Rural ITS Progress Study – Arizona 2004

Final Report 570

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16. Abstract

This research was an evaluation of the Arizona Department of Transportation's (ADOT's) intelligent transportation systems (ITS) in rural Arizona, with the objectives of 1) Measuring the performance and documenting the benefits of deployed systems and ADOT's rural ITS program; 2) Identifying and documenting operating and maintenance (O&M) costs and issues; 3) Determining travelers' perceptions and reactions to rural ITS ser-vices; and 4) Determining how well ADOT has adhered to the vision of its 1998 ITS Strategic Plan. Eighteen ITS elements were selected for detailed study. The methodology included: literature review (earlier ITS plans, performance measures); surveys of and interviews with institutional users (ADOT, Department of Public Safety, other agencies) and the general public; ITS infrastructure performance data collection and information analysis.

The study concluded that: 1) ADOT has succeeded in mainstreaming the use of high-profile ITS elements (Variable Message Signs, cameras, Road Weather Information Systems) within rural Districts and has suitable plans for deployment/enhancement of these devices and systems; 2) Several other ITS elements are worthy of broader deployment; 3) Overall performance of most deployed systems is good; 4) Key needed improvements should focus on field equipment performance, communication systems, central software, information quality and format, maintenance, and public outreach; 5) O&M costs for rural ITS are substantial; 6) Maintenance of ITS systems is a high priority for ADOT both for operational and potential liability reasons; 7) Travelers are gaining familiarity with and perceive ITS elements as useful; and 8) ADOT has adhered well to the 1998 ITS Strategic Plan's vision.

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SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
	ILLUMINATION			
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
	FORCE AND PRESSURE OR STRESS			
lbf	poundforce	4.45	Newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	KPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.315	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
	TEMPERATURE (exact)			
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
	FORCE AND PRESSURE OR STRESS			
N	Newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

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ACKNOWLEDGMENTS

ADOT's Tim Wolfe (Transportation Technology Group) and Sam Elters (Kingman District Engineer), served as project champions. Steve Owen was the Project Manager for this pioneering *Rural ITS Progress Study*. Each ADOT District provided a wealth of valuable information on the performance of the ITS devices under their control. The Department of Public Safety actively participated in the study throughout its duration. A project Technical Advisory Committee, listed below, gave guidance and support to the Consultant team.

Technical Advisory Committee (alphabetically)

Team Member	Agency
Carl Burkhalter	ADOT Flagstaff District
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Sam Elters	ADOT Kingman District
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Bill Harmon	ADOT Safford Maintenance
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ABBREVIATIONS

Term	Definition
511	Toll-free telephone number for traveler information; statewide, regional and citywide systems have been and are being deployed
911	Toll-free telephone number for emergencies; an existing nationwide resource
AAA	American Automobile Association
ADA	Americans with Disabilities Act of 1990
ADT	Annual Daily Traffic (average daily traffic volume on a roadway)
ADOT	Arizona Department of Transportation
ALISS	Accident Location Identification Surveillance System - ADOT's vehicle accident database
AM	Before noon (Latin: Ante Meridiem)
AMBER	America's Missing: Broadcast Emergency Response (common usage - AMBER plan, AMBER alert).
ARIS	Alternate Route Interactive System
ARTS	Advanced Rural Transportation System
ASO	Administrative services officer
ATIS	Advanced Traveler Information Systems
ATRC	Arizona Transportation Research Center
AVL	Automatic Vehicle Location
AZ511.com	Arizona Department of Transportation web site presenting road conditions and traveler information
AZTech	A regional agency partnership providing an integrated Intelligent Transportation System for the Phoenix metropolitan area
CalTrans	California Department of Transportation
CATV	Cable Television
CCTV	Closed-Circuit Television [camera]
Clarus	Latin for "clear" - the name for the nationwide surface transportation weather observing and forecasting system
CPR	Cardio-Pulmonary Resuscitation
CPU	Central Processing Unit
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operator, or Operations (corporate entity involved in trucking) *interchangeable in this report*
DE	District Engineer
DOT	Department of Transportation
DPS	Department of Public Safety
DSRC	Dedicated Short Range Communications
E-mail	Electronic mail
E911	Enhanced 911

Term	Definition
EDP	Early Deployment Plan
Electronic Message Board	Variable Message Sign (Term used in CVO and public surveys)
EMS	Emergency Management System
EPIC / EPIC II	Expedited Processing at International Crossings (EPIC II is the current system)
ERC	Emergency Roadside Callbox (Referred to as "Roadside Emergency Phone" in CVO and public surveys)
ESS	Environmental Sensor Stations
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
GPS	Global Positioning Systems
HAR	Highway Advisory Radio
HAZMAT	HAZardous MATerials
HCRS	Highway Condition Reporting System (also/originally known as Highway Closure & Restriction System); developed by ADOT for tracking events, incidents and work activities impacting travel on Arizona highways
I-[#]	Interstate [Number]
ISP	Internet Service Provider
ITG	Information Technology Group (ADOT)
ITI	Intelligent Transportation Infrastructure
ITIS	International Traveler Information Interchange Standards
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
KRMC	Kingston Regional Medical Center
LAN	Local Area Network
LOS	Level of service
MAP	Motorist Assist Patrol
Mayday systems	Systems such as wireless communications, crash detection, computer control and GPS to facilitate or automate the notification of authorities about incidents / motorists in trouble
MP	Mile post or mile point
MVD	Motor Vehicle Division
NDOT	Nevada Department of Transportation
NFS	National Forest Service
NMDOT	New Mexico Department of Transportation
NWS	National Weather Service
OH-VMS	Overhead VMS
O&M	Operations and Maintenance
OpComm	Operational Communications
OSH	Occupational Safety and Health (ADOT)

Term	Definition
PAD	Passive Acoustic Detector
PDA	Personal Digital Assistant
PeCoS	Performance Control System
PM	After noon (Latin: Post Meridiem)
POE	Port of Entry
PrePass	An electronic system automating the clearance of commercial vehicles (allowing bypass at ports of entry)
PSA	Public Service Announcement
PTM-VMS	Portable Trailer-Mounted VMS
RCRS	Roadway Closures and Restrictions System
REP	Roadside Emergency Phone (alternative name for Emergency Roadside Callbox)
RFID	Radio Frequency Identification
RHODES	Real-time Hierarchical Optimized Distributed Effective System
RPU	Remote Processing Unit
RTEO	Regional Traffic Engineering Office
RWIS	Road Weather Information System
SAFER	Safety and Fitness Electronic Records
SM-VMS	Shoulder-Mounted VMS
SPR	State Planning and Research
SR [#]	State Route - used with #
T-1	Telecommunications standard - information transfer rate of 1.544 Mbps – Named for First (1st) ANSI Telecommunications Standards Committee
TAC	Technical Advisory Committee
TDCS	Traffic Data Consolidation System
TOC	Traffic Operations Center
TMS	Traffic Management System
TTG	Transportation Technology Group (ADOT) - responsible for design and operation of the freeway management system and related ITS elements
TTY	Telecommunications Device for the Deaf (also use TDD)
TV	Television
UDOT	Utah Department of Transportation
US [#]	United States Highway - used with #
USDOT	United States Department of Transportation
VMS	Variable Message Sign (same as Electronic Message Board / EMB)
VRAS	Voice Response Activated System
WIM	Weigh-In-Motion
ZIP	Zone Improvement Plan - mailing location code (implemented July 1, 1963)

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.

1. INTRODUCTION

The Arizona Department of Transportation (ADOT) began deploying intelligent transportation systems (ITS) in the early 1990s. The deployments have included both infrastructure (such as field hardware, communications systems, and centralized computers) and software systems (such as databases and database input software, software for control of and communications with field devices, and Internet web pages and content). The remainder of this document refers to specific types of hardware and software that function as a unit (such as variable message signs or the az511.com website) as "intelligent transportation infrastructure" or ITI. "Intelligent transportation systems," or ITS, is used more generically to refer to ADOT's overall program or non-specific types of ITI.

A large portion of ADOT's deployed ITS serves rural areas of the state. This study represents the first unified effort to evaluate deployed ITS statewide. The purpose of the evaluation is to help ADOT in focusing future expenditures and resources on the most useful rural ITI and provide the feedback necessary to enhance the quality of services ADOT provides to the highway users, including traveler information, electronic clearance, emergency support, and so on.

The objectives of this project, *Rural ITS Progress Study – Arizona 2004*, were to:

1) Measure the performance and document the benefits of the deployed systems and ADOT's rural ITS program:
    a) Review operational status of deployed devices and systems
    b) Identify performance issues
    c) Document and confirm utilization of ITS information resources by ADOT and key ADOT partners
2) Identify and document current operating/maintenance costs and issues
3) Determine travelers' perceptions and reactions to rural ITI elements:
    a) Document highway users' awareness and perceptions of rural ITS
    b) Document utilization of ITS information resources by the public
4) Determine to what extent ADOT has adhered to the vision of the 1998 Statewide ITS Strategic Plan.

The workplan for the project consisted of four phases, with a report prepared for each phase. There was significant overlap between these phases on the project calendar. The following is a list of the project phases and the time periods in 2004 during which they were performed:

1) Review of ADOT's ITS Program Concepts and System Design (April 21-June 18)
2) Data Collection and Findings (May 10-October 27)
3) Data Analysis, Conclusions and Recommendations (September 3-October 14)
4) Final Report Preparation (October 14-November 12)

The project technical advisory committee (TAC) included representatives from a number of core ADOT organizations including the Flagstaff, Holbrook, Kingman and Safford Districts, Transportation Technology Group (TTG), Community Relations, Information Technology Group (ITG), and the Arizona Transportation Research Center, as well as the Arizona Department of Public Safety (DPS), the National Weather Service (NWS), and the Federal Highway Administration (FHWA). The TAC was relied upon to identify stakeholders and information resources, review task reports and provide guidance on project methodology, survey instruments, and conclusions and recommendations. The two primary project stakeholders, providing the bulk of the most pertinent information, were the TTG and the ADOT Districts.

At the project kickoff meeting in May 2004, the TAC laid out a plan for the data collection phase, proposing the use of a matrix. The "ITI matrix" featured ITI elements in rows, and the respective data to be collected in columns (4: 2-3). To facilitate comparison, the 18 key ITI identified by the TAC were grouped into four functional groups. Table 1 lists the key ITI grouped by function and provides a brief summary of the extent of deployment of the elements within each group.

Table 1: Key Rural ITI by Functional Groups

Group A ITI: Surveillance and Data Collection Systems	**Group B ITI: Information Fusion and Dissemination Systems**
A1. Road Weather Information Systems (RWIS) A2. Passive Acoustic Detectors (PAD)/Other Traffic Detectors A3. Remote Cameras A4. Speed Detection/Warning Devices A5. License Plate Readers **Deployment Summary:** A1, A2 and A3 have been deployed in about half of ADOT Districts; statewide deployment is anticipated. A4 and A5 have been deployed in the Kingman District only.	B1. Highway Condition Reporting System (HCRS) – Data Entry B2. 511 Traveler Information (511) B3. Traveler Information Website (az511.com) B4. Overhead Variable Message Sign (OH-VMS) B5. Shoulder-Mounted Variable Message Sign (SM-VMS) B6. Portable Trailer-Mounted Variable Message Sign (PTM-VMS) B7. Highway Advisory Radio (HAR) **Deployment Summary:** B1, B2 and B3 are statewide systems. B4 and B6 have been deployed statewide. B5 has been deployed in the Kingman and Globe Districts. B7 has been used in several Districts.
Group C ITI: Traffic Control and Commercial Vehicle Electronic Clearance Systems	**Group D ITI: Emergency Detection and Response Systems**
C1. Portable Traffic Signals C2. Commercial Vehicle Electronic Clearance/PrePass C3. Expedited Processing at International Crossings (EPIC) **Deployment Summary:** C1 has been used statewide. C2 is deployed at state border crossings, mostly on Interstate highways. C3 has been deployed only at the Nogales port of entry.	D1. Instrumented Truck Escape Ramps D2. Emergency Roadside Callboxes D3. Motorist Assist Patrols (MAPs) **Deployment Summary:** D1 and D3 have been deployed in the Kingman District. D2 has had limited deployment, in the Kingman and Tucson Districts.

2. PROJECT BACKGROUND

2.1 RURAL ITS PLANNING AND DEPLOYMENT HISTORY IN ARIZONA

ADOT's rural ITS deployment planning has generally adhered to the standard process developed by the U.S. Department of Transportation's (USDOT) Advanced Rural Transportation Systems (ARTS) program. This process emphasizes linking of transportation needs to user services and market packages, which in turn define needed project/technology deployments.

The two ITS plans that defined the needs and set the future direction of rural ITS in Arizona were the I-40 Corridor ITS Strategic Plan and the Statewide ITS Strategic Plan. Completed in 1997, the I-40 plan paved the way for rural ITS planning in Arizona. The 1998 Statewide ITS Strategic Plan combined the results of previous ITS deployment planning, inclusive of the I-40 plan, into a comprehensive ADOT agenda for the future of ITS in rural Arizona. The 1998 statewide plan identified and prioritized the key **needs** that could be addressed with ITS technologies and selected suitable **user services** and **market packages** to deploy in the short term (1999 to 2001), mid term (2002 to 2007), and long term (2008+) timeframes. The plan also included a phased deployment project plan. See Appendix A for tables summarizing needs, user services, market packages, and deployment projects identified under the Statewide ITS Plan.

Importantly, the 1998 statewide plan drafted a statewide ITS architecture concept, tying together the planned systems into a coherent, integrated and interoperable structure (Figure 1). A critical legacy of the plan was the clearly defined methodology to conduct periodic performance evaluations of the deployed systems, based on data collected before and after deployment and using pre-defined performance measures, including:

- Accident rates and fatalities.
- Coverage of early detection and warning systems.
- Emergency service call-outs and tow truck service calls.
- Mayday system performance and system coverage on rural highways.
- Availability of traveler information and timeliness of traveler data.
- Customer survey data (customer feedback).
- Conformance/response to messages.
- Highway Level of Service (LOS).

Based on the results of the ITS early deployment planning, ADOT developed and continues to maintain a detailed infrastructure deployment plan. This is the *ADOT Statewide Plan: Intelligent Transportation Infrastructure*, also known as the ITI Plan (5). The ITI Plan tracks the planned, programmed, and deployed ITS devices throughout the state, including Variable Message Signs, cameras, Road Weather Information Systems, visibility sensors, and electronic clearance systems at ports of entry into the state.

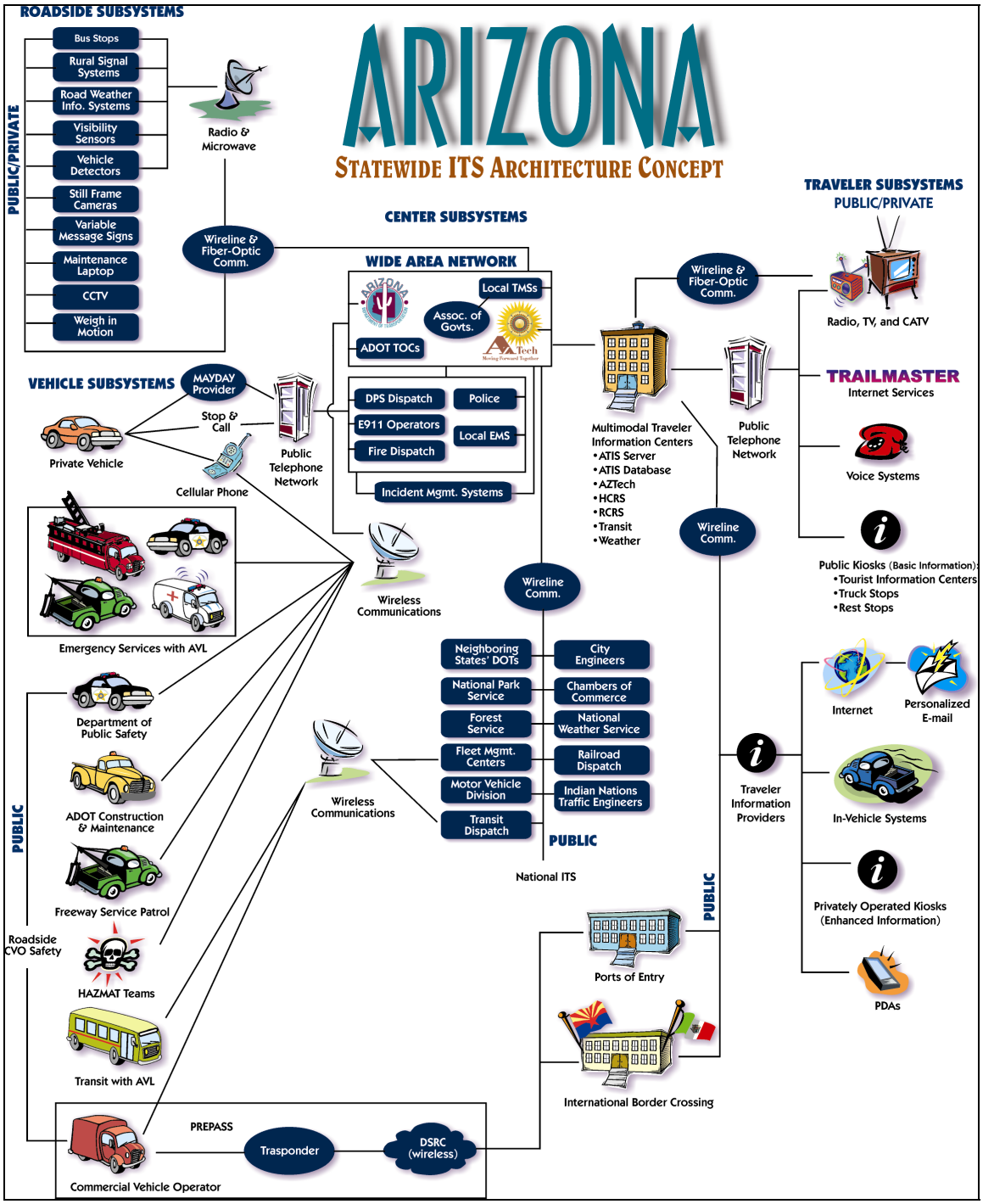

Figure 1: Statewide ITS Architecture Concept - in 1998 (Source: 2:6-3)

The I-40 Corridor Short Term Implementation Plan presents a vision statement that is also representative of rural ITS planning statewide: "To have new, innovative ITS technologies operational (throughout the I-40 corridor), 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). This

vision statement succinctly addresses key goal areas identified by ADOT and its partners (system innovation and functionality, safety and efficiency), user needs (short and long-term), and the rural ITS stakeholders or user groups (visitors, local communities, commercial operators, the traveling public).

