EXECUTIVE SUMMARY

INTRODUCTION

Since the completion of the pioneering I-40 Corridor ITS Strategic Plan in 1997 (1) and the 1998 Statewide ITS Strategic Plan (2), the Arizona Department of Transportation (ADOT) has deployed and maintains a considerable inventory of intelligent transportation infrastructure (ITI) in rural Arizona. This study evaluated the performance of eighteen key elements of ADOT's rural ITI to help focus the Agency's resources on the most useful devices and systems.

STUDY OBJECTIVES

The objectives of this research were to:

1) Measure the performance and document the benefits of the deployed systems and ADOT's rural ITS program;
2) Identify and document current operating and maintenance (O&M) costs and issues;
3) Determine travelers' perceptions and reactions to rural ITS elements; and
4) Determine how well ADOT has adhered to the 1998 Statewide ITS Plan's vision.

STUDY METHODOLOGY AND FINDINGS

Information on previous deployment plans, typical and actual costs and benefits, relevant performance measures, and evaluation methodologies was acquired via literature review. Study stakeholders provided extensive feedback on usage, performance, and costs of deployed ITI and on unmet rural ITS needs. Stakeholders and related data collection activities included:

1) Project Technical Advisory Committee (TAC)–Five meetings, needs scoring matrix;
2) ADOT Districts – Interview meetings with key staff in all 10;
3) Transportation Technology Group (TTG) – Two meetings and other communications;
4) Regional Traffic Engineering Offices (RTEOs) – participation in District interviews and other communications;
5) Information Technology Group (ITG) – phone interview;
6) Motor Vehicle Division (MVD) - survey;
7) Equipment Services – e-mail;
8) The Department of Public Safety (DPS) – participation in District interviews, survey;
9) The National Weather Service (NWS) – phone interview;
10) Neighboring state departments of transportation (DOTs) - survey;
11) Equipment vendors and consultants – phone interviews, websites and e-mail;
12) Commercial vehicle operators (CVO) - survey; and
13) The general public - survey.

Study conclusions and recommendations were derived with significant TAC input. The following page presents the key findings for each of the eighteen ITS elements studied:

