could be confusing would be having a microwave backbone with low capacity transmission equipment. at each end. In theory microwave is a high bandwidth application (i.e. high capacity data transmission) but can be operated at low bandwidth based on what equipment is used to support the backbone. So having a microwave system does not in itself mean that the system is operating as a high bandwidth/high capacity system.
WV	West Virginia Division of Highways	None
WY	Wyoming DOT	None

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