2.2 RURAL ITS DEPLOYMENT MODELS

Rural ITI deployments in Arizona fall into one of four physical categories: permanent, semi-permanent, portable and mobile. Rural ITI may be owned or leased by ADOT, its partners, or by both. Most depend on private service providers for power and communications (wireline telephone, wireless telephone, and the Internet). Funding for various ITI has come from a wide variety of sources. Taken together, these aspects of ITI deployment constitute the "deployment model" under which the rural ITI have been implemented in Arizona.

Table 2: Summary of ADOT's Rural ITS Deployment Models

ITI	Type of Installation	Ownership	Service Depen-dencies*	Funding Source(s)
Road Weather Information System (RWIS)	Permanent	Owned (ADOT)	P, T	State Highway Construction Funds
Passive Acoustic Detector (PAD) at RWIS	Permanent	Owned (ADOT)	P, T	State Highway Construction Funds
Remote Camera at RWIS	Permanent	Owned (ADOT)	P, T	State Highway Construction Funds
Remote Camera at Variable Message Sign (VMS)	Permanent	Owned (ADOT)	P, T	District minor funds; in the future, State Highway Construction Funds
Speed Detection/ Warning Device	Permanent	Owned (ADOT)	P	Kingman District
License Plate Readers	Semi-permanent	Leased by Contractor	P, T, M	Construction bid item
Highway Condition Reporting System (HCRS) Data Entry	Permanent	Owned (ADOT)	P, T, I	Phoenix FMS Phase 2 software development
511 Telephone Information	Permanent	Owned (ADOT)	P, T	National 511 Model Deployment funds; ADOT maintenance funds

Table 2 (cont'd): Summary of ADOT's Rural ITS Deployment Models

ITI	Type of Installation	Ownership	Service Depen-dencies*	Funding Source(s)
www.az511.com Website	Permanent	Owned (ADOT)	P, I	TTG; ADOT maintenance funds
Overhead VMS	Permanent	Owned (ADOT)	P, T	District minor funds; State Highway Construction Funds
Shoulder-Mounted VMS	Semi-Permanent	Owned (ADOT) Or Leased (Contractor)	T	Construction bid item
Portable Trailer-Mounted VMS	Portable	Owned (ADOT) Or Leased (Contractor)	T	Equipment Services revolving fund; construction bid item
HAR - Highway Advisory Radio	Semi-Permanent	Leased (Contractor)	T, S	Construction bid item
Portable Traffic Signals	Portable	Leased (Contractor)	P	Construction bid item
Electronic Clearance at Interstate Borders (PrePass)	Permanent	Owned (Vendor)	P, M, I	None required for equipment
Expedited Processing at International Crossings (EPIC)	Permanent	Owned (ADOT)	P, I	ADOT Motor Vehicle Division and Federal Motor Carrier Safety Administration
Instrumented Truck Escape Ramp	Permanent	Owned (ADOT)	T, E	Construction bid item
Emergency Roadside Call-boxes	Permanent	Owned (ADOT)	T	Grant (US 93)
Motorist Assist Patrols	Mobile	Leased (Contractor)	T, R	Construction bid item

* P=Power; T= Telephone; M= Microwave; I= Internet; S= Satellite; E= e-mail; R=Radio

The capital (installation) funding for the key ITI elements (e.g. VMS, RWIS) statewide is centrally controlled by TTG. ADOT Regional Traffic Engineering offices are provided with maintenance funding designed to cover the needs of all ADOT-maintained traffic control devices, including the ITI. ADOT Districts may use excess construction funds to install needed ITI or incorporate certain services, such as the US 93 motorist service patrols, into the project construction budget. ADOT Equipment Services works with Districts to determine appropriate specifications for and numbers of portable trailer-

mounted VMS to be purchased. The requested units are purchased using competitive procurement policy and procedures through ADOT Contracting. Equipment Services then "owns" the equipment and "rents" them to the Districts.

Periodically, ADOT receives demonstration project funds or grants, e.g., ADOT won a $250,000 USDOT grant to fund the I-40 corridor traveler information kiosks deployment in the late 1990s. Other examples follow:

- In 1994, the Governor's Office of Highway Safety awarded a grant to a multi-agency effort called Project Elk Alert. The grant was specified for use in installing two shoulder mounted VMS for elk warnings along State Routes (SR 260).
- In 1999, ADOT's US 93 Mayday research project (6:16-18) recommended the installation of five callboxes along US 93 between milepost 136.8 and milepost 153.6, but the Kingman District had no funding to install them. One research TAC member, a nurse at the Kingman Regional Medical Center (KRMC), took the initiative of applying for a Department of Health Services grant to fund the callboxes. The Kingman District advised the KRMC on the grant application process, and when the grant was awarded, also supported the design and installation of a four-unit callbox system with the available grant money.

2.3 KEY ORGANIZATION ROLES

ADOT Transportation Technology Group (TTG) bears responsibility for planning, funding, installation and maintenance of ITI statewide. ADOT TTG is also responsible for the operation of the Phoenix Traffic Operations Center (TOC), which serves as the focal communications node for all Districts statewide as well as the emerging Tucson TOC. "Amber Alerts" issued by DPS are sent directly to the TOC and represent the TOC's highest priority for posting of VMS messages. The TOC also responds to requests from the ADOT Districts to post VMS messages. The TTG plays an integral role in the establishment of VMS usage policies. TTG staff works with ADOT's Information Technology Group (ITG) to provide hardware and software resources required to integrate the operation of the various ITS resources throughout the state. In doing so, TTG's focus is on field equipment, communications, and the software applications that help control various ITI. ADOT TTG makes a multitude of critical decisions that shape ADOT's rural ITS program, from determining device locations, to selecting specific vendors and products, to contracting for outsourced maintenance support, to identifying and programming the funding for all aspects of the program.

The ADOT Maintenance and Construction Districts are the primary end users of Arizona's rural ITS. Their use of ITS includes monitoring field information systems such as RWIS, updating HCRS events, verifying event accuracy as posted in 511, developing and posting VMS and HAR messages, and sponsoring or providing resources for motorist assist patrols. The Districts field a significant level of phone calls and emails from the public about road and weather conditions and roadwork. In the course of performing these activities, they often coordinate with ADOT TTG, DPS and neighboring state departments of transportation. The Districts typically call on their Regional Traffic

Engineering personnel (RTEO) for support in the event of equipment problems. In the Kingman District, because of the unique nature of some of their rural ITI, some special arrangements have been made for equipment maintenance.

ADOT Information Technology Group (ITG) is responsible for installing and maintaining computer hardware, operating systems, and other software in support of many ADOT functions, including ITS. ITG contributions to rural ITS include: setup of central server systems and telephone lines for the VMS and RWIS remote camera sites; setup of HCRS terminals; setup of 511 subsystems; EPIC subsystems; and the Kingman District's instrumented truck escape ramps. ITG's focus is on providing the foundational hardware and operating systems to which TTG connects field equipment and on which TTG installs central control software.

ADOT Motor Vehicle Division (MVD), particularly the Ports of Entry (POEs), depends on rural ITS elements such as VMS, HCRS, PrePass and EPIC. VMS are used in conjunction with PrePass transponders to provide messages to commercial vehicle operators approaching the POE. Information on load width, clearance heights or other restrictions, available through 511 and based on information posted through the HCRS data entry system, facilitates the issuing or denial of permits. EPIC has recently been enhanced (EPIC II) to further facilitate and streamline international border crossing activities at Nogales on Arizona's border with Mexico.

ADOT Equipment Services Group has responsibility for purchasing new portable ITS equipment such as the portable, trailer-mounted VMS. They provide such equipment to the ADOT Districts at internal rental rates intended to ensure that they can repair or replace the equipment when breakdowns occur.

The Department of Public Safety (highway patrol) provides law enforcement on all of Arizona's state highways. The highway patrol districts coordinate closely with the ADOT districts and TTG on critical matters such as timing and duration of road closures (in the event of heavy snow, dust storms, hazardous materials accidents, etc.) and preparation of resulting detour routes. DPS also initiates "Amber Alerts" and may suggest specific usage for VMS in response to emergencies. DPS officers provide enforcement of reduced speeds and overall traffic control in highway construction zones. Supporting the DPS in rural areas of the state are their own Civilian Reserve volunteers as well as ADOT's motorist assist patrols (MAPs) on US 93. These programs reduce the demand on DPS resources by responding to minor motorist problems. Also, DPS highway patrol officers may be dispatched to respond to calls received from emergency roadside callboxes or to emergencies on truck escape ramps.

DPS Operational Communications Centers are regional dispatch centers that handle emergency ("911") calls, whether they come from regular landline or cellular telephones or from emergency roadside callboxes located along US 93 and I-19.

Neighboring State Departments of Transportation include California, Nevada, Utah, Colorado and New Mexico. A significant level of coordination of ITS-related issues

already takes place with these departments of transportation, often on an informal basis and at a sub-District level. ADOT maintenance staff in areas bordering other states will frequently need to know and communicate with their counterparts across the border (for instance, in response to incidents with potential cross-border impacts). Truck restrictions and other issues associated with the Hoover Dam, located on US 93, naturally require significant coordination with both Nevada and the Hoover Dam Police. Events such as the annual Four Corners Maintenance Conference (Arizona, Utah, Colorado, and New Mexico) are held to discuss shared issues and relevant technologies, including rural ITS. Despite differences in the level of ITS development and commitment to specific technologies in the neighboring states, many of the issues faced are similar from state to state. ITI for which some degree of coordination (or at least mutual understanding) is particularly important include VMS, RWIS, HCRS, 511, HAR and Commercial Vehicle Electronic Clearance (e.g., PrePass).

The National Weather Service (NWS) has an interest in accessing ADOT's RWIS data. While some of the RWIS data is available via the 511 website, the NWS has expressed interest in obtaining more complete data, more directly. At this point ADOT and NWS have not yet worked out all the details of data sharing. In one case, NWS has installed their own field equipment at the ADOT Willcox Maintenance Yard. The data from this equipment originally passed through the Phoenix TOC, but now is linked directly to a NWS computer in the Tucson area. ADOT staff provide a minimal level of support in checking the equipment and/or local computer server if any problems arise.

ADOT's highway contractors are frequently required to use specific ITS elements during construction projects, or, they simply find that certain ITS elements are cost effective to have on hand to enhance work zone safety. As a result, contractors often use or deploy portable trailer-mounted VMS, HAR, license plate readers, MAPs, and portable traffic signals. ADOT district staff frequently interfaces with the contractors throughout the course of highway project to obtain current information about construction activities and provide guidance on use of rural ITS elements, such as messages to be posted on portable trailer-mounted VMS.

Equipment Vendors: ADOT recognizes the need for continuing vendor support after making purchasing commitments to specific makes and models of rural ITS elements. This support is critical both during and after the warranty period. ADOT has established maintenance agreements with vendors to ensure both periodic preventive maintenance support and access to parts when device failures occur.

Third-Party Information Providers: ADOT districts sometimes outsource the public information tasks on construction projects. This frees up ADOT resources to focus on project management. Third-party information providers exist that specialize in providing turnkey HAR systems, from setup to broadcast updates to equipment maintenance and removal at the end of the project. Commercial radio stations, TV stations, and traffic information websites also provide traffic information to the public. This information can come in the form of Public Service Announcements (PSAs), or as regularly scheduled

programming. Such information is obtained both independently and with cooperation from ADOT.

2.4 PRIOR AND CURRENT RURAL ITS ACTIVITIES

ADOT and its partners are involved in research, planning, design, construction, operation, maintenance, and evaluation functions with regard to rural ITI. The following list summarizes some of ADOT's notable prior and current activities with respect to rural ITS. The next section provides details about Kingman District's rural ITS innovations.

- **Research and Planning:** ADOT's Arizona Transportation Research Center has performed many research projects in the past decade with ties to rural ITS, such as:
  - SPR-406: Advanced Traveler Information Systems for Rural Arizona *(not published, refer to 431)*
  - SPR-407: SCAN Weather System Evaluation *(not published; ref. 431, 457, 525)*
  - SPR-416: I-10 / I-17 Phase I Freeway Management System Evaluation
  - SPR-422: Strategic Plan for ITS Communication for Arizona
  - SPR-431: I-40 Corridor Strategic Plan for ITS Deployment (and the Short Term Implementation Plan for Early Deployment of Intelligent Transportation Systems on Interstate 40 Corridor)
  - SPR-435: Incident Management Systems & Strategies: TOC Operations Manual
  - SPR-457: Strategic Plan for Statewide Deployment of ITS in Arizona
  - SPR-466: Fuzzy Variable Speed Limit Device Project (Phases I and II)
  - SPR-473: Arizona Intelligent Vehicle Research Program (Phases I, II, II(b), III)
  - SPR-480: Rural Highway MAYDAY Deployment Plan
  - SPR-481: RHODES-ITMS-MILOS Ramp Metering System Test
  - SPR-485: Arizona Statewide Alternate Route Plan
  - SPR-497: Arizona Statewide Incident Management Plan
  - SPR-507(3): Tourism's Impact on Future Transportation Needs
  - SPR-507(4): Technology and ITS: The Implications for Future Transportation
  - SPR-512: ITS Traffic Data Master System *(in progress)*
  - SPR-513: Alternate Routing Information System (ARIS)
  - SPR-525: Road Weather Information System (RWIS) Communications Plan
  - SPR-532: Variable Speed Limit Research (Phase III) *(not published)*
  - SPR-535: CVISN Safety Information Exchange Needs Assessment, Nogales Port of Entry
  - SPR-542: Congestion Mitigation Resources and Strategies for Arizona's State Highway System
  - SPR-561: Transportation Communications Interoperability: Phase 1 - Needs Assessment
  - SPR-562: ITS Technologies and Mature Drivers

  Additionally, the TTG has developed and periodically updates the ADOT Statewide ITI Plan (5). Currently, ADOT Districts are in various stages of planning for use of ITI. For instance, the Kingman District is considering deployment of "advanced" HAR for dissemination of information for travelers approaching key decision points.

- **Design:** ADOT is involved in ongoing design of ITS infrastructure.
- **Construction / System Enhancement:** ADOT is involved in ongoing construction of ITS infrastructure. ADOT is actively involved in enhancements to the 511 system and the az511.com website.
- **Operation:** ADOT Districts, TTG, MVD and contractors are involved in the operation of rural ITS throughout Arizona.
- **Maintenance:** ADOT Districts, TTG, ITG, RTEOs and Equipment Services (with contractor and vendor support when required) are involved in the maintenance of rural ITS throughout Arizona.
- **Evaluation:** Through this project (SPR-570), ADOT is evaluating rural ITS statewide.

2.5 KINGMAN DISTRICT INNOVATIONS

The Kingman District is a leader in the innovative use of ITS for rural applications. The District has aggressively pursued obtaining the maximum benefit from the available hardware, which includes:

- **Shoulder-Mounted (Semi-Permanent) Variable Message Signs (VMS)** – Kingman is currently the only ADOT District that has installed shoulder-mounted VMS on semi-permanent basis. The shoulder-mounted VMS have radar capability and are used to display speed warning messages and HAR station information.
- **Speed Detection/Warning Devices** - Kingman is the only ADOT District to have installed a permanent speed detection/warning device. The District coordinated with the City of Kingman because the device is located so close to the city boundary, but ADOT is the sole owner and operator of the device. The District is working to standardize the messages provided on such devices.
- **Highway Advisory Radio (HAR)** - The District is a leader in the use of HAR for construction projects and is currently planning to implement what would be Arizona's first "Advanced HAR" system, to provide route, condition and incident information to drivers approaching decision points at key junctions.
- **Emergency Roadside Callboxes** - Only the Kingman and Tucson Districts have emergency roadside callboxes. The Kingman District's callboxes were procured via a grant application by an outside local agency working together with ADOT.
- **Instrumented Truck Escape Ramps** - The Kingman District is the only ADOT District to have instrumented their truck escape ramps with sensors, cameras, shoulder-mounted VMS, and communications to provide a warning system of ramp occupancy to the TOC, the District, and highway users upstream of the ramps.
- **License Plate Readers** - Kingman is the only ADOT District to have managed a project for which the contractor made use of license plate readers to verify travel times through the work zone.
- **Motorist Assist Patrol (MAP)** - The Kingman District is the only ADOT District currently sponsoring a MAP in conjunction with a construction project, and pioneered the operation of a MAP during the nighttime. As one US 93 project is completed, the MAP becomes part of the next project, thus assuring continuity of service.

3. STUDY METHODOLOGY

3.1 PROJECT APPROACH

The remaining sections provide more detail about this project's evaluation methodology, goal areas, performance measures, stakeholders and information resources, data collection processes, and geographic distribution of survey responses. The following table summarizes the major project activities and accomplishments:

Table 3: Major Project Activities and Accomplishments

Project Phase	Activities	Accomplishments
1 – Review of ADOT's ITS Program Concepts and System Design (Apr. 21-June 18)	Reviewed ADOT-specific background documents; performed literature review; produced task report (see Appendix O for a bibliography).	Report identified guidelines for evaluation methodology; identified performance measures and initial performance evaluation plan for each ITI; and laid groundwork for data collection.
2 – Data Collection and Findings (May 10-Oct. 27)	Collected information about key and additional ITI from ADOT and non-ADOT stakeholders (including postcard and website surveys of commercial vehicle operators and the public; produced task report.	Report identified stakeholders; how information was gathered; geographic distribution of survey responses; and findings about ITI deployed statewide, with special emphasis on Kingman District innovations.
3 – Data Analysis, Conclusions and Recommendations (Sept. 3-Oct. 14)	Analyzed information about key and additional ITI from ADOT and non-ADOT stakeholders; formulated recommendations; produced task report.	Report provided information on the quantity of ADOT's rural ITI; where and how deployments have occurred; ITI performance, costs, benefits, and problems/issues; funding sources, deployment plans and maintenance arrangements; needs met and unmet; recommendations for future rural ITI deployment, performance measurement and promotion.
4 – Final Report Preparation (Oct. 14-Nov. 12)	Reviewed and incorporated comments on task reports; incorporated late-arriving information; produced draft final report and research note.	Report summarizes all project activities, methodologies, findings, conclusions and recommendations.
Throughout	Held five TAC meetings (May 10, June 24, July 20, Sept. 9, Oct. 19).	The TAC provided invaluable feedback, guidance and assistance at the TAC meetings.