	ITS Element	Outputs	Outcomes/Benefits	Costs
Surveillance and Data Collection Systems	Road Weather Information Systems (RWIS)	Wind, temperature, precipitation, chemical	Plowing & deicing operations; dust storm prediction/warning; additional data for National Weather Service (NWS); traveler safety	Capital cost - $137,200-145,200 per site; annual operating & maintenance (O&M) costs - $170/$3,328 per site
	Passive Acoustic Detectors (PAD)	Speed, volume, occupancy	Supplement automatic traffic recorder data; improves employee safety	Integral part of RWIS stations; about $2,500 per unit.
	Remote Cameras (CCTV)	Camera images (still frame)	Verify current weather and pavement conditions; public can access images	Capital cost to install 2 cameras at existing VMS site: $20,000
	Speed Detection/ Warning Devices	Speed warning messages	Reduced 85th percentile speed 18%; improved safety/reduced repair costs	Capital cost for pilot installation on existing structure - $48,820
	License Plate Readers	License plate matches (11%-data from 2001)	96% of incentive was collected; improved level of service/reduced delay	Incentive to maintain travel time: <1% of project cost
Information Fusion and Dissemination Systems	Highway Condition Reporting System (HCRS)	Traveler information entries (12,450/year – data from 2000 2002)	Improved project and emergency communications; traveler information is quickly available to the public	$270,000 to develop HCRS; $62,000/yr for data entry labor; monthly maintenance costs
	Traveler Information via Telephone (511)	About 344,000 calls / year (data from 2003)	Less demand on public agency staff for information; public relations; better travel decisions; easy to remember	$270,000 to develop voice interface; $85,000-system upgrades; $137,000/yr O&M; promotion
	Traveler Information via Internet (az511.com)	75 million hits/yr; 10 million page views/yr (data from 2003)	Less demand on public agency staff for information; public relations; better travel decisions; restrictions data access.	System hardware/software development & maintenance costs; promotion costs
	Overhead Variable Message Signs (VMS)	About 8,800 messages/year (data from 2003)	Less demand on public agency staff for information and congestion management; better travel decisions	Capital costs - $385,000; O&M costs - $1,035/$2,478/year
	Shoulder-Mounted VMS	Speed warnings; steep grades ahead/HAR frequency messages	Safety improvements; lower infrastructure repair costs	Installation - approx. $70,000 per sign; O&M costs – under $1,000/yr (estimated)
	Portable Trailer-Mounted VMS	Many deployments/ year	Deployment flexibility; ease of set up; better travel decisions.	Solar $925/mo.; diesel $450/mo (Equipment Services rates)
	Highway Advisory Radio (HAR)	HAR messages (broadcast as needed or continually)	Effective part of public outreach program for construction projects; better travel decisions.	Typical turnkey cost $1,900/ month (includes licensing, setup, maintenance, removal)
Commercial Vehicle Electronic Clearance	Portable Traffic Signals	Traffic signal indications	As flagger replacement, reduces labor costs, improves safety (more visible).	About $70,000 to purchase; rental $200 to $300/day
	Commercial Vehicle Electronic Clearance (PrePass)	85% of trucks bypass during times ports are open (data from Aug. 2004)	Improve business environment by port automation; improve compliance/ enforcement; more economic delivery of goods; fuel savings; reduce truck wear and tear; improve on-time service	Equipment installation free; labor costs for creating software/database links - minimal. PrePass funded by others.
	Expedited Processing at International Crossings (EPIC)	Average queue wait time	Improved port throughput and compliance verification; increased security, efficiency, traffic management; public access to queue wait time information	Construction costs: about $700,000; Systems integration: $275,000; Annual O&M costs $30,000.
Emergency Detection and Response Systems	Instrumented Truck Escape Ramps	Intrusions detected: 37/ramp/yr (data: Jan-Sep 2004)	Improved agency coordination; improved safety; improved emergency response and ramp repair time	$227,350-design/instrument two ramps; $16,200/yr/ramp for O&M
	Emergency Roadside Callboxes	153/yr/callbox; calls requesting services: 18% (data from July 2003-June 2004)	Improved incident response time; identification of call location; increases public sense of safety; booster antennas increase cellular communications range	US 93: $6,845/site to install (low; other costs absorbed by concurrent project); $1,720/yr/site for O&M
	Rural Nighttime Motorist Assist Patrols (MAPs)	124 assists/year (data from 2001-2003)	Public relations; quickly assess needs; relieve Department of Public Safety resources; improved incident response time/safety; accident prevention	Bid item on current US 93 project represents less than one-half percent of total project cost - $150,000 for 30 month project

STUDY CONCLUSIONS

ADOT has succeeded in introducing many ITS elements into mainstream rural highway operations. Variable Message Signs (VMS), Road Weather Information Systems (RWIS), and remote cameras have become indispensable, standard equipment within ADOT's rural districts. Relative to the mid- and late 1990's, rural ITS in Arizona has advanced from the introduction and tentative acceptance stage to nearly universal use and the associated maintenance and operational considerations.

Performance and Benefits

The following briefly summarizes ADOT attitudes and/or plans with regards to underdeployed ITS elements:

- ADOT plans to deploy more RWIS, remote cameras and VMS statewide as these systems have a strong positive impact and are in high demand within the rural districts.
- Continuing ADOT efforts to improve and promote 511 and az511.com (e.g., via static 511 signs) will broaden these systems' user base and increase their effectiveness.
- Based on benefits and level of interest expressed by non-user Districts, good candidates for expanded deployment are: shoulder-mounted VMS, HAR, emergency roadside callboxes, and motorist assist patrols. Less popular but also providing benefits are speed detection/warning devices, license plate readers, and instrumented truck escape ramps.

ADOT has installed many ITS elements that contribute to safety, mobility and cost reduction, and has worked steadily to improve system reliability and usefulness. Further actions ADOT can take to improve the performance of underperforming ITS elements include:

- RWIS – improve communications and sensor reliability;
- 511– improve voice recognition and navigation;
- az511.com – improve content presentation/quality (accuracy, timeliness), and provide for low-bandwidth access;
- Highway advisory radio – improve quality of content and reception;
- PrePass electronic clearance at Arizona ports of entry – improve compliance; and
- Emergency roadside callboxes – reduce hang-ups and driver misunderstanding, and expand coverage.

Operating & Maintenance Costs and Issues

A substantial O&M funding commitment to deployed ITS elements is required. Failure to maintain equipment causes negative perceptions of ITS among the driving public and can create liability issues for ADOT. The practice of requiring RTEOs to provide maintenance for RWIS and VMS has drawbacks (insufficient funding, training, parts inventory and manpower). Some equipment vendors do not always provide the hoped-

for level of support, or do so at a high price. It is hoped that the recent contract outsourcing RWIS maintenance works well; other ITS elements may benefit from similar or alternative arrangements.

Traveler Perceptions and Reactions

- Combining CVO and public survey results, respondents ranked information dissemination systems, both by level of awareness and by use frequency as: VMS, az511.com, 511, and HAR. The same ranking holds in perceptions of these systems' contributions to safety, mobility and cost savings.
- A large majority of CVO respondents were aware of PrePass and instrumented truck escape ramps; these systems are perceived as contributing to safety and cost savings.
- More than half of public respondents were aware of emergency roadside callboxes; less than a quarter were aware of the one active rural nighttime motorist assist patrol. However, a large majority views the systems as contributing to safety. The public's awareness of these systems is relatively high, given their very limited deployment.

ADOT Adherence to the 1998 Statewide ITS Strategic Plan's Vision

ADOT's vision of the statewide rural ITS program (which guided the 1998 Statewide ITS Strategic Plan) was: "To have new, innovative ITS technologies operational statewide, providing a safer and more efficient intermodal transportation system, meeting the short and long-term needs of visitors, local communities, commercial operators, and the traveling public" (3: 1). Some key words in the vision statement and brief comments about how well ADOT has adhered to that vision follow:

- Innovative: ADOT has been a national leader with the Highway Condition Reporting System (HCRS) and 511 innovations. Within ADOT, the Kingman District has demonstrated creative ways of securing funding for ITI and in maximizing the utility of available technology by deploying combinations of devices, such as the shoulder-mounted VMS used for advance notification of active Highway Advisory Radio (HAR), with speed detection/driver warnings also, or the well-utilized instrumented truck escape ramps. The District is also leading the way in continued deployment of emergency roadside callboxes on remote highways and motorist assistance patrols.
- Operational statewide: ADOT has deployed and operates rural ITS elements and the HCRS program across the state.
- Safer/efficient: ADOT and the public generally perceive that rural ITS elements contribute to safety and efficiency.
- Short/long-term needs: The ITS plan accounts for short and long-term deployment horizons.
- Visitors, local communities, commercial operators and the traveling public: ADOT has deployed ITS benefiting all of these user groups.

STUDY RECOMMENDATIONS AND ACTION PLAN OUTLINE

ITI Maintenance

An inadequate level of available maintenance resources is perhaps the largest roadblock to continued mainstreaming of ITS solutions into ADOT's rural highway management tool chest. Insufficient maintenance funds are often the reason that ADOT Districts may be hesitant to deploy new ITS devices or systems. While ADOT has taken first steps to contract outside maintenance resources for the key infrastructure (VMS and RWIS), a more in-depth approach is required to address the ITI maintenance needs. Programming of funds for future ITI deployments must include realistic maintenance budgets. Vendor contracts should be structured to prohibit gaps in preventive maintenance and parts replacement. More focused deployment of the top priority, best performing ITI may help offset any deficits in capital caused by increasing maintenance budgets.