3.2 EVALUATION METHODOLOGY

An important outcome of Phase 1 (the review of ADOT's ITS program concepts and system design) was the identification of several guidelines, which were used to design this project's evaluation methodology, as summarized below:

1. Using a goal-based approach for this project's evaluation methodology made sense. The goal-based approach is touted by USDOT (7), has already been used for an evaluation of I-40 in Arizona (8), and coincides with the approach taken in the strategic action plans that ADOT organizations are familiar with preparing and working from (9:2).

2. In selecting the goal areas for this project, consideration was given to:
    a. The National ITS Program Plan (7) goal areas (Safety Improvements, Delay Savings, Throughput, Customer Satisfaction, Cost Savings, Environmental).
    b. The goal areas used for evaluating I-40 (8:12-17) (Mobility, Access, Congestion, Economic Impact, Safety).
    c. The TTG Fiscal Year 2004 Strategic Action Plan goals (9:2):
        i. Assist in maintaining the security and safety of the public;
        ii. Reduce congestion in urban areas;
        iii. Provide statewide incident management;
        iv. Provide quality and timely information to the public;
        v. Design, construct, and implement quality ITS projects in a timely manner;
        vi. Develop and retain a high performing, successful workforce;
        vii. Support, maintain, and operate ITS infrastructure; and
        viii. Improve public and political support.
    d. System objectives identified in the I-40 Corridor and Statewide ITS Strategic Plans (1:39; 2:4-12 – 4-13, 7-3):
        i. Collect, process, and disseminate accurate and up-to-date information;
        ii. Ensure conformance with laws;
        iii. Improve driver/traveler safety and personal security, HAZMAT operations, and inter- and intra-agency coordination, cooperation and information exchange; and
        iv. Provide accurate and timely directions to travelers, centralized storage and retrieval of information, efficient traffic flow, and timely emergency services.

3. For this project, there was little impetus or need to attempt to quantify in monetary terms all the rural ITS benefits in Arizona. A Texas Transportation Institute report (Turner et al., 10:23) states that "…another basic approach to evaluating ITS [is] economic analyses which attempted to quantify the specific monetary value of all ITS impacts. These approaches typically report a single benefit-to-cost ratio for ITS deployments, but these analyses are based on many

assumptions about monetary benefits." Also, "[a]lthough non-technical audiences or decision-makers may prefer or even demand that ITS benefits be described in purely monetary terms, there appears to be a lack of credibility for such analyses among the transportation profession. Because of this lack of credibility, the researchers recommend that ITS benefit analyses concentrate on basic measures of effectiveness."(10:xiii)

4. As suggested by Turner et al. (10:19), the evaluation methodology for this project was designed to take various stakeholder groups into account. While the primary focus of the study was on ADOT's internal needs, surveys of additional stakeholders such as DPS, NWS, commercial vehicle operators, and the general public broadened the types of information gathered.

5. The past recommendations for performance measures in the I-40 Corridor and Statewide ITS strategic plans (1:43; 2:7-3) took ease of data collection into account. This approach corresponds with the recommendation in Turner et al. (10:xiii) that performance measures depend as much as possible on data already collected by the deployed systems themselves, or in any case on data already being collected. This project used that approach.

3.3 GOAL AREAS

Based on feedback from the TAC and the Districts, the goal areas to be evaluated by this study were identified as follows:

- To improve traveler and worker safety;
- To improve rural mobility;
- To reduce highway construction, operations, maintenance and user costs; and
- To improve system reliability and usefulness.

3.4 PERFORMANCE MEASURES

In selecting performance measures to be employed in this evaluation, consideration was given to:

- The information obtained from stakeholders during the data collection and findings phase of the project;
- The performance measures' value to assessing the overall usefulness of each ITS element; and
- The performance measures' ability to assess the contribution of each ITS element to ADOT's rural ITS goal areas.

Given that the ITS elements under consideration share some characteristics but are unique in other aspects, the performance measures were subdivided into universal and element-specific categories. Both sets of performance measures are listed below.

Table 4: Universal Rural Intelligent Transportation System (ITS) Performance Measures

Goal Area	Performance Measures by Stakeholder Group		
	ADOT and Partners	**Commercial Vehicle Operators**	**The General Public**
Improve Safety	The ITS element improves ADOT employee and/or partner safety.	The ITS element improves commercial vehicle operator safety.	The ITS element improves the safety of the driving public.
Improve Rural Mobility		The ITS element improves commercial vehicle mobility.	The ITS element improves public mobility.
Reduce Infrastructure and User Costs	The ITS element reduces infrastructure construction costs. The ITS element reduces infrastructure maintenance and operations costs. The ITS element reduces workload of ADOT and/or partners.	The ITS element reduces trucking costs.	The ITS element reduces public travel costs.
Improve System Reliability and Usefulness	The ITS element is quickly replaced or repaired and returned to service. The ITS element has widespread and frequent use by ADOT and/or partners. ADOT Districts and / or partners unfamiliar with ITS element express interest in using it. ADOT partners (Department of Public Safety, National Weather Service) depend on or have interest in the ITS element.	The ITS element is familiar to commercial vehicle operators. The ITS element is used frequently by commercial vehicle operators. The ITS element is useful to commercial vehicle operators.	The ITS element is familiar to the public. The ITS element is used frequently by the public. The ITS element is useful to the public.

The following performance measures were used to evaluate individual ITS elements:

GROUP A: SURVEILLANCE AND DATA COLLECTION SYSTEMS

A1. Road Weather Information Systems (RWIS)
- Number of full RWIS Stations
- Number of Districts using RWIS
- RWIS percent deficiency

A2. Passive Acoustic Detectors (PAD)/Other Traffic Detectors
- Number of permanent PAD sites

A3. Remote Cameras
- Number of remote cameras located at full RWIS stations
- Number of remote cameras located at VMS sites
- Number of remote cameras in instrumented truck escape ramp systems
- Remote camera percent deficiency

A4. Speed Detection/Warning Devices
- Number of permanent speed detection/warning devices
- Reduction in 85th percentile speed (before vs. after installation)

A5. License Plate Readers
- Number of license plate reader systems used by ADOT contractors
- Detection rate

GROUP B: INFORMATION FUSION AND DISSEMINATION SYSTEMS

B1. Highway Condition Reporting System (HCRS) Input Application
- Number of HCRS users in ADOT Districts
- Number of HCRS entries statewide
- HCRS ease of training and use
- HCRS availability
- HCRS ease of updating

B2. 511 Traveler Information (511)
- Number of 511 calls
- Awareness of 511 by non-ADOT stakeholders
- 511 usefulness to non-ADOT stakeholders

B3. az511.com Traveler Information Website (www.az511.com)
- Number of az511.com hits and page views
- Awareness of az511.com by non-ADOT stakeholders
- az511.com usefulness to non-ADOT stakeholders

B4. Overhead Variable Message Signs
- Number of overhead VMS owned by ADOT
- Number of planned and unplanned messages on overhead VMS
- Overhead VMS percent deficiency
- Awareness of VMS by non-ADOT stakeholders
- VMS message usefulness to non-ADOT stakeholders

B5. Shoulder-Mounted Variable Message Signs
- Number of shoulder-mounted VMS owned or leased by ADOT
- Number of Districts that use or have used shoulder-mounted VMS

B6. Portable Trailer-Mounted Variable Message Signs
- Number of portable trailer-mounted VMS managed for ADOT Districts by Equipment Services (diesel-powered, solar-powered)
- Typical number of trailer-mounted VMS in to Equipment Services for repairs at any given time

B7. Highway Advisory Radio (HAR)
- Number of ADOT construction projects currently using HAR
- Number of ADOT Districts that are using or have used HAR
- Awareness of HAR by non-ADOT stakeholders
- HAR message usefulness to non-ADOT stakeholders

GROUP C: TRAFFIC CONTROL / COMMERCIAL VEHICLE ELECTRONIC CLEARANCE SYSTEMS

C1. Portable Traffic Signals
- Number of portable traffic signals owned by ADOT
- Number of Districts that are using or have used portable traffic signals

C2. Commercial Vehicle Electronic Clearance/PrePass
- Number of PrePass-equipped ports of entry
- Statewide and site-specific PrePass statistics
- Awareness of PrePass by non-ADOT stakeholders
- PrePass usefulness to non-ADOT stakeholders

C3. Expedited Processing at International Crossings (EPIC)
- Number of ports of entry involved in EPIC
- Total number of international ports of entry

GROUP D: EMERGENCY DETECTION AND RESPONSE SYSTEMS

D1. Instrumented Truck Escape Ramps
- Number of instrumented truck escape ramp systems
- Total number of truck escape ramps in Arizona
- Number of uses of instrumented truck escape ramp system
- Awareness of instrumented truck escape ramps by non-ADOT stakeholders
- Instrumented truck escape ramp usefulness to non-ADOT stakeholders

D2. Emergency Roadside Callboxes
- Number of emergency roadside callbox systems
- Total number of emergency roadside callboxes
- Number of calls received at DPS Operational Communications (OpComm) Centers
- Awareness of emergency roadside callboxes by non-ADOT stakeholders
- Emergency roadside callbox usefulness to non-ADOT stakeholders

D3. Motorist Assist Patrols (MAPs)
- Number of assists/other activities
- Awareness of MAPs by non-ADOT stakeholders
- MAP usefulness to non-ADOT stakeholders

3.5 STAKEHOLDERS AND INFORMATION RESOURCES

This project's Technical Advisory Committee (TAC) included representatives from several of the primary ADOT and non-ADOT stakeholder organizations, mentioned previously. The TAC, the ADOT Districts and TTG guided the Consultant effort of identifying rural ITS stakeholders and information resources. The lists below enumerate the various ADOT and non-ADOT stakeholders and other information resources whose input was desired for this study.

ADOT Rural ITS Stakeholders

1. Transportation Technology Group (TTG)

2. ADOT Districts (Flagstaff, Globe, Holbrook, Kingman, Phoenix Construction, Phoenix Maintenance, Prescott, Safford, Tucson, and Yuma)
    a. District engineers
    b. Administrative services officers
    c. Maintenance engineers
    d. Maintenance superintendents
    e. Maintenance supervisors
    f. Senior construction resident engineers
    g. Operations center coordinators (other than Phoenix)
    h. Snow desk coordinators
    i. HCRS coordinators
    j. Specialists involved in ITS element planning and installation

3. Regional Traffic Engineering Offices (RTEOs: Baja Regional Traffic, Northern Regional Traffic, Phoenix Maintenance District, Western Regional Traffic)
    a. Regional traffic engineers
    b. Traffic signal and lighting managers
    c. Regional signal technicians
    d. Field signal technicians
    e. Analysts

4. Information Technology Group (ITG)

5. Motor Vehicle Division (MVD)

6. Equipment Services
    a. Fleet Management Manager
    b. Regional Equipment Managers

Other ADOT Rural ITS Information Resources

1. Occupational Safety and Health (OSH) – for ADOT Employee Safety Statistics

2. Traffic Records Section – for the ALISS Accident Database

3. Roadway Design Section – for background information about truck escape ramps

Non-ADOT Rural ITS Stakeholders

1. Arizona Department of Public Safety (DPS)
    a. Highway patrol (district commanders and other patrol officers)
    b. Operational Communications Center supervisors (Phoenix, Flagstaff, Tucson)

2. National Weather Service (NWS) forecast offices
    a. Flagstaff office (located in Bellemont)
    b. Tucson office

3. Neighboring state departments of transportation (California, Nevada, Utah, Colorado, New Mexico)

4. Equipment vendors and consultants

5. Other Organizations
    a. Native American Nation police forces
    b. Hoover Dam police (Bureau of Reclamation)
    c. Counties, cities and metropolitan planning organizations/councils of government
    d. School districts
    e. US Forest Service
    f. US Bureau of Land Management

6. Commercial Vehicle Operators

7. The general public

Other Non-ADOT Rural ITS Information Resources

1. Other state departments of transportation (Montana and Iowa)

3.6 DATA COLLECTION PROCESSES

A wide variety of techniques were used to collect data from the various stakeholders and information resources. The Consultant designed the approach for information gathering from each of the rural ITS stakeholder groups based on:

- Guidance from the project TAC,
- The groups' roles or relationships to rural ITS,
- The information available from the groups, and the groups' accessibility.

Table 5 summarizes the information obtained about the various ITI from each group, and how the information was obtained.

Table 5: Data Collection Activities Summary

Group Contacted	Information Obtained	How Information Was Obtained
Project TAC	**General information** **Key ITI:** All	Five TAC meetings were held in 2004 (May 10, June 24, July 20, September 9, October 19). Meeting agendas were sent in advance of meetings; minutes were prepared and distributed afterward. Other communications took place as required. The Unmet Needs Scoring Matrix (see Appendix B) was distributed via e-mail on October 22; as of Nov. 9, the Consultant had received 10 responses.
TTG	**General information** **Key ITI:** All	Consultant held meetings with TTG on May 17 and September 27, 2004 and followed up with TTG staff as needed. TTG staff facilitated link from www.az511.com to online versions of Commercial Vehicle Operator (CVO) and public surveys. Consultant received comments during Safford and Phoenix Construction District interviews.
ADOT Districts	**General information** **Key ITI:** All except Expedited Processing at International Corridors (EPIC)	Between May 10 and August 16, 2004, Consultant interviewed staff from all 10 ADOT Districts in person or via phone (see Appendix C for a list of District interviews; Appendix D for the District Questionnaire). Formal follow-up questions (see Appendix E) were sent to Districts via e-mail on Aug. 11; other follow-ups were made as needed.
RTEOs	**Key ITI:** Road Weather Information Systems (RWIS), Passive Acoustic Detectors (PAD), remote cameras, variable message signs (VMS), shoulder-mounted VMS, emergency roadside callboxes	Consultant recorded comments received during Flagstaff, Prescott and Tucson District interviews. Consultant conducted phone interview with Phoenix Maintenance District staff on Aug. 16, 2004. Formal follow-up questions (see Appendix E) were sent to RTEO staff via email on Aug. 17.
ITG	**Key ITI:** RWIS, PAD, remote cameras, Highway Condition Reporting System (HCRS), 511, az511.com, VMS, instrumented truck escape ramps, EPIC	Consultant conducted phone interviews with ITG staff.
Motor Vehicle Division (MVD) – Ports of Entry (POEs)	**Key ITI:** PrePass	Via an e-mail dated Aug. 16, 2004 Consultant distributed surveys (see Appendix F) to managers of POEs at which PrePass is used; three responses were received (representing the Kingman [and Topock], St. George and San Simon POEs). Consultant conducted phone interviews with other MVD staff.

Table 5: Data Collection Activities Summary (Cont'd)

Group Contacted	Information Obtained	How Information Was Obtained
Equipment Services	**Key ITI:** portable trailer-mounted VMS (PTM-VMS)	Questions to Equipment Services staff were e-mailed on Sep. 14.
Office of Safety and Health (OSH)	**General information**	Consultant downloaded public employee accident reports available at OSH's website.
Traffic Records Section	**General information**	Consultant acquired ALISS accident records for segments of the state highway system where ITI has been installed.
Roadway Design Section	**Key ITI:** Instrumented truck escape ramps	Consultant conducted phone interview with Roadway Design Section staff on June 2.
Department of Public Safety (DPS) – Highway Patrol	**Key ITI:** 511, az511.com, VMS/shoulder-mounted VMS (SM-VMS), PTM-VMS, HAR, Instrumented truck escape ramps, Emergency roadside callboxes, Motorist Assist Patrols (MAPs)	Consultant recorded comments received during Globe, Willcox and Phoenix Construction District Interviews (representing highway patrol Districts 11, 9 and Phoenix Metro, respectively). On July 23, Consultant distributed 150 copies of the DPS questionnaire (see Appendix G) to highway patrol Districts; as of Sep. 14, Consultant had received 70 responses.
DPS – Operational Communi-cations (OpComm)	**Key ITI:** Emergency roadside callboxes	Consultant recorded comments received during Tucson District interview (representing the Tucson DPS OpComm Center). Consultant conducted phone interviews with DPS-OpComm staff and followed up via phone and email as needed.
National Weather Service (NWS)	**Key ITI:** RWIS, remote cameras, az511.com	Consultant conducted a phone interview with NWS staff.
Neighbor-ing State departments of trans-portation	**Key ITI:** RWIS, HCRS, 511, az511.com, VMS, HAR, PrePass	Consultant recorded neighboring state DOT comments received during Safford District interview (representing New Mexico DOT). Consultant distributed the Neighboring State Questionnaire (see Appendix F) via e-mails dated Aug. 17 to neighboring state DOT contacts; two responses were received (representing California DOT and Nevada DOT).
Equipment Vendors and Consultants	**Key ITI:** RWIS, PAD, 511, PTM-VMS, HAR, Portable Traffic Signals, PrePass, EPIC	Consultant gather information via phone interviews, vendor website visits, and literature review documents

Table 5: Data Collection Activities Summary (Cont'd)

Group Contacted	Information Obtained	How Information Was Obtained
Other Organi-zations	**Key ITI:** 511, az511.com, VMS/ SM-VMS/PTM-VMS, HAR, Emergency roadside callboxes, MAPs	Consultant recorded City of Tucson comments received during Tucson District interview. Consultant invited members of other organizations to fill out the general public survey and to return any other comments online or by e-mail or letter. The Consultant received one online survey from other organizations (the US Forest Service).
Commercial Vehicle Operators	**Key ITI:** 511, az511.com, VMS/ SM-VMS/PTM-VMS, HAR, PrePass, Instrumented truck escape ramps	On July 23, the Consultant distributed 2000 postcard surveys (see Appendix G) to CVO via Ports of Entry, and prepared an online survey version. From July 28 through August 31, the www.az511.com website included a link to the online survey. Truck drivers were invited to return comments online or by e-mail or letter. As of Sep. 14, the Consultant had received 82 postcards and five online surveys.
General Public	**Key ITI:** 511, az511.com, VMS/ SM-VMS, PTM-VMS, HAR, Emergency roadside callboxes, MAPs	On July 23, the Consultant distributed 5000 postcard surveys (see Appendix G) to the general public via ADOT districts and DPS, and prepared an online survey version. From July 28 through August 31, the www.az511.com website included a link to the online survey. The public was invited to return comments online or by e-mail or letter. As of Sep. 14, the Consultant had received 112 postcards and 261 online surveys. Between July 28 and August 29, a total of 17 e-mails were received at ruralsurvey@itsengineers.com, all probably from the general public.
Other State DOTs	**Key ITI:** RWIS	Consultant visited Montana and Iowa DOT websites to gather information on their RWIS.