Incident Management

Feedback by ADOT District staff and DPS confirms the need to consider further investment of resources in incident response and associated traffic management issues on remote rural highways in Arizona. Issues to consider include more reliable communications options on remote highway segments to facilitate quicker incident notification. ADOT or DPS should consider installing more emergency callboxes, perhaps utilizing radio bands outside of the cellular spectrum, based on ADOT's or DPS' existing radio equipment, where cell coverage is not readily available, or other innovative solutions.

Integration of ITS Resources

Integration of traveler information is a top priority. The key common information integration and dissemination system in operation by ADOT is the HCRS/511 system. The system should be continuously expanded to allow timely integration of information provided through standalone dissemination systems, such as portable trailer-mounted VMS and HAR. To facilitate more timely updates of construction-related delays, a remote HCRS interface for personal digital assistant (PDA)-type devices could be conceived and implemented, allowing on-site personnel to update local status via a cellular phone or PDA.

Deployment of remote cameras should continue wherever there is available communications equipment, such as on VMS and as part of RWIS. The more dense the network of strategically placed cameras and other sensors, the more useful the overall sensor/surveillance system becomes to any one district. Over the past decade, ADOT has made a significant investment in RWIS infrastructure, and in incorporating RWIS sensor data into the daily maintenance process. While data from existing RWIS stations is used where available, an exponentially greater benefit could be achieved with additional RWIS placed to systematically cover key segments of selected highway corridors.

Innovation

Sharing of innovative uses of ITI among the Districts should be strongly encouraged. For example, Kingman District's instrumented "smart" truck escape ramps on State Route (SR) 68 have proven useful beyond expectations. The systems could become standard equipment for any new escape ramps in the state, as well as selected existing ones.

Utilizing the resources already available to ADOT, the Districts can enhance safety of travel on rural corridors. For example, new portable VMS come equipped with radar speed detectors. A number of these VMS have been converted to semi-permanent installations on US 93, displaying "SLOW DOWN" messages upon detecting a speeding vehicle. ADOT should consider making such use of the portable VMS a standard application, whenever and wherever the devices are available for use in this manner.

Keeping up with Growth

One by one, traditionally rural communities in the state are becoming more urbanized as the population grows. Through careful deployment planning, ADOT needs to ensure that those areas are appropriately served by available ITS.

Recommended Actions by System

<u>A. Surveillance and Data Collection Systems</u>

1. For RWIS, upgrade communications to digital cellular, satellite, or radio. Consider other data sources (NWS, airports, observers). Request NWS weather emergency notification. Provide bucket-truck-ready pullouts at pole-mount sites or use truss towers. Upgrade software to allow temporary polling frequency changes.
2. Consider portable Passive Acoustic Detection (PAD) or other non-intrusive technology for conducting traffic counts.
3. Consider using speed detection/warning devices on curvy mountain roads and at transitions from higher to lower speed limits.
4. Consider license plate readers for travel time estimation on projects with long detours, high business impact, or high road user costs. Require backup system or assign penalty for downtime.

<u>B. Information Fusion and Dissemination Systems</u>

1. Upgrade HCRS program to allow verification of 511 audio messages and to interface with HAR systems.
2. For 511, expand marketing, improve Voice Response Activated System (VRAS) and provide more user-friendly menu options.
3. For az511.com, offer data in a format that better accommodates Internet access for users with low-bandwidth connections, i.e. 56 Kbps modems (many of whom live in rural areas); list HCRS events automatically.
4. Strive for data quality and completeness.
5. Customize traveler data via route registration and data dissemination to 511, website, e-mail and pagers.

6. For VMS maintenance, consider improved RTEO funding and training or a specialized statewide team, and add catwalk extensions to VMS sign structures that currently require lane closures.
7. Consider HAR for construction project outreach, with broadcast quality, communications links, update frequency, and mode of operation (continuous broadcast versus broadcast only when a new message is available) as factors. Consider using HAR to provide international or state border crossing information.