3.7 DPS, CVO AND PUBLIC SURVEYS AND RESPONSES

DPS Highway Patrol Surveys

Because DPS and ADOT work together so closely on highway closures and other matters, the project TAC asked the Consultant to gather DPS input on related ITS elements. The Consultant prepared 150 copies of a DPS survey and on July 23, transmitted the surveys to a DPS representative on the project TAC. Shortly thereafter, DPS prepared an explanatory memo and distributed the surveys to DPS highway patrol officers throughout the state. Additional copies of the survey were made in some instances, bringing the total estimated number of surveys to 200.

As of September 14, the Consultant had received 70 responses. With an estimated 200 total surveys distributed, the 70 survey responses represent a 35% response rate. Figure 2 shows the geographic distribution of survey responses from DPS highway patrol officers.

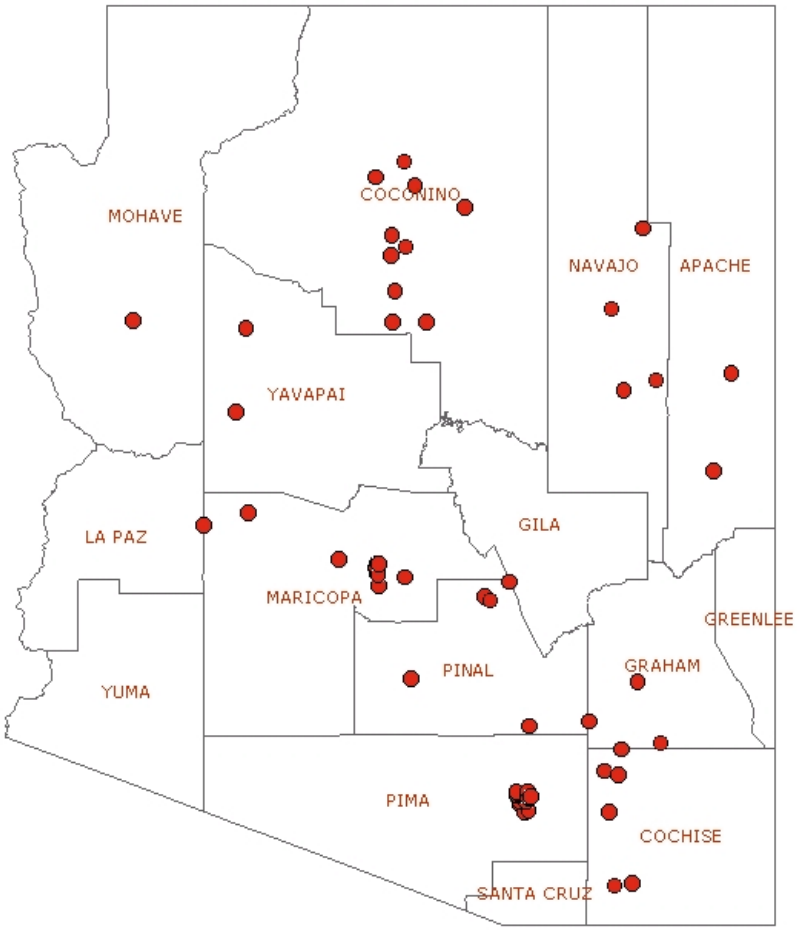

Figure 2: Geographic Distribution of DPS Survey Responses (N=70)

DPS highway patrol officers participating in the survey were asked to declare their home ZIP code. Figure 2 indicates that at least one DPS survey response was received from all but Gila, Greenlee, La Paz, Santa Cruz, and Yuma counties; all DPS highway patrol districts are represented. More responses were received from DPS officers located in Pima County than in any other county. A substantial number (32) were received from areas defined as rural for the purposes of this project (ZIP codes outside of Phoenix and Tucson). Eleven surveys of indeterminate origin were received.

Commercial Vehicle Operator (CVO) Surveys

Because CVO stakeholders have a vested interest in reliable traveler information and emergency systems, the project TAC asked the Consultant to gather CVO input on related ITS elements. By telephone, the Consultant contacted Motor Vehicle Division (MVD) representatives at nine ports of entry and confirmed their willingness to participate. The Consultant prepared 2000 copies of the CVO survey and on July 23, transmitted 1800 of the surveys to the MVD contacts, along with posters to advertise the survey and a list of talking points and frequently asked questions to help MVD explain

and address driver questions about the survey. The Consultant placed emphasis on the importance of person-to-person contact as the surveys were distributed since it was felt this would enhance driver understanding and willingness to participate. The Consultant personally distributed 200 CVO surveys during late July and early August. Postcard survey participants were invited to return comments online or by e-mail or letter. From July 28 through August 31, 2004, the www.az511.com website included a link to the online version of the survey.

As of September 14, the Consultant had received five online and 82 postcard surveys (5.7% online). One of the five online surveys (20%) included comments. The postcard response rate was 4.1% (82 of 2000). No e-mails or letters were received from truck drivers. Figure 3 shows the geographic distribution of online and postcard survey responses from commercial vehicle operators.

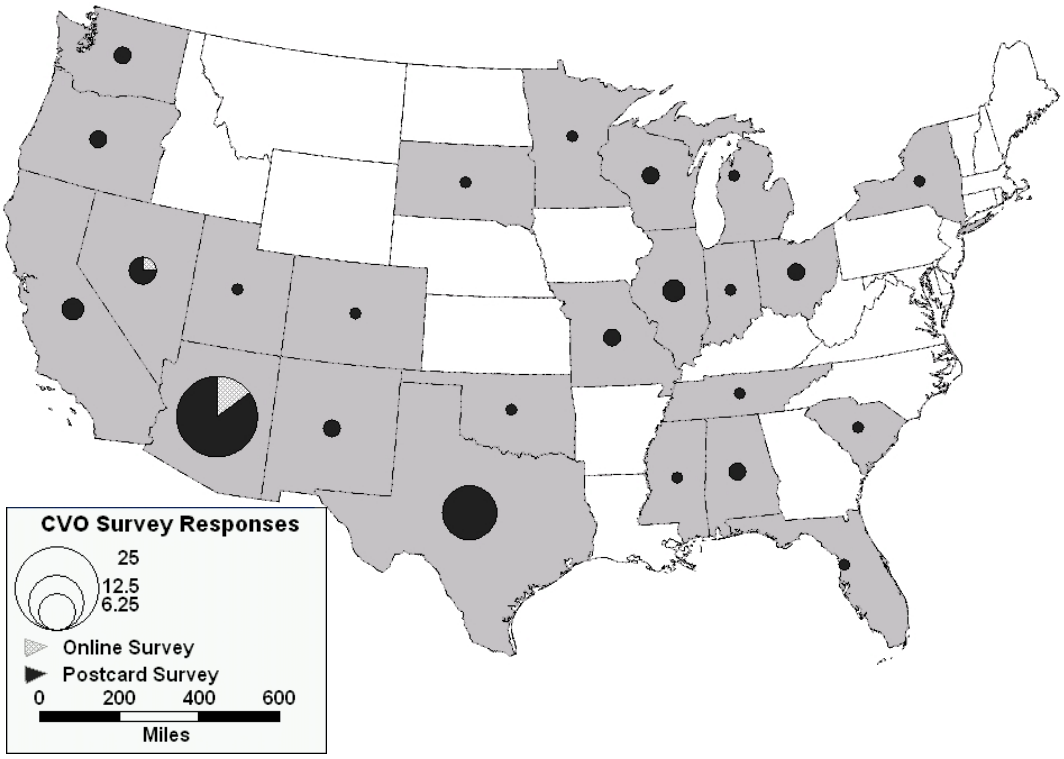

Figure 3: Geographic Distribution of CVO Survey Responses (N=87)

CVO survey respondents were asked to declare their home state. More CVO from Arizona (22) responded than from any other state. A total of 24 states are represented in the survey results. Only five online surveys were received (less than 6% of the total surveys returned), with four from Arizona and one from Nevada. Nineteen surveys of indeterminate origin were received.

Public Surveys

Because the public has a vested interest in reliable traveler information and emergency systems, the project TAC asked the Consultant to gather public input on related ITS elements. The Consultant confirmed the willingness of ADOT Districts and DPS highway patrol districts to participate in survey distribution. The Consultant prepared 5000 copies of the public survey and on July 23, transmitted 4800 surveys to the ADOT and DPS district contacts, along with posters to advertise the survey and a list of talking points and frequently asked questions to help survey distributors explain and address driver questions about the survey. Three thousand of the surveys went to the ADOT Districts and 1800 surveys went to DPS. The Consultant suggested that ADOT Districts tailor a distribution plan suitable to their local circumstances, with driver's license offices, chambers of commerce, visitors centers, and District offices suggested as likely distribution points. The DPS distributed the surveys primarily through highway patrol contacts with the public – in both enforcement and traveler-assistance contacts.

In both cases, the Consultant placed emphasis on the importance of person-to-person contact as the surveys were distributed, since it was felt this would enhance driver understanding and willingness to participate. The Consultant personally distributed 200 public surveys during late July and early August. From July 28 through August 31, 2004 the www.az511.com website included a link to the online version of the survey. Postcard survey participants were invited to return comments online or by e-mail or letter.

As of September 14, the Consultant had received 261 online and 112 postcard surveys (70% online). One hundred seventy-four, or 67% of the 261 online surveys included comments. Between July 28 and August 29, 2004, a total of 17 e-mails were received at ruralsurvey@itsengineers.com, all probably from the general public; no letters were received. The postcard response rate was 2.2% (112 of 5000). Among the 112 postcard survey responses, the 17 e-mails with additional comments represent 15% of the total. Figure 4 shows the geographic distribution of survey responses from the general public.

General public survey respondents were asked to declare their home ZIP code. Based on the ZIP code information, responses were received from 346 in-state respondents, 11 out-of-state respondents, and 16 responses of indeterminate origin (no ZIP code provided, ZIP code illegible etc.). Two hundred forty-two (222 or 92% online) in-state respondents declared ZIP codes from areas defined as urban for the purposes of this project (the Phoenix and Tucson metropolitan areas); 104 (29 or 28% online) declared rural ZIP codes. Out-of-state responses were received from a total of 10 states, including California, Indiana, Louisiana, Missouri, Montana, Nevada, South Carolina, Texas, Washington, and Wisconsin.

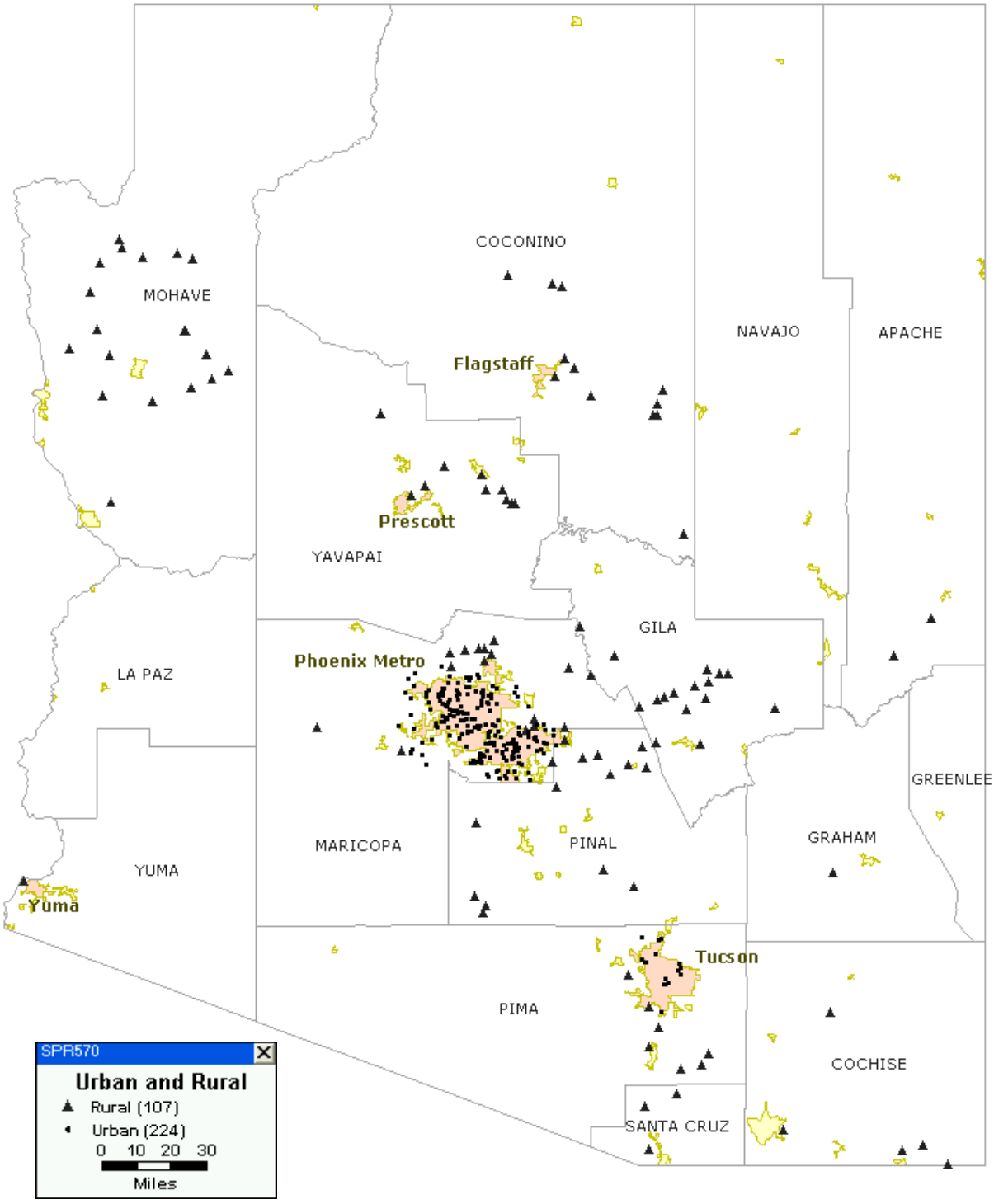

Figure 4: Geographic Distribution of General Public Survey Responses (N=373)

4. STUDY FINDINGS – OVERVIEW

4.1 INTRODUCTION

The various survey instruments used in this project were designed for collecting information from stakeholders about specific ITS elements. Depending on the stakeholder group, appropriate subsets of the 18 key ITS elements were selected and questions about that subset were prepared. In many cases, particularly during the District interviews and meetings with TTG, discussions of "the big picture" emerged, as well as comments about ITS elements outside of the 18 key ones. The study findings fall into three categories:

1. **ADOT's rural ITS program in general:** These findings were based on discussions or comments that do not relate uniquely to any particular ITS element but do have significant impact on multiple ITS elements or to ADOT's rural ITS program as a whole. Examples are distinctions between rural and urban ITS, communication impacts and limitations, maintenance, system architecture, and the role of public education. Discussion of these items is provided later in this chapter.

2. **Information about key ITS elements:** The data collection process for the 18 key ITS elements generated a wealth of information including:
   a. Typical installation components;
   b. System functions/outputs;
   c. Quantity of deployed ITI and deployment plans;
   d. Maintenance arrangements;
   e. System enhancement, integration and standardization attributes and issues;
   f. Stakeholder awareness and usage of systems;
   g. Costs;
   h. Perceived and reported benefits;
   i. Key problems, issues and lessons learned;
   j. Operational status/individual system performance measures; and
   k. Performance evaluation based on universal performance measures.

   Discussion of findings with regards to key ITS elements in Groups A, B, C and D is provided in Chapters 5 through 8.

3. **Information about additional ITS elements:** Additional ITS elements mentioned by various stakeholders include:
   a. **ITS elements in use by ADOT:** Rural operations centers (Flagstaff and Holbrook Districts); snow desks (Flagstaff, Holbrook and Kingman Districts); truck-mounted message boards (several Districts); visibility sensors (Flagstaff, Holbrook, Kingman and Prescott Districts); and road surface temperature sensors on snowplows.
   b. **ITS elements not in use by ADOT:** Variable speed limit system (software program developed and bench-tested).

   Discussion of findings with regards to these additional ITS elements is provided in Chapter 9.

4.2 ADOT'S RURAL ITS PROGRAM

The ADOT Districts and TTG offered feedback on a number of aspects of ADOT's rural ITS program. Topics for which comments – varying from a simple mention of interest to more in-depth discussion – were received included:

Rural versus Urban ITS in Arizona – Topics discussed included applicability of ITI to rural situations; key differences between the rural and urban needs for congestion mitigation; and traveler safety and traveler information.

For the purposes of this project, rural ITS was defined as anything that is not within the Phoenix or Tucson Freeway Management System (FMS). During the District interviews, some ADOT Districts discussed a number of items that the Consultant considered to be strictly urban in character. For the record, these ITS elements included the City of Tucson's TOC, ramp metering, lane control signals, CCTV, and emergency telephones located in a tunnel on I-10 in the Phoenix area. Other items included traffic signals, since they are largely though not exclusively located in urban areas, and DPS' Freeway Service Patrols (FSPs), since the FSPs operate in urban areas.

The Phoenix Construction District noted that several Arizona cities are transitioning from rural to a more urban character. In the midst of this transition, the ADOT Districts and other transportation professionals sometimes overlook steps that they should be taking to accommodate the changes inherent in urbanization.

The Kingman District mentioned that incident response and maintenance are both more difficult in rural than in urban areas due to less traffic, less reliable communications, and longer distances between points from which help can arrive. That is, problems take longer to be discovered, longer to be reported, and longer to respond to. These delays are particularly critical when crashes occur and lives are at stake during the "golden hour," the one-hour period following a severe injury (practice shows that severe trauma patients who reach surgery within this period have a higher survival rate.)

The Role and Impact of Communications on Rural ITS – Topics discussed included gaps in rural cellular coverage vs. the growing dependence on wireless communications, and Internet access (i.e. access to web-based traveler information).

Spotty cellular coverage affects placement and effectiveness of any rural ITS device dependent on cellular communications, such as portable trailer-mounted VMS and emergency roadside callboxes. The Holbrook District mentioned that even internal ADOT communications are sometimes affected by poor cellular and/or radio coverage.

DPS' plans regarding Computer-Aided Dispatch (CAD) and Mobile Data Terminals (MDTs) were discussed at a July 8 meeting between ADOT and DPS executives. The Phoenix TOC may end up having a live feed of the DPS CAD, which will make it easier for the TOC to find the DPS personnel in the field that are being contacted via radio by ADOT staff. This will also help with keeping 511 information up to date.

Rural ITS Maintenance – Many Districts expressed some dissatisfaction with the level of service rural ITS receives when problems occur. The Yuma District went so far as to say that they don't want any more VMS until better maintenance arrangements are made. ADOT has already had to face public and partner issues of not keeping RWIS equipment functional. The bottom line is that funding for equipment installation must be followed by a continuing commitment of dollars for repairs and eventual replacement. The RTEOs will continue to play a maintenance role, but require more labor, materials and equipment resources to meet ADOT District needs and expectations with regards to rural ITS maintenance. As Districts experiment with new rural ITS elements, it will be important for TTG to determine the likelihood of statewide application of the technologies, review ITS program priorities and carefully plan maintenance funding and staffing options.

Rural ITS Architecture – As much as possible, ADOT wants to see ITS elements tied into HCRS. ADOT is seeking ways that the information now being provided on standalone dissemination systems, such as portable trailer-mounted VMS and HAR, can be incorporated into the HCRS so that the information will be accessible to as many people as possible.

Another trend in ADOT's rural ITS is the collocation of different types of ITS elements, sometimes taking advantage of leftover communications bandwidth and available power connections. Examples are the mounting of remote cameras on VMS and the placement of PADs and remote cameras at RWIS sites. Some new combinations of ITS elements have been devised to meet special needs, such as the use of weigh-in-motion and PrePass technology at ports of entry and the use of cameras, loop detectors and shoulder-mounted VMS in the instrumented truck escape ramp system. Vendors are offering standalone devices with improved features such as portable trailer-mounted VMS equipped with radar for speed detection and remote updating capability via cellular communication.

Public Education about Rural ITS – Driver ignorance of many ITS elements was readily apparent based on responses to the CVO and public surveys. Even some DPS survey responses indicated unfamiliarity. Many District staff themselves admitted not making much use of resources like 511. There is a need to educate the driving public about 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. There is also a need to continue the 511 publicity in order to encourage more drivers to use the available highway conditions information.

On an informal basis, many of ADOT's direct communications with the public via phone and e-mail represent opportunities to educate. It is important for ADOT staff to be polite, clear, precise, and informative in their communications with the public.

5. STUDY FINDINGS - SURVEILLANCE AND DATA COLLECTION SYSTEMS

The Group A ITI (Surveillance and Data Collection Systems) include the following:

1. **Road Weather Information Systems (RWIS)** are a combination of field equipment, communications links, and central computer equipment that enables automatic recording, transmittal and storage of weather data. As currently configured, RWIS stations include weather sensors, PAD traffic counters, remote cameras, and visibility sensors. RWIS will be deployed statewide.
2. **Passive Acoustic Detectors (PADs)** are field devices that generate traffic data by "listening" to noise produced by traffic. Thus far, PADs have been implemented in rural Arizona only as a component of RWIS stations. PADs will be deployed statewide.
3. **Remote Cameras** are fixed (no pan-tilt-zoom capability) still-frame units. Remote cameras have been deployed in at least three types of installations: at RWIS stations; on overhead VMS; and instrumented truck escape ramps. Remote cameras will be deployed statewide. This section addresses only remote cameras installed at RWIS stations and on overhead VMS; images from these cameras are available via remote polling on a timed or on-demand basis. The Kingman District's instrumented truck escape ramps, including the camera component, are discussed in Chapter 8.

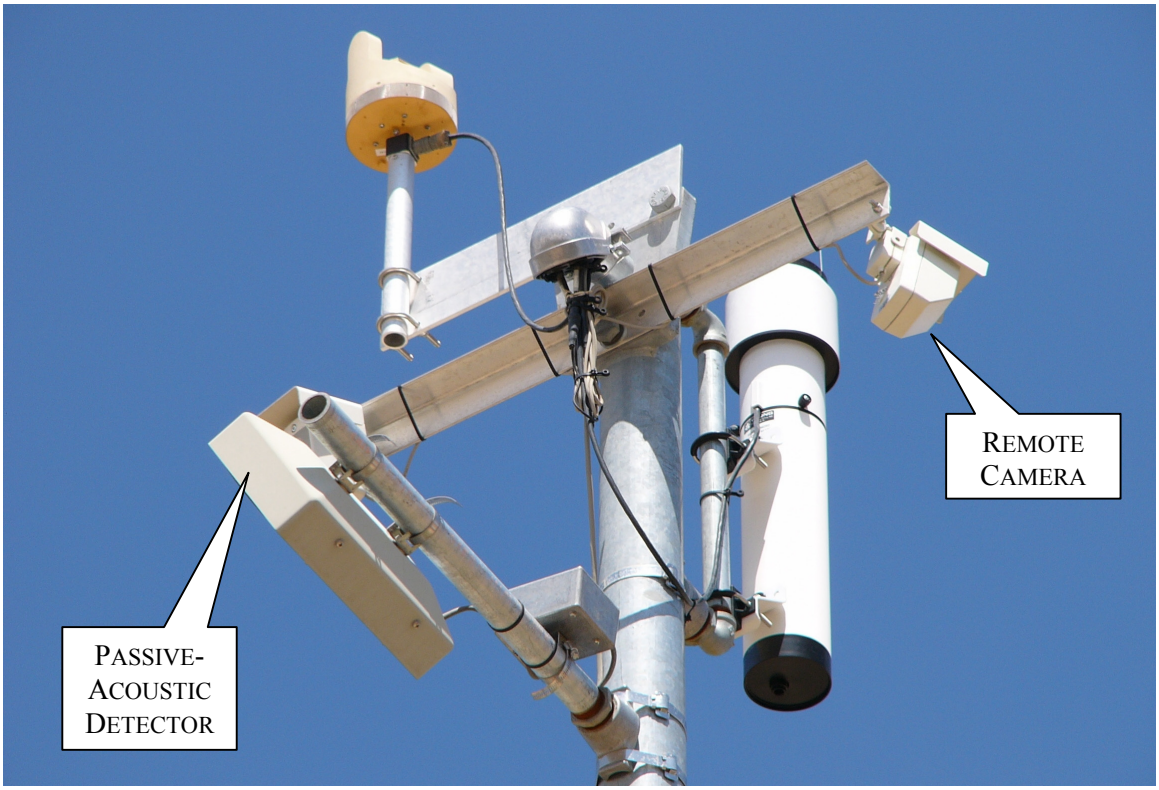

Figure 5: RWIS Sensor Assembly

4. **Speed Detection/Warning Devices** are radar-equipped VMS that are programmed to provide speed warning messages on detecting a speeding vehicle. ADOT currently has permanent (overhead), semi-permanent (shoulder-mounted) and portable (trailer-mounted) VMS devices that could be considered speed detection/warning devices. This section addresses only the permanent type; the shoulder-mounted and portable trailer-mounted VMS are discussed in the Chapter 6. Thus far, these devices have been deployed only on a local level.

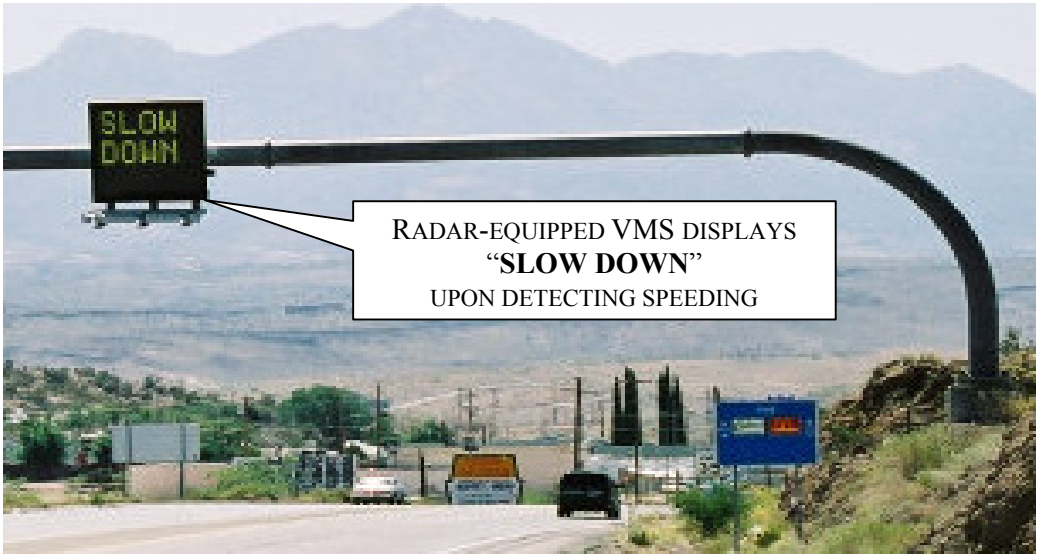

Figure 6: Overhead Mounted Speed Detection and Feedback Sign

5. **License Plate Readers** at the basic level are camera-based systems that capture license plate images and process the images using character recognition. One application of license plate readers is to estimate travel time by matching license plate numbers from two readers and calculating elapsed time between vehicle passage at the two locations. This particular setup is the system referred to in this section as a "license plate reader;" a more accurate description is "camera-based travel time estimation system." Thus far, this system has been deployed only on a local level.

Figure 7: Roadside License Plate Readers

Table 6 summarizes typical installation components and system functions/outputs associated with ADOT's surveillance and data collection systems.

Table 6: Group A ITI – Components and Functions

ITI	Typical Installation Components	System Functions / Outputs
A1. Road Weather Information Systems (RWIS)	A typical ADOT RWIS station is comprised of a weather pod, a road surface sensor ("puck"), a subsurface sensor, a traffic sensor, a camera, a remote processing unit (RPU), a cabinet on a concrete pad, and internal power and data connections, and power and communications equipment. Two different mounting structures have been used: a hinged three-sided truss tower and a pole.	The system provides the following reports: - Weather Conditions - Precipitation Information - Road Surface Conditions - Road Subsurface Conditions - Traffic Conditions - RPU Status
A2. Passive Acoustic Detectors (PAD)	A typical PAD (installed at an RWIS station) requires the PAD detector unit itself and internal power and data connections.	The PAD units provide traffic volume, speed and occupancy data.
A3. Remote Cameras (Fixed, Still-Frame)	**RWIS station cameras:** A typical RWIS station camera installation requires just two cameras (one per direction) and internal power and data connections. **VMS cameras:** A typical VMS camera installation requires two cameras (one per direction), internal power and data connections, and an RPU. The installation takes advantage of existing power and communications equipment, cabinet and concrete pad at the VMS site.	Both camera types provide fixed, still-frame bi-directional roadway images (i.e., the camera view can't be adjusted). The images are available via remote polling on a timed or on-demand basis.
A4. Speed Detection / Warning Devices	A typical permanent speed detection/ warning device is a radar-equipped VMS mounted on an overhead structure; other components include internal power and data connections, cabinet and controller, concrete pad, and power and communications equipment.	As a default, the device displays a speed limit message; on detection of a speeding vehicle, a speed warning ("SLOW DOWN") messages is displayed.
A5. License Plate Readers	A license plate reader system consists of the following: cameras; triggering systems; Central Processing Unit (CPU) to handle data reporting, image manipulation and control functions; Character Recognition Engine; data storage/ transmission system; and lights.	The system output is estimated travel time, based on a rolling average of individual vehicle travel times attained from matching license plate numbers at two readers.

Table 7 summarizes the quantity of deployed ITI, deployment plans and maintenance arrangements associated with ADOT's surveillance and data collection systems.

Table 7: Group A ITI – Quantity Deployed/Planned and Maintenance Arrangements

ITI	Quantity Deployed/Planned	Maintenance Arrangements
A1. Road Weather Information Systems (RWIS)	14 sites deployed; 50 new sites planned	ADOT currently has contracted with a consultant to provide RWIS maintenance statewide. The previous maintenance arrangement with the RTEOs had shortcomings, as these Regional offices were not funded for this activity, and viewed it as a low priority.
A2. Passive Acoustic Detectors (PAD)	14 sites deployed; 50 new sites planned	See above. The contracted consultant also provides rural PAD maintenance statewide.
A3. Remote Cameras (Fixed, Still-Frame)	**RWIS station cameras:** 28 cameras at 14 sites deployed; 100 cameras at 50 new sites planned **VMS cameras:** Eight cameras / four sites deployed; 222 cameras / 111 new sites planned	See above. The contracted consultant provides remote camera maintenance statewide for both types of installations.
A4. Speed Detection/ Warning Devices	One site deployed; no new sites planned	ADOT directly contacts the equipment vendor in the event of maintenance needs.
A5. License Plate Readers	Previously deployed for one project/construction zone (four cameras at two bi-directional sites); no new deployments planned	The Contractor was responsible for system maintenance.

See Appendix H for maps of deployed and planned ITI in Group A.

Table 8 summarizes planned system enhancements and integration and standardization attributes or issues associated with ADOT's surveillance and data collection systems.

Table 8: Group A ITI – Enhancements, Integration and Standardization

ITI	Planned Enhancements / Integration / Standardization
A1. Road Weather Information Systems (RWIS)	The remote processing units (RPUs) are polled periodically by a central RWIS server that resides at the Flagstaff District office. ADOT Districts are able to run RWIS reports based on polled data over the ADOT Intranet. ADOT captures images and data from the RWIS server and makes the information available on the Internet via the "Roadway Conditions – Closures & Restrictions"" links of the az511.com website.
A2. Passive Acoustic Detectors (PAD)	Currently, the only PAD units installed in rural locations are located at ADOT RWIS stations. The unit is mounted on the RWIS station's tower or pole and interfaces with the station's RPU.
A3. Remote Cameras (Fixed, Still-Frame)	The central RWIS server at Flagstaff periodically polls the RWIS and VMS RPUs, thereby transferring camera image data.
A4. Speed Detection/ Warning Devices	A permanent speed detection/warning device operates as a standalone system.
A5. License Plate Readers	A license plate reader system operated as a stand-alone system for travel time estimation in a particular area. Internal system integration was required to gather license plate data from different areas. Initial plans to disseminate estimated travel times to the public via integrated VMS were scratched due to liability concerns.

Table 9 summarizes stakeholder awareness and usage of ADOT's surveillance and data collection systems.

Table 9: Group A ITI – Stakeholder Awareness and Usage

ITI	Awareness	Usage
A1. Road Weather Information Systems (RWIS)	Most ADOT personnel are aware of RWIS. Public awareness of RWIS data availability at the az511.com website seems to be growing.	ADOT personnel in the Flagstaff, Holbrook, Kingman and Safford Districts make use of RWIS information.
A2. Passive Acoustic Detectors (PAD)	PAD data is not available to the public via az511.com. ADOT personnel have some awareness of PAD data availability via RWIS.	Currently, there appears to be very little ADOT or partner usage of PAD data.
A3. Remote Cameras (Fixed, Still-Frame)	ADOT personnel have some awareness of remote camera image availability. Public awareness of remote camera image availability at az511.com seems to be growing.	ADOT personnel in the Flagstaff, Holbrook, Kingman and Safford Districts make use of remote camera images; some consider images the most useful data provided by RWIS.
A4. Speed Detection/ Warning Devices	ADOT personnel have some awareness of the device.	The Kingman District operates the device continuously.
A5. License Plate Readers	ADOT personnel have some awareness of this system.	No known current usage, and little interest expressed by ADOT.

Table 10 summarizes the costs and perceived and reported benefits associated with ADOT's surveillance and data collection systems.

Table 10: Group A ITI – Costs and Benefits

ITI	Costs	Perceived and Reported Benefits
A1. Road Weather Information Systems (RWIS)	$137,200 to $145,200 capital costs; $170/yr to operate; $3,328/yr to maintain	- Manage plowing & deicing operations - Dust storm prediction/warning - Share data with the National Weather Service (NWS) - Improved traveler safety via public access to data at the az511.com website
A2. Passive Acoustic Detectors (PAD)	Integral part of RWIS installation (see above)	- Supplement automatic traffic recorder data - Non-intrusive technology simplifies maintenance and improves personnel safety
A3. Remote Cameras (Fixed, Still-Frame)	**RWIS station cameras:** Integral part of RWIS installation (see above) **Variable Message Sign cameras:** Cost to retrofit at existing overhead VMS: $20,000 per site (two cameras)	- Remotely verify pavement and weather conditions - Improved traveler safety via public access to images at az511.com website
A4. Speed Detection/ Warning Devices	$48,820 capital costs	- Speed study observed speed reduction - Perceived safety and repair costs improvements
A5. License Plate Readers	Incentive to maintain travel time was less than 1% of total project cost	ADOT - improved level of service through construction zone; Contractor - received 96% of incentive; public - less delay, frustration, and need for detours

Table 11 summarizes the key issues and operational status and element-specific performance measures associated with ADOT's surveillance and data collection systems.

Table 11: Group A ITI – Key Issues and Operational Status

ITI	Key Issues	Operational Status / Element-Specific Performance Measures
A1. Road Weather Information Systems (RWIS)	- Road surface sensor inaccuracy/short lifetime - Software problems - Maintenance arrangement - Unreliable communications - Truss tower with hinge simplifies maintenance but is susceptible to vandalism; pole mount requires bucket truck for access - Polling frequency and high telephone bills	Percent RWIS deficiency (tracked by TTG on a monthly basis) varies between 29% and 100% (data from Nov. 2003-August 2004). Both communications (cellular and wireline) and software reported by ADOT as contributing factors to deficiency.
A2. Passive Acoustic Detectors (PAD)	- Low installation, maintenance and data archival costs - Low data demand - VMS-mounted PADs did not function well - Other in-pavement and non-intrusive detector options exist, including portable - See RWIS issues	PAD, located as they are at RWIS, are subject to RWIS communications failures (see above).
A3. Remote Cameras (Fixed, Still-Frame)	- Frequently updated camera images valuable for both ADOT and the public, but communications bandwidth and costs limit ability to provide desired update frequency (camera image is large part of total data flow during polling) - See RWIS issues	Remote cameras located at RWIS and Variable Message Signs (VMS) are subject to RWIS communications failures (see above). Statewide camera deficiency: 0% to 79% (data from Jul. 2003-Aug. 2004; includes 12 Tucson closed-circuit television (CCTV) cameras
A4. Speed Detection/ Warning Devices	- This device can alleviate a chronic spot speed problem even if root causes of problem (such as geometrics) continue - Flashing "SLOW DOWN" message more effective than showing drivers' actual speed	The permanent speed detection/ warning device is generally reliable. Reduced 85th percentile speed 18% from 51 to 42 mph (comparing speed studies from Jan. 2002 and Aug. 2003).
A5. License Plate Readers	- Camera mounting deterred vandalism - Public privacy concerns resolved - Lack of communications resolved via microwave link - Provide for penalty or alternative time estimation method during system downtime - Lighting angle affects image clarity - Criteria for application: important corridor location, high business impact, lengthy detour, high road user costs	Some problems with system downtime were experienced. System matched 11% of vehicle license plates (considered adequate for travel time estimation).