C. Traffic Control & Commercial Vehicle Electronic Clearance Systems

1. For portable traffic signals, consider hard-wiring power or having a backup power supply. For one-lane section control, consider use of signals or flaggers, with costs, visibility, high-profile vehicles, driver expectations and DPS support as factors. For temporary replacement of damaged permanent signals, consider use of portable or temporary signals, with estimated length of time and rental costs as factors.
2. For PrePass, train ports of entry on reporting of violations. Install mainline weigh-in-motion at all PrePass-equipped ports of entry.

D. Emergency Detection and Response Systems

1. For instrumented truck escape ramps, review images to identify high-risk trucks/companies to target in outreach efforts. Consider instrumenting additional ramps in Arizona, with ramp location, accident experience, traffic level, availability of communications, and level of roadway use by high-risk trucks/companies as factors.
2. In any expanded use of emergency roadside callboxes, consider accident experience, traffic levels, DPS coordination, ADA (Americans with Disabilities Act) compliance, communications, and system self-diagnostics.
3. Consider expanding use of Motorist Assist Patrols (MAPs), with accident experience and traffic levels as factors. Consider making MAP operators state employees. Consult existing operators to help specify vehicle requirements, equipment lists and job requirements, and to train new operators.

E. General – Strategic Vision for ITS in Arizona

1. Review ADOT project prioritizing methods. Consider application of performance measures and quantification of benefits (if practical) from this study.
2. Update Statewide ITS Strategic Plan; prioritize new construction and features; take technology changes, funding constraints, system goals, need priorities and usage experience into account.
3. Incorporate ITS concepts into driver education. Institute outreach program to introduce children to ITS concepts; this could include school presentations and a "kids only" portion of the az511.com website. **Educating the driving public** on the use of traveler information resources, the availability of motorist assistance resources, and compliance with signs, signals, and traffic control, e.g. in construction zones is critical to improving the effectiveness of rural ITS. In particular, there is strong need to continue the 511 publicity in order to encourage more drivers to use the available highway conditions information.
4. Create opportunities for Districts to share practical rural ITS ideas and experiences.

RESEARCH SUMMARY

In meeting its stated goals and objectives, this first unified effort to evaluate deployed ITS in rural Arizona accomplished the following:

- A comprehensive, practical, goal-based evaluation methodology to measure the performance and effectiveness of ADOT's rural ITS program and of individual rural ITS elements was established, using a combination of universal and element-specific performance measures.
- Rural ITS stakeholders and information resources were identified and contacted and a wealth of information pertinent to the evaluation and assessment of ADOT's rural ITS program and of individual rural ITS elements was obtained and organized.
- The information was analyzed, with particular emphasis on rural ITS innovations in the Kingman District.
- A gap analysis identifying and prioritizing unmet needs helped in the formulation of a preliminary action plan for addressing the unmet needs.
- Conclusions addressing the core project objectives were identified.
  - The performance and benefits of rural ITS elements were identified, including identification of underdeployed and underperforming elements.
  - Operating and maintenance costs and issues were identified. Overall, rural ITS maintenance appears to be underfunded, and some creative alternative maintenance arrangements have been implemented.
  - Traveler perceptions and reactions to rural ITS elements were documented. Travelers are growing in familiarity with rural ITS elements, even those that are deployed only locally, and generally feel that they contribute significantly to desirable outcomes such as safety, efficiency and cost savings.
  - ADOT has largely adhered to the 1998 Statewide ITS Strategic Plan's vision.
- Recommendations were formulated about future rural ITS deployment, performance measurement and promotion.

In summary, ADOT now has in hand baseline information with which to make informed decisions about future expenditures for additional rural ITS deployments and enhancements. It is expected that implementation of this study's recommendations will help improve the quality of ADOT's rural ITS services.