Appendix I presents scores assigned to the 18 key ITI on the basis of universal performance measures, or performance measures that apply to all key ITI. The scores, varying from 1 for "least impact" to 5 for "most impact," were somewhat subjective but were an attempt to gauge the strength with which the various ITI contribute to system goals, using stakeholder feedback as a primary basis.

To better gauge the overall effectiveness of individual ITI in contributing to the four evaluation goal areas (improve safety, improve mobility, reduce costs, and improve system reliability/usefulness), composite goal area scores and an overall composite score were calculated based on the universal performance measure scores.

First, raw composite goal area scores were calculated by adding individual scores for each applicable goal within each goal area. Then, since not every goal applied to each ITI, the maximum composite goal area score for each ITI was determined. The composite goal area scores were calculated as the ratio of the raw composite score to the maximum composite score. Since the initial scores varied from 1 to 5, the composite goal area scores vary from a minimum of 20 (when all individual goal scores are 1) to a maximum of 100 (when all individual goal scores are 5). The overall composite score, taken by adding the four composite goal area scores, can vary from 80 to 400.

The key ITI were ranked on the basis of the overall composite score, both among all ITI and among the ITI within their group. Table 12 summarizes the performance evaluation of ADOT's surveillance and data collection systems, based on these universal performance measure composite scores.

Table 12: Group A ITI – Evaluation Based on Universal Performance Measures

ITI	Composite Goal Area Scores				Composite Overall Score (Overall/Group Rankings)
	Safety	Mobility	Costs	Reliability/ Usefulness	
A1. Road Weather Information Systems (RWIS)	40	40	52	56	188 (16 of 18 / 3 of 5)
A2. Passive Acoustic Detectors (PAD)	20	20	24	32	96 (18 of 18 / 5 of 5)
A3. Remote Cameras (Fixed, Still-Frame)	40	40	60	56	196 (15 of 18 / 2 of 5)
A4. Speed Detection/Warning Devices	100	60	76	52	288 (8 of 18 / 1 of 5)
A5. License Plate Readers	40	40	52	32	164 (17 of 18 / 4 of 5)

6. STUDY FINDINGS - INFORMATION FUSION AND DISSEMINATION SYSTEMS

The Group B ITI (Information Fusion and Dissemination Systems) include the following:

1. **Highway Condition Reporting System (HCRS) input** is accomplished using an interface available to authorized users via ADOT's Intranet or the Internet. The interface allows entry of information about a variety of events impacting travel on Arizona roadways. HCRS subsequently fuses the information into a database that feeds the 511 and az511.com dissemination systems. This is a statewide system.
2. **511** is ADOT's Traveler Information by Telephone system. The system is highly automated, providing callers with computerized voice prompts, responding automatically to user requests for HCRS-based highway conditions information and other information (such as transit), and recording user comments. This is a statewide system.
3. **az511.com** is ADOT's Traveler Information by Internet system. It provides HCRS-based highway conditions information, RWIS-based weather data and images, and Phoenix area speed map and camera images. This is a statewide system.

Figure 8: The HCRS-511 System Concept

4. **Overhead Variable Message Signs (VMS)** are large VMS mounted on overhead structures. Overhead VMS have been deployed statewide.

Figure 9: Overhead VMS (Globe District)

5. **Shoulder-Mounted VMS** are small VMS mounted on posts on the roadway shoulder. It is essentially a semi-permanent installation of the same type of sign enclosures used on portable trailer-mounted VMS. These signs have been deployed only on a local basis.

Figure 10: Shoulder-Mounted VMS

6. **Portable Trailer-Mounted VMS** are small trailer-mounted VMS that are temporarily deployed wherever they are needed. These signs have been deployed statewide.

Figure 11: Portable VMS

7. **Highway Advisory Radio (HAR)** is a system that broadcasts traveler information via radio. When used in conjunction with construction projects, these systems typically run in one of two modes: 1) continuous broadcast (providing general project information), or 2) periodic broadcast (providing as-needed information about impending scheduled events such as blasting). Beacons are typically used to indicate new messages for the second mode of operation. Thus far, these systems have been deployed only to meet temporary local construction project needs.

Figure 12: Highway Advisory Radio

Table 13 summarizes typical installation components and system functions and outputs associated with ADOT's information fusion and dissemination systems.

Table 13: Group B ITI – Components and Functions

ITI	Typical Installation Components	System Functions / Outputs
B1. Highway Condition Reporting System (HCRS) Input	Originally, HCRS terminals (dedicated computers) had to be installed wherever a data point of entry was needed. The HCRS input application has most recently been implemented as a Java applet. Authorized users access the applet on ADOT's Intranet or via the Internet. The input program automatically updates the HCRS database, housed on a computer server located at the Phoenix TOC.	The HCRS database forms the information base for ADOT's 511 and az511.com traveler information systems. The system allows the entry of 21 distinct event types. Advanced notice of planned events is limited to two weeks.
B2. Traveler Information by Telephone (511)	The physical components of 511 are grouped into two subsystems: Voice Response Activated System (VRAS) and HCRS (already described above). VRAS, located at the Phoenix TOC, is composed of: 1) Two T-1 data lines accommodating 24 voice channels each; 2) Two Interactive Voice Response (IVR) workstations; and 3) The 511 workstation, housing a multi-user database. The HCRS database feeds the 511 workstation's database.	511 receives commands via voice and/or touch tones and then performs a variety of tasks in response to the input, including: 1) provision of road conditions information; 2) provision of basic transit, airport and tourism information or forwarding of calls to other information centers; and 3) voice recording of customer comments.
B3. Traveler Information by Internet (az511.com)	The az511.com website may be considered to have six subsystems: 1) the website server – presents introductory web page and responds to requests; 2) the HCRS server – provides highway conditions information; 3) RWIS subsystem – provides weather data and images from RWIS stations/VMS; 4) Speed map subsystem – provides Phoenix area speed map; 5) CCTV camera subsystem – provides Phoenix area live and still camera images; and 6) Documents subsystem – provides electronic copies of miscellaneous documents. These subsystems are composed of a wide array of computers, communications equipment, databases and other software and electronic files, video equipment, and so on.	
B4. Overhead Variable Message Signs (VMS)	A typical overhead VMS installation consists of a sign enclosure, an overhead mounting structure with catwalk and foundations, a cabinet and controller, a modem, a voice telephone, and communications and power cabling.	Overhead VMS are used to provide messages on either a planned or unplanned basis. Examples of events for which planned messages are provided are: advanced notice of construction; 511 or az511.com promotion; and event-related traffic. Examples of unplanned events are: Amber Alerts, incidents, and weather.

Table 13: Group B ITI –Components and Functions (Cont'd)

ITI	Typical Installation Components	System Functions / Outputs
B5. Shoulder-Mounted VMS (SM-VMS)	The shoulder-mounted VMS currently in use in the Kingman District are essentially signs from portable trailer-mounted VMS but mounted instead on two posts. Other system components include a cabinet mounted on a concrete pad and a controller, keypad, modem and batteries. All of the signs feature cellular communications, solar power and radar speed detection capability.	- The signs on SR-68 are part of the instrumented truck escape ramp system. They provide a "STEEP GRADES AHEAD" message as a default, with notification of ramp intrusions when they occur, and speed warnings to speeding vehicles. - The signs on US 93 are part of a semi-permanent HAR system. They are used to provide notification of new HAR message and speed warnings.
B6. Portable Trailer-Mounted VMS (PTM-VMS)	A typical PTM-VMS currently consists of a VMS mounted on a trailer. The trailer features an on-board controller with a keyboard for direct setup and cellular communications equipment for remote setup. Leveling jacks provide for sign stability. The units include solar panels to supply power and have radar speed detection capability. Older diesel-powered units are still in use but will be phased out over the next three to five years.	The signs are used for a variety of purposes, including advance warning of planned closures or roadwork, ongoing roadwork, flash flood or road washout warning, accidents, queue warnings, special events, fire warnings, and drug stops and checkpoints.
B7. Highway Advisory Radio (HAR)	A typical HAR system is composed of: (1) a transmitter, complete with antenna, solar power panel, batteries, communications equipment, and recorder; and (2) signage, with or without flashing beacons, to inform the public of the frequency that they can tune into for information. The signage can be static or some type of VMS. A HAR system on US 93 features two transmitters, two beacons, two portable VMS and two shoulder-mounted VMS.	A typical transmitter has a broadcast radius of six to 12 miles. HAR units typically have communications capability to allow them to be updated remotely. HAR is an effective way to provide in-depth project information to the public, although it is normally just part of a multi-pronged public outreach effort. Other potential applications of HAR include providing weather or congestion advisories, detour route, and international border crossing information

Table 14 summarizes the quantity of deployed ITI, deployment plans and maintenance arrangements associated with ADOT's information fusion and dissemination systems.

Table 14: Group B ITI – Quantity Deployed/Planned and Maintenance Arrangements

ITI	Quantity Deployed/Planned	Maintenance Arrangements
B1. Highway Condition Reporting System (HCRS) Input	One system; available to authorized users on ADOT computers via the Intranet; also available via the Internet.	Transportation Technology Group (TTG) performs monthly HCRS maintenance on the second Thursday of each month. TTG and Information Technology Group (ITG) provide demand maintenance as required.
B2. Traveler Information by Telephone (511)	One system, available via two different phone numbers: 511 and 1-888-411-ROAD. ADOT will deploy about 50 static 511 signs in the near future.	The voice system is maintained by the system vendor. TTG and ITG provide demand maintenance on other system components as required.
B3. Traveler Information by Internet (az511.com)	One system.	TTG and ITG provide demand maintenance on system components as required.
B4. Overhead Variable Message Signs (VMS)	115 signs deployed statewide (44 in rural areas). Current plans call for 150 new signs statewide, including 71 in rural areas.	The Regional Traffic Engineering Offices (RTEOs) provide demand maintenance for overhead VMS, with vendor support as required. The RTEOs view VMS as a high priority even though they are not funded for VMS maintenance. The RTEOs are interested in increased funding or an alternative arrangement.
B5. Shoulder-Mounted VMS (SM-VMS)	The Kingman District has installed 4 SM-VMS. Until a recent road realignment project, the Prescott District had two signs. No new deployments are planned.	See comments on highway advisory radio and instrumented truck escape ramps.
B6. Portable Trailer-Mounted VMS (PTM-VMS)	ADOT District maintenance organizations are utilizing 87 PTM-VMS statewide, including 65 solar-powered and 22 diesel-powered. There are no known plans to increase the total number of signs. Many ADOT contractors rent signs during construction projects.	The Districts perform routine preventive maintenance. Equipment Services performs demand maintenance, calling on vendor support as needed. Controller and circuit board problems are common. Equipment Services reported that they rarely have more than one sign in for repairs at any given time.
B7. Highway Advisory Radio (HAR)	There are currently six ADOT construction projects for which HAR is being used. HAR is also used during Phoenix International Raceway events. No known planned deployments.	Turnkey HAR service providers typically agree to include equipment maintenance in their contract. The US 93 contractor is responsible for maintenance of all HAR system components (including SM-VMS and PTM-VMS).

See Appendix J for maps of deployed and planned ITI in Group B.

Table 15 summarizes planned system enhancements and integration and standardization attributes or issues associated with ADOT's information fusion and dissemination systems.

Table 15: Group B ITI – Enhancements, Integration and Standardization

ITI	Planned Enhancements / Integration / Standardization
B1. Highway Condition Reporting System (HCRS) Input	The HCRS Input program is in a sense the center of ADOT's integration efforts. The distributed nature of ADOT's roadway systems and events occurring on them (construction activities, incidents, and so on) necessarily means that information about those events is available only at a local level initially. The HCRS input application allows rapid fusion and dissemination of local, distributed information.
B2. Traveler Information by Telephone (511)	ADOT continues to update the 511 system on a monthly basis. 511 is tightly integrated with HCRS and with existing airport, transit and tourism information services
B3. Traveler Information by Internet (az511.com)	az511.com is integrated with HCRS and computer networks tying into field devices such as RWIS, traffic detectors, and cameras. ADOT is working with local agencies to provide more surface street information. ADOT will incorporate information from additional RWIS stations and VMS-based remote cameras as they come online.
B4. Overhead Variable Message Signs (VMS)	At the Phoenix TOC, a server is set up with Mercure, software allowing central communications with and control of all overhead VMS in Arizona. Authorized users in the Flagstaff, Globe, Holbrook, Kingman and Safford Districts also have control and access to the signs in their respective areas. Plans call for remote cameras to become a standard feature of installed VMS.
B5. Shoulder-Mounted VMS (SM-VMS)	See discussion of highway advisory radio and instrumented truck escape ramp integration.
B6. Portable Trailer-Mounted VMS (PTM-VMS)	Portable trailer-mounted VMS are currently used as stand-alone units. Remote control of units via cellular communications is possible. At least one vendor offers central software that can control as many as 200 units simultaneously; many potential applications are possible. However, ADOT's experience has been that cellular coverage in many rural areas is not reliable.
B7. Highway Advisory Radio (HAR)	ADOT's HAR systems are internally integrated but standalone. It may be desirable to integrate HAR into HCRS; ways to do this could include expanding the HCRS database content to contain the text of HAR scripts or actual recorded audio files.

Table 16 summarizes stakeholder awareness and usage of ADOT's information fusion and dissemination systems.

Table 16: Group B ITI – Stakeholder Awareness and Usage

ITI	Awareness	Usage
B1. Highway Condition Reporting System (HCRS) Input	All ADOT Districts have authorized HCRS users; ADOT staff in general appear to have awareness and appreciation of the value of the system.	ADOT has about 150 to 200 authorized users. Non-ADOT authorized users include DPS, City of Chandler, City of Gilbert, City of Glendale, Maricopa County Department of Transportation, and consultant staff. The Phoenix TOC enters approximately 81% of all events, although all Districts are participating in use of the system. The system records about 12,500 events per year (based on data from 2000-2002).
B2. Traveler Information by Telephone (511)	ADOT staff in general appeared to be aware of 511; internal ADOT promotion of the system has occurred. 86% of Department of Public Safety (DPS) survey respondents reported being aware of ADOT's 511. The figures were 65% for Commercial Vehicle Operators (CVO), and 60% for public from rural Arizona ZIP codes, and 71% for public from urban Arizona ZIP codes.	- The Districts reported use of 511 to verify HCRS input event data. Usage of 511 for other purposes by ADOT staff appears to be low. - The annual number of 511 calls grew from 307,862 in 2002 to 344,468 in 2003, a 12% increase. The first five months of 2003 versus 2004 saw an increase of 80%. The 511 promotion efforts this year have had a dramatic immediate impact and have helped set a course for long-term growth in system use. - 27% of DPS survey respondents reported using ADOT's 511 often or rarely. The figures were 30% for CVO, 41% for public from rural Arizona ZIP codes, and 40% for public from urban Arizona ZIP codes.
B3. Traveler Information by Internet (az511.com)	ADOT staff in general appeared to be aware of 511; internal ADOT promotion of the system has occurred. 70% of DPS survey respondents reported being aware of az511.com. The figures were 56% for CVO, and 67% for public from rural Arizona ZIP codes, and 79% for public from urban Arizona ZIP codes.	- There is some usage of az511.com by ADOT staff. RWIS information available at the website is not complete, so staff typically would check the more complete set of data available on the Intranet when needed. Motor Vehicle Division (MVD) staff checks restrictions in the course of truck permitting. - The website received about 75 million "hits" and about ten million page views in 2003. Through August of 2004, those statistics had already been nearly equaled or surpassed. - 20% of DPS survey respondents reported using az511.com often or rarely. The figures were 26% for CVO, 48% for public from rural Arizona ZIP codes, and 80% for public from urban Arizona ZIP codes.

Table 16: Group B ITI – Stakeholder Awareness and Usage (cont'd)

ITI	Awareness	Usage
B4. Overhead Variable Message Signs (VMS)	All ADOT staff are familiar with overhead VMS. 100% of DPS survey respondents reported being aware of ADOT's overhead VMS. The figures were 93% for commercial vehicle operators (CVO), and 90% for public from rural Arizona ZIP codes, and 75% for public from urban Arizona ZIP codes. Note that the DPS, CVO and public surveys did not distinguish between various types of VMS.	8,761 messages were displayed on VMS statewide in 2003. Of those, 3,585 were planned and 5,176 were unplanned. By August of 2004, those statistics had all been surpassed. 90% of DPS survey respondents reported using ADOT's VMS information often or rarely. The figures were 94% for CVO, 83% for public from rural Arizona ZIP codes, and 81% for public from urban Arizona ZIP codes. Note that the DPS, CVO and public surveys did not distinguish between various types of VMS.
B5. Shoulder-Mounted VMS (SM-VMS)	Some ADOT staff are familiar with shoulder-mounted VMS. The Kingman District's use of the signs is increasing ADOT's level of familiarity. See comments on overhead VMS for VMS awareness survey statistics.	The shoulder-mounted VMS used in the Kingman District have messages displayed continuously. See comments on HAR and instrumented truck escape ramps. See comments on overhead VMS for VMS usage survey statistics.
B6. Portable Trailer-Mounted VMS (PTM-VMS)	All ADOT staff are familiar with portable trailer-mounted VMS. See comments on overhead VMS for VMS awareness survey statistics.	Portable trailer-mounted VMS are used often in all ADOT Districts. See comments on overhead VMS for VMS usage survey statistics.
B7. Highway Advisory Radio (HAR)	All ADOT staff are familiar with HAR. 67% of DPS survey respondents reported being aware of ADOT's HAR. The figures were 79% for CVO, and 57% for public from rural Arizona ZIP codes, and 48% for public from urban Arizona ZIP codes.	The Flagstaff, Holbrook, Kingman, and Prescott Districts are currently using HAR on construction projects. HAR is also used in the Phoenix area for International Raceway events. The Globe District used HAR on a past project. 35% of DPS survey respondents reported using ADOT's HAR information often or rarely. The figures were 61% for CVO, 36% for public from rural Arizona ZIP codes, and 22% for public from urban Arizona ZIP codes.

Table 17 summarizes the costs and perceived and reported benefits associated with ADOT's information fusion and dissemination systems.

Table 17: Group B ITI – Costs and Benefits

ITI	Costs	Perceived and Reported Benefits
B1. Highway Condition Reporting System (HCRS) Input	ADOT spent about $270,000 develop HCRS. ADOT spends about $62,000/year for data entry labor. Unspecified monthly maintenance costs are incurred.	HCRS encourages good project communications between ADOT and contractors and good emergency communications among ADOT, the Department of Public Safety (DPS) and other agencies. The system allows traveler information to be made quickly available to the public.
B2. Traveler Information by Telephone (511)	The original Voice-Response Activated System (VRAS) software development costs totaled $270,000. Annual 511 operating and maintenance costs for 2002 were about $137,000. Labor costs are incurred in system promotion and in working with telephone service providers.	-511 improvement and promotion efforts are good for public relations. -511 answers questions that ADOT and DPS staff might otherwise need to answer. -The 511 number is short/easy to remember. -511 customers enjoy the benefits of real-time information (reduced frustration, ability to make informed travel decisions, time savings, and avoidance of potentially dangerous situations).
B3. Traveler Information by Internet (az511.com)	Unspecified capital costs were incurred for computer and communications equipment. ADOT also incurs operations, maintenance and promotion costs.	- As with 511, ADOT's provision and promotion of the website represent opportunities to build positive public relations. Load restrictions information facilitates the Motor Vehicle Division's (MVD's) issuing of CVO permits. The existence of the website removes some burden from ADOT and DPS in answering calls for travel information from the public. - The website is a good tool for pre-trip planning. The visual interface simplifies information access. The public appreciates advance notice of closures. In general, the information provided allows people to make travel decisions that improve safety, save time and reduce costs.
B4. Overhead (OH) Variable Message Signs (VMS)	A typical rural OH-VMS installation costs $385,000, including design, construction and system integration costs. The PECOS-Intelligent Transportation Infrastructure Report (11:22) estimates an overall annual average operating cost of $1,035 per site, and an annual average maintenance cost of $2,478 per site.	- ADOT and DPS both perceive VMS as a tremendous aid in providing information to travelers. Without VMS, ADOT and DPS would require more resources to respond to congestion. - As with other information dissemination ITS elements, overhead VMS can help travelers make better decisions, improving safety and efficiency and reducing costs. VMS messages, particularly advance warnings, frequently reduce motorist frustration.

Table 17: Group B ITI – Costs and Benefits (cont'd)

ITI	Costs	Perceived and Reported Benefits
B5. Shoulder-Mounted (SM) Variable Message Signs (VMS)	The cost for turnkey installation of the two SM-VMS on SR 68 in the Kingman District was $137,200. Based on this, cost per sign is about $68,600. Unspecified operations and maintenance costs are also incurred.	The shoulder-mounted VMS are important parts of HAR and instrumented truck escape ramps systems. In addition to their primary functions, these radar-equipped signs provide speed warning messages, which are believed to have some impact on traffic speeds.
B6. Portable Trailer-Mounted VMS (PTM-VMS)	Districts pay into the Equipment Services revolving fund for use of portable trailer-mounted VMS. The rates are $925 per month for solar units; and $400 to $500 per month for diesel units. The Districts are charged are an additional charge for the time the diesel units are actually in use. Sign setup and removal requires fairly minor labor costs. The solar-powered models are self-sustaining, while the diesel-powered models require periodic refueling visits during sustained usage.	The signs offer ADOT ease of setup and deployment flexibility. Remote programming is not used often but can be helpful. Preprogrammed messages simplify sign use. It is believed that the signs are effective at reducing vehicle speeds in roadwork zones; this is particularly true when DPS has an enforcement presence. As with other information dissemination ITI, CVO and the general public enjoy improvements in safety and time savings and reductions in costs as they make use of the information provided on the signs.
B7. Highway Advisory Radio (HAR)	A typical "turnkey" HAR service (which includes Federal Communications Commission (FCC) licensing costs, set up and removal of equipment, message updates, and maintenance) costs $1,900 per month.	HAR is ideal for application to construction projects since such projects frequently feature rapidly changing conditions. HAR is capable of providing detailed information about specific project dates, times of day, activities, expected delays, and so on. Project-related and other applications of HAR have the potential, as with other information dissemination ITI, of contributing to reduced driver frustration, increased safety, time savings and cost reductions. Advance notice of construction activity provides opportunity for drivers to make alternate route or trip timing decisions.

Table 18 summarizes the key issues and operational status and element-specific performance measures associated with ADOT's information fusion and dissemination systems.

Table 18: Group B ITI – Key Issues and Operational Status

ITI	Key Issues	Operational Status / Element-Specific Performance Measures
B1. Highway Condition Reporting System (HCRS) Input	- The "event expiration" feature curtails the occurrence of the system having outdated information. - The time commitment to enter HCRS data is not excessive, although it requires consistent effort. Good communication with the contractor and frequent on-site field inspections are critical.	Not counting monthly maintenance, HCRS system is online over 98% of the time (data from Jan. 2003-Oct. 2004). 12,450 entries per year (data from 2000-2002). Districts report system is easy to learn and use.
B2. Traveler Information by Telephone (511)	- People generally prefer to speak to a human being, but 511 seems to be gaining some acceptance among some people and for some types of information. The costs of a system with human operators would be significantly higher. - Effectiveness of voice recognition is highly subject to background noise, but otherwise offers some advantages over keypad navigation (which is still an option). - People would prefer navigation options that would not require them to know route numbers or mileposts. - Cell phone coverage issues impact plans for static 511 sign deployment. - Level of use varies widely, from very regular to occasional to experimental use. - Many people are still unfamiliar with 511. Promotion and system improvements are key to continuing growth in utilization.	- Voice Response Activated System (VRAS) is available over 99% of the time (data from Apr. 2003-Oct. 2004) - 52% of Department of Public Safety (DPS) survey respondents reported strongly or moderately agreeing that 511 information contributes to travel safety. The figures were 53% for Commercial Vehicle Operators (CVO) and 51%/ 28% for public from rural /urban Arizona ZIP codes. - For 511 information contribution to time savings, the figures were 58% (DPS), 40% (CVO), and 48%/30% (public from rural/urban Arizona). - 39% of CVO survey respondents reported strongly or moderately agreeing that 511 information contributes to cost savings.

Table 18: Group B ITI – Key Issues and Operational Status (cont'd)

ITI	Key Issues	Operational Status / Element-Specific Performance Measures
B3. Traveler Information by Internet (az511.com)	- Many people dislike close spacing of HCRS event icons. They don't understand the "list all events" button would rather have the system list the events automatically. - Low bandwidth (dial-up) Internet connections are still common (especially in rural areas) and would benefit having access to a less intensive graphics-intensive interface. - The public would like to have access to messages currently being shown on VMS. - Alternative sources of information exist but are scarcer for rural areas.	-36% of DPS survey respondents reported strongly or moderately agreeing that az511.com information contributes to travel safety. The figures were 64% for CVO and 58%/61% for public from rural/urban Arizona ZIP codes. - For az511.com information contribution to time savings, the figures were 46% (DPS), 44% (CVO), and 59%/65% (public from rural/urban Arizona). - 45% of CVO survey respondents reported strongly or moderately agreeing that az511.com information contributes to cost savings.
B4. Overhead Variable Message Signs (VMS)	- Suggested factors for new locations include response to rapid population growth, better detour information, filling gaps between existing signs, and addressing Mexican border information needs. - VMS have good maintenance support from Regional Traffic Engineering Offices (RTEOs) and equipment vendors. However, the RTEOs lack funding and manpower. A specialized statewide VMS maintenance team has been suggested as a possible alternative. - Lane closures are currently required for maintenance access at some VMS. - Some motorists expect VMS to be used only for "real-time information." Some negative comments were received about 511, az511.com, and bus/carpool promotion. However, it is believed that such messages have a positive overall impact.	- 76% of DPS survey respondents reported strongly or moderately agreeing that VMS information contributes to travel safety. The figures were 74% for CVO, 72% for public from rural Arizona ZIP codes, and 66% for public from urban Arizona ZIP codes. Note that the DPS, CVO and public surveys did not distinguish between various types of VMS. - For VMS information contribution to time savings, the figures were 70% (DPS), 62% (CVO), and 64%/65% (public from rural/urban Arizona). - 50% of CVO survey respondents reported strongly or moderately agreeing that VMS information contributes to cost savings.
B5. Shoulder-Mounted VMS (SM-VMS)	- Shoulder-mounted VMS have lower capital costs than overhead VMS. - Sign size and position makes them suitable for lower-speed/lower-volume facilities - more susceptible to vandalism. - Portable trailer-mounted VMS are less costly and more flexible; shoulder-mounted VMS are more secure.	See Overhead VMS comments.

Table 18: Group B ITI – Key Issues and Operational Status (cont'd)

ITI	Key Issues	Operational Status / Element-Specific Performance Measures
B6. Portable Trailer-Mounted VMS (PTM-VMS)	- The interface for message setup on portable trailer-mounted VMS varies on different units and is perceived as not user-friendly. "Cheat sheets" help people with commonly used features. - Programming the sign prior to deployment is standard procedure. Remote programming is perceived as unreliable. - Portable units deployed for speed reduction are believed to be much more effective with DPS enforcement. - Proper sign placement for sign legibility requires skill and forethought. Portable units should not be placed close to overhead VMS or on extremely sloped shoulders. - Newer solar powered units are greatly preferred over older diesel-powered units. - Portable signs have significantly less target value (are not as easily perceived) as overhead VMS. - Portable signs are tough but are subject to harsh conditions both en-route to deployment and in position.	See Overhead VMS comments.
B7. Highway Advisory Radio (HAR)	- HAR requires an active response from travelers (tuning to a particular radio frequency). An ADOT survey found that only about 10% of drivers passing through a construction project tuned into the HAR station. - Some HAR stations have poor reception quality, often due to mountainous terrain. - HAR is more effective when used in conjunction with flashing beacons. - Some motorists want a wider HAR broadcast radius, more advanced notice of events, more time to react and plan. - Provision of real-time information is a challenge but is key to retaining public trust and interest. - Some people prefer to drive without radio noise – it is perceived as a distraction from driving tasks. - HAR used for construction project information should be viewed as part of an overall public outreach effort.	- 46% of DPS survey respondents reported strongly or moderately agreeing that HAR information contributes to travel safety. The figures were 65% for CVO, 41% for public from rural Arizona ZIP codes, and 14% for public from urban Arizona ZIP codes. - 48% of DPS survey respondents reported strongly or moderately agreeing that HAR information contributes to time savings. The figures were 44% for CVO, 36% for public from rural Arizona ZIP codes, and 15% for public from urban Arizona ZIP codes. - 45% of CVO survey respondents reported strongly or moderately agreeing that HAR information contributes to cost savings.

Table 19 summarizes the performance evaluation of ADOT's information fusion and dissemination systems, based on universal performance measure composite scores.

Table 19: Group B ITI – Evaluation Based on Universal Performance Measures

ITI	Composite Goal Area Scores				Composite Overall Score (Overall / Group Rankings)
	Safety	Mobility	Costs	Reliability/ Usefulness	
B1. Highway Condition Reporting System (HCRS) Input	60	60	60	64	244 (12 of 18 / 6 of 7)
B2. Traveler Information by Telephone (511)	60	60	64	60	244 (12 of 18 / 6 of 7)
B3. Traveler Information by Internet (az511.com)	60	60	68	67	255 (9 of 18 / 5 of 7)
B4. Overhead Variable Message Signs (VMS)	100	100	100	94	394 (1 of 18 / 1 of 7)
B5. Shoulder-Mounted VMS (SM-VMS)	80	80	84	84	328 (4 of 18 / 3 of 7)
B6. Portable Trailer-Mounted VMS (PTM-VMS)	80	80	84	94	338 (2 of 18 / 2 of 7)
B7. Highway Advisory Radio (HAR)	80	80	84	60	304 (7 of 18 / 4 of 7)

7. STUDY FINDINGS - TRAFFIC CONTROL AND COMMERCIAL VEHICLE ELECTRONIC CLEARANCE SYSTEMS

The Group C ITI (Traffic Control/Commercial Vehicle Electronic Clearance Systems) include the following:

1. **Portable Traffic Signals** are trailer-mounted traffic signals that are temporarily deployed wherever they are needed. Multiple signals can be linked together in a variety of configurations. Thus far, these signals have been deployed only to meet temporary local needs.

(Dunklin County, MO. ADDCO)

(VER-MAC Signal)

Figure 13: Portable Traffic Signals

2. **Commercial Vehicle Electronic Clearance systems (such as PrePass)** are port-of-entry based systems that automatically determine whether a passing commercial vehicle is required to pull into the port; the vehicle is given a "pull-in" or "bypass" signal. These systems have been deployed statewide.

Figure 14: PrePass Detection on VMS in Arizona

3. **Expedited Processing at International Crossings (EPIC)** is a system providing tracking of commercial vehicle and driver movements through the complex series of inspections and other processes required at the Nogales Port of Entry. The system provides detailed information for internal agency use (both ADOT and other agencies) and publicizes general information such as queue wait times). Thus far this system has been deployed only on a local basis; it may expand to other international ports of entry in the future.

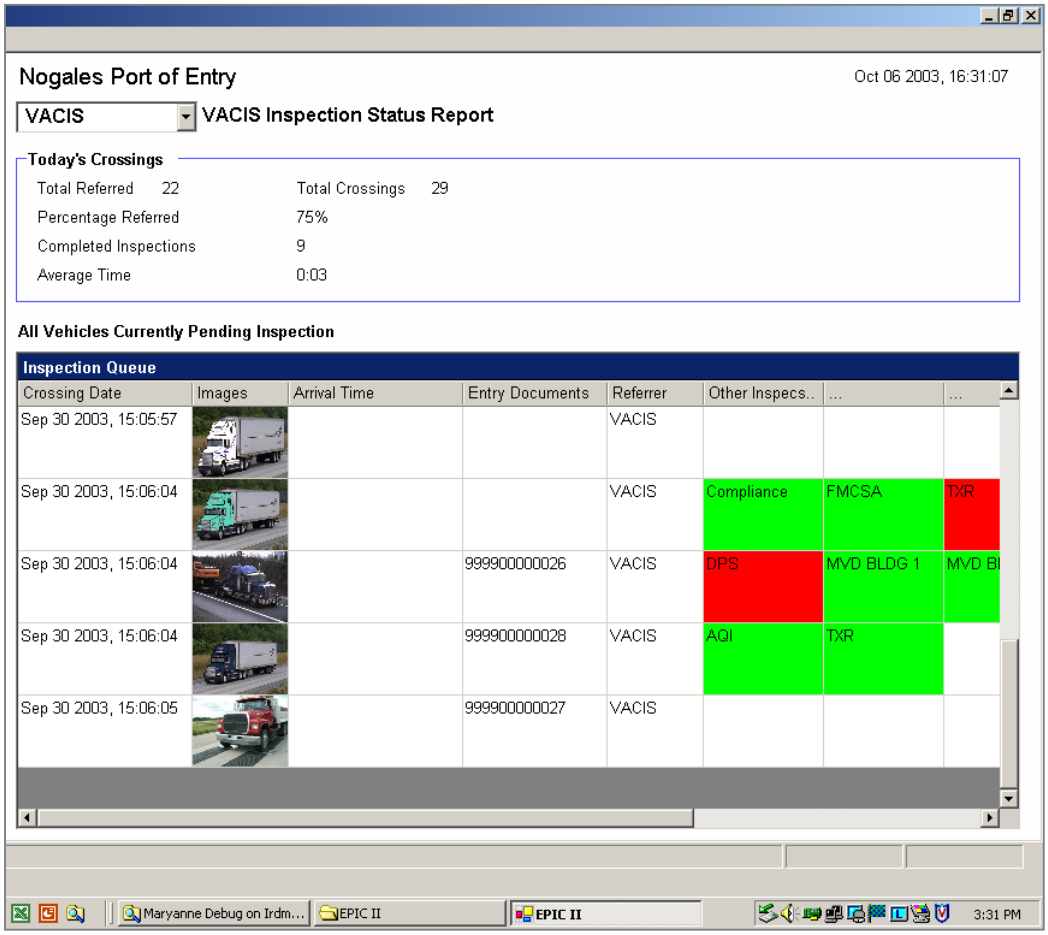

Figure 15: EPIC Operator Interface (Partial)

Table 20 summarizes typical installation components and system functions/outputs associated with ADOT's traffic control/commercial vehicle electronic clearance systems.

Table 20: Group C ITI – Components and Functions

ITI	Typical Installation Components	System Functions / Outputs
C1. Portable Traffic Signals	A single unit typically consists of two traffic signal heads mounted on a trailer, hydraulics for extension of the overhead signal head support, solar power panels and equipment for intra-signal and remote control communications.	Portable traffic signals are frequently used in pairs as a means of controlling traffic through a one-way section of roadway (for instance, across a narrow bridge or through a roadwork zone). However, signals can also be used singly or in other configurations, to replace a damaged permanent signal or for other reasons.
C2. Commer-cial Vehicle Electronic Clearance (PrePass)	A typical PrePass system includes a tag reader, communication equipment, and a computer server. The eight ports of entry at which PrePass is installed also rely on weigh-in-motion (WIM) devices, which are sometimes located in the mainline and sometimes located in the exit ramp to the port.	The tag reader reads identification information stored on transponders carried in participating trucks. Upon identification of a passing truck, the PrePass computer checks a database to verify the truck's permits; the truck may also be asked to pull in on the basis of weight issues identified via mainline WIM or for random testing.
C3. Expedited Processing at Inter-national Crossings (EPIC)	The system consists of a large array of hardware and software components, including Radio Frequency Identifi-cation (RFID) tags and readers, Closed-Circuit Television (CCTV), Variable Message Signs (VMS), computer workstations, a remote broker system, a fiber optic Limited-Area Network (LAN), a central server system, and software interfaces and databases.	The second generation of this system, the EPIC II system, provides expedited processing, compliance monitoring, and traffic management at the Nogales international border crossing.

Table 21 summarizes the quantity of deployed ITI, deployment plans and maintenance arrangements associated with ADOT's traffic control/commercial vehicle electronic clearance systems.

Table 21: Group C ITI – Quantity Deployed/Planned and Maintenance Arrangements

ITI	Quantity Deployed/Planned	Maintenance Arrangements
C1. Portable Traffic Signals	There are no known uses or planned uses of portable traffic signals by ADOT at this time. Most Districts have used them in the past.	The construction contractor is typically responsible for maintenance of the signals.
C2. Commercial Vehicle Electronic Clearance (PrePass)	PrePass systems are installed at eight sites. No known planned deployments or system enhancements.	The equipment vendor is responsible for maintenance of local computer and field equipment.
C3. Expedited Processing at International Crossings (EPIC)	EPIC II is operating at one site. No known deployment plans for other sites.	The Information Technology Group (ITG) and the equip-ment vendor are responsible for system maintenance.

See Appendix K for maps of deployed ITI in Group C.

Table 22 summarizes planned system enhancements and integration and standardization attributes or issues associated with ADOT's traffic control / commercial vehicle electronic clearance systems.

Table 22: Group C ITI – Enhancements, Integration and Standardization

ITI	Planned System Enhancements/Integration/Standardization
C1. Portable Traffic Signals	Portable traffic signals are designed to work together in multiple-unit configurations as needed. Most rural applications would not require any broader integration than a multiple-unit setup at an intersection or relatively short roadway section.
C2. Commercial Vehicle Electronic Clearance (PrePass)	The local PrePass database housed on computer servers at individual ports of entry are periodically refreshed via information stored in remote databases.
C3. Expedited Processing at International Crossings (EPIC)	Similar to PrePass, the EPIC II system depends on a local database that is periodically refreshed via information from remote databases. The system is also integrated in the sense that it satisfies needs shared by multiple agencies and by Commercial Vehicle Operators at the Nogales port of entry. Future improvements under consideration or development include mobile vehicle identification systems; increased sensor reliability; greater system integration at state, national and international levels; use of barcodes; central administration of multiple ports of entry; and integration of transponder technology with toll, weigh station, and sea transportation.

Table 23 summarizes stakeholder awareness and usage of ADOT's traffic control/ commercial vehicle electronic clearance systems.

Table 23: Group C ITI – Stakeholder Awareness and Usage

ITI	Awareness	Usage
C1. Portable Traffic Signals	ADOT staff is generally familiar with Portable Traffic Signals.	Nearly all ADOT Districts have used the signals in the past.
C2. Commercial Vehicle Electronic Clearance (PrePass)	ADOT MVD staff is very familiar with PrePass. The Districts have general familiarity with PrePass. 79% of CVO survey respondents reported being aware of ADOT's PrePass.	PrePass is used primarily at ports of entry (POEs) located on interstates at state borders. The Kingman port of entry is an exception, located at the junction of US 93 and SR 68. August 2004 statistics indicate that 87% of PrePass-eligible truck traffic passed by or through the POEs during times the POE was open. Some PrePass POEs are operated 24 hours a day. 48% of CVO survey respondents reported using ADOT's PrePass often or rarely.
C3. Expedited Processing at International Crossings (EPIC)	Some ADOT staff (especially the Information Technology Group and the Motor Vehicle Division) are familiar with EPIC II.	The EPIC II system is now operational. Some trucking companies are participating.

Table 24 summarizes the costs and perceived and reported benefits associated with ADOT's traffic control/commercial vehicle electronic clearance systems.

Table 24: Group C ITI – Costs and Benefits

ITI	Costs	Perceived and Reported Benefits
C1. Portable Traffic Signals	A single portable signal costs about $70,000 to $75,000 to purchase. For a single signal, short-term rental rates from equipment rental companies are about $300 per day; longer-term rates are about $200 per day.	- The ability of portable traffic signals to replace flaggers has potential safety and cost benefits to ADOT and contractors. Contractor employees who might otherwise be called on for flagger duties can be used more effectively. Signals are larger than flaggers and therefore should be more visible to motorists; this improves work zone safety. The traveling public will benefit by traversing the construction area more safely. - Portable traffic signals may also be used to quickly replace a permanent signal that has been damaged or destroyed.
C2. Commercial Vehicle Electronic Clearance (PrePass)	Because the company that invented the PrePass system receives a fee for every bypassed vehicle, the company charges no costs to ADOT for PrePass equipment installation or maintenance. ADOT has incurred costs in integrating the PrePass system into its overall commercial vehicle information systems and networks (CVISN) plan.	- PrePass improves ADOT's ability to enforce Commercial Vehicle Operator (CVO) compliance with safety regulations, which improves safety for everyone on the ADOT roadways. ADOT is better able to collect monies from motor carriers to compensate for truck impacts on Arizona roads. The automation of these and other functions also provides a better business environment, reducing consumer costs for goods. - CVO benefits include fuel savings, reduction in parts wear and tear, better on-time performance, improved scheduling, and ease of use. - The traveling public passing by ports of entry benefits as it is safer for trucks to bypass ports of entry than to go through deceleration on exiting and acceleration on re-entering the roadway.
C3. Expedited Processing at International Crossings (EPIC)	Construction costs for EPIC II totaled about $700,000. System integration cost nearly $275,000. Annual operations and maintenance costs are $30,000.	- EPIC II increases the ability of ADOT and its partner agencies at the Nogales compound to process and verify compliance of drivers, tractors and trailers, and to manage traffic within the compound. Border crossing security, screening efficiency and port management are improved. - CVO benefit from having access to information about queue wait times at various places within the compound. The public benefits from improved truck safety via enforcement of regulations.

Table 25 summarizes the key issues and operational status/element-specific performance measures associated with ADOT's traffic control/commercial vehicle electronic clearance systems.

Table 25: Group C ITI – Key Issues and Operational Status

ITI	Key Issues	Operational Status/ Element-Specific Performance Measures
C1. Portable Traffic Signals	- Driver compliance with portable traffic signals improves with the nearby presence of Department of Public Safety (DPS) or construction staff. - Some people feel that in spite of lesser visibility, flaggers provide more effective traffic control. - High-profile vehicles sometimes collide with the overhead traffic head. - The Districts consider the signals most suitable for longer-term construction projects, not for maintenance. - Battery-operated signals are perceived as unreliable. - Signal rental costs are steep. Temporary signals as a replacement for damaged permanent signals may make more sense than renting a portable unit.	Not applicable.
C2. Commercial Vehicle Electronic Clearance (PrePass)	- To protect Commercial Vehicle Operator (CVO) privacy, timestamp information (the precise time at which vehicles pass the reader) is no longer collected by the PrePass system. - It can be difficult to receive service from the vendor when the system malfunctions. - CVO non-compliance with pull-in requests vary from port to port. Not all ports know how to report non-compliance events/violations to the equipment vendor. - It is believed that many overweight trucks take advantage of ports without mainline weigh-in-motion. This is a particularly sensitive issue at the St. George port of entry.	63% of CVO survey respondents reported strongly or moderately agreeing that PrePass contributes to travel safety. The figure was 50% for PrePass contribution to cost savings.
C3. Expedited Processing at International Crossings (EPIC)	- Future plans for system improvements will greatly aid in global tracking of shipments and closely related homeland security issues.	System is operational. No performance information available at this time.

Table 26 summarizes the performance evaluation of ADOT's traffic control/commercial vehicle electronic clearance systems, based on universal performance measure composite scores.

Table 26: Group C ITI –Evaluation Based on Universal Performance Measures

ITI	Composite Goal Area Scores				Composite Overall Score (Overall / Group Rankings)
	Safety	Mobility	Costs	Reliability/ Usefulness	
C1. Portable Traffic Signals	100	100	92	40	332 (3 of 18 / 1 of 3)
C2. Commercial Vehicle Electronic Clearance (PrePass)	67	80	92	69	308 (6 of 18 / 3 of 3)
C3. Expedited Processing at International Crossings (EPIC)	67	80	92	75	314 (5 of 18 / 2 of 3)

8. STUDY FINDINGS - EMERGENCY DETECTION AND RESPONSE SYSTEMS

The Group D ITI (Emergency Detection and Response Systems) include the following:

1. **Instrumented Truck Escape Ramps** are escape ramps that have an electronic monitoring system designed to automatically detect and notify authorities of intrusions. The system also features shoulder-mounted VMS upstream of the ramp to provide intrusion warnings and other information. Thus far, this system has been deployed only on a local basis.

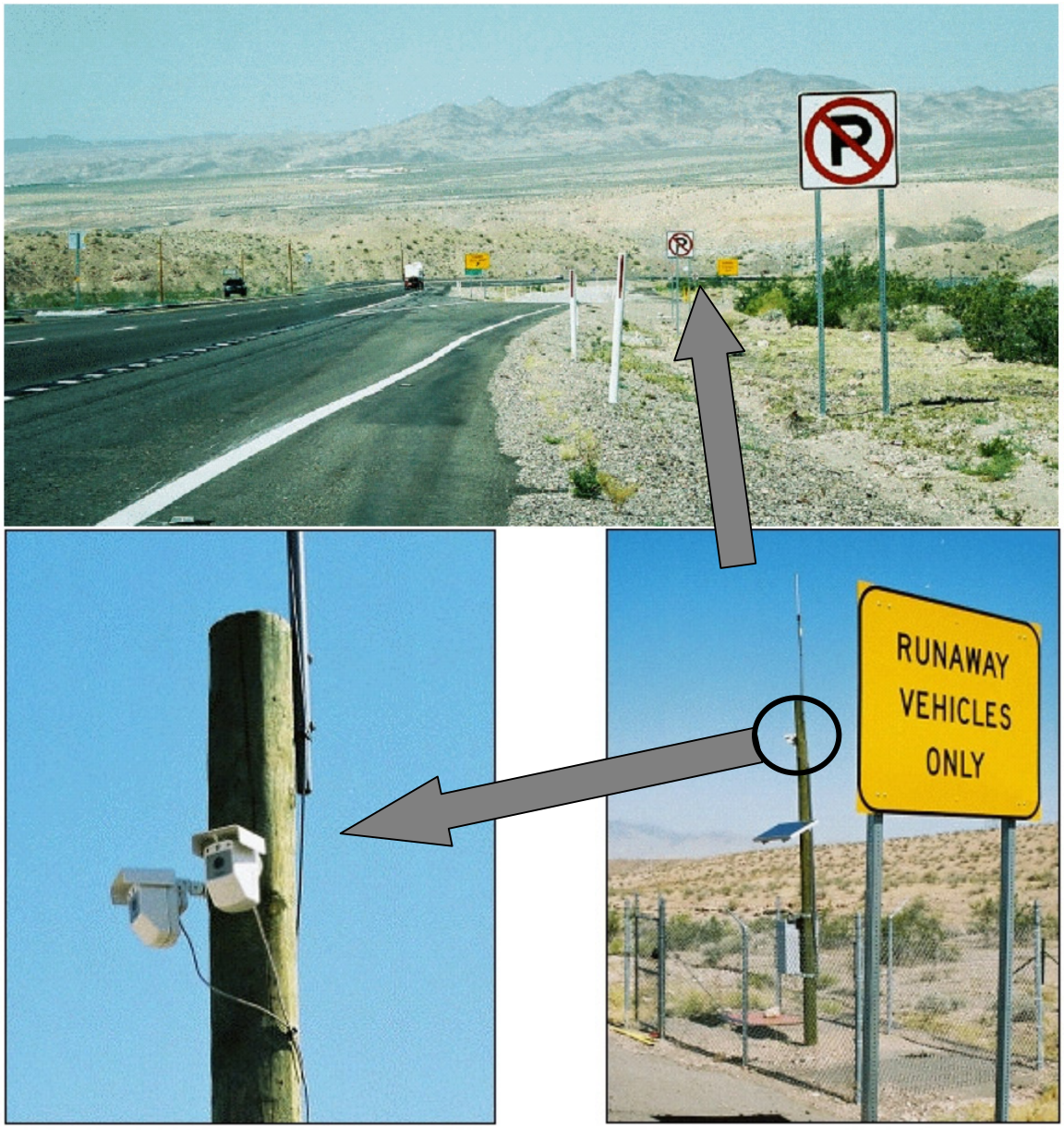

Figure 16: Truck Escape Ramp Instrumentation

2. **Emergency Roadside Callboxes** are cellular-based telephones for emergency use installed at intervals along roadways. Thus far, callboxes have been installed only on a local basis (I-19 south of Tucson and US 93)

Figure 17: Callbox on US 93

3. **Motorist Assist Patrols (MAPs)** involve an operator equipped with a vehicle and emergency response equipment who monitors a section of roadway during nighttime hours, and responds to any motorists experiencing trouble or to hazardous conditions that could cause traffic problems. MAPs play a strong supportive role to the DPS highway patrol's duties. Thus far, rural MAPs have been utilized only on a project-by-project basis by ADOT, in the Kingman District.

Figure 18: Motorist Service Patrol Vehicle

Table 27 summarizes typical installation components and system functions/outputs associated with ADOT's emergency detection and response systems.

Table 27: Group D ITI –Components and Functions

ITI	Typical Installation Components	System Functions/ Outputs
D1. Instrumented Truck Escape Ramps	An instrumented truck escape ramp as implemented in the Kingman District includes three subsystems: 1. Truck escape ramp monitoring (magnetic in-pavement detector for triggering cameras, two pole-mounted cameras, remote processing unit, power supply) – senses ramp intrusion, captures camera image, transmits image via email to Phoenix Traffic Operations Center (TOC), Kingman District, Department of Public Safety (DPS), and local authorities. 2. Ramp intrusion notification to authorities (software running on computers at the Phoenix TOC and the Kingman District) – receives ramp intrusion image. Authorities can then coordinate emergency response. 3. Ramp intrusion notification to the public (using shoulder-mounted VMS, with components as previously discussed) – warns oncoming traffic upstream of ramps about ramp intrusion.	
D2. Emergency Roadside Callboxes	Callboxes include a telephone in a bright yellow enclosure mounted on a pole on a concrete pad. The sites in Arizona all have a keyboard for teletypewriter (TTY) usage of the phone, cellular communications and a solar powered light that is activated when the enclosure's door is opened. The US 93 callboxes include booster antennas.	Calls from both systems are set up to ring directly into DPS Operational Communications (OpComm) Centers as 911 calls.
D3. Motorist Assist Patrols (MAPs)	A successful MAP depends on 1) a skilled operator; 2) a vehicle; 3) emergency equipment. Desirable operator skills include first aid training, Cardio-Pulmonary Resuscitation (CPR), radio communication skills, traffic control training, basic mechanical skills, people skills, basic computer literacy, and fluency in English and Spanish. Vehicle needs may vary from place to place; the Kingman District uses a two-wheel drive pickup truck. A few of the key emergency equipment items include front push bumper, spotlights, digital cell phone, camera, flashlights, jumper cables, fuel, tools, tow rope, flares, ABC- and D-class fire extinguishers, three-ton jack, first aid kit / accessories, citizens band radio, ADOT radio, multichannel mobile scanner, traffic cones, and drinking and coolant water.	A MAP operator performs a wide variety of tasks, including direct motorist assistance, removal of roadway debris, replacement of displaced/ fallen barricades, and animal control. The Kingman MAP runs every weekday from 10:00 PM to 6:00 AM, covering a time period during which DPS patrols are rare. The official coverage area extends about 25 miles. Depending on events the operator becomes aware of, the patrol on any given night may extend to about 60 miles in length.

Table 28 summarizes the quantity of deployed ITI, deployment plans and maintenance arrangements associated with ADOT's emergency detection and response systems.

Table 28: Group D ITI – Quantity Deployed/Planned and Maintenance Arrangements

ITI	Quantity Deployed/Planned	Maintenance Arrangements
D1. Instrumented Truck Escape Ramps	The Kingman District has instrumented two truck escape ramps. No known deployment plans.	ADOT has contracted with a consultant to provide maintenance of the field equipment located at the ramps. The Western Regional Traffic Engineering Office (RTEO) provides demand maintenance of the shoulder-mounted Variable Message Sign (VMS).
D2. Emergency Roadside Callboxes	Two callbox systems: 1) The US 93 system has four callboxes over 40 miles; and 2) the I-19 system has 12 callboxes over 14 miles. No known deployment plans.	The Kingman District has a maintenance agreement with the equipment vendor for the US 93 system. The Baja RTEO provides maintenance of the I-19 system, with vendor support as required.
D3. Motorist Assist Patrols (MAPs)	The Kingman District has operated one patrol via consecutive construction contracts more or less continuously for four and a half years. No known deployment plans.	The construction contractor is responsible for maintenance of the MAP vehicle. The MAP operator voluntarily contributes to minor MAP vehicle upkeep such as carwashes.

See Appendix L for maps of deployed ITI in Group D.

Table 29 summarizes planned system enhancements and integration and standardization attributes or issues associated with ADOT's emergency detection and response systems.

Table 29: Group D ITI – Enhancements, Integration and Standardization

ITI	Planned System Enhancements/Integration/Standardization
D1. Instrumented Truck Escape Ramps	Communications allow remote monitoring of the instrumented truck escape ramp system by operators at the Phoenix Traffic Operations Center (TOC), where the main system server resides. This is because the TOC has 24-hour operations and ramp intrusions can happen at any time.
D2. Emergency Roadside Callboxes	Both emergency roadside callbox systems are integrated in the sense that calls from the boxes are answered as 911 calls at Department of Public Safety (DPS) Operational Communications (OpComm) centers. Another type of integration is that the I-19 system features a central computer server and software for system maintenance; the callboxes are programmed to call in and self-report on diagnostics and other system data.
D3. Motorist Assist Patrols (MAPs)	Because the US 93 MAP vehicle is not state-owned, it has not been possible to install a DPS radio in the vehicle. However, the MAP operator uses a scanner to listen to DPS communications and can easily contact DPS within coverage areas via a cellular telephone call to the Phoenix TOC. In general, the MAP operator has succeeded at dovetailing MAP duties and emphasis with DPS needs. Further, the operator's familiarity with truck drivers that frequent the area and ready use of Citizen's Band Radio to communicate with them is an invaluable asset and a boost to the patrol's success.

Table 30 summarizes stakeholder awareness and usage of ADOT's emergency detection and response systems.

Table 30: Group D ITI – Stakeholder Awareness and Usage

ITI	Awareness	Usage
D1. Instrumented Truck Escape Ramps	Some ADOT staff are familiar with shoulder-mounted Variable Message Signs (VMS). The Kingman District's use of the system is increasing ADOT's level of familiarity. 24% of DPS survey respondents reported being aware of ADOT's instrumented truck escape ramps. The figure was 59% for Commercial Vehicle Operators (CVO).	- The instrumented truck escape ramps are operational 24-hours a day; the Phoenix Traffic Operations Center (TOC) provides 24-hour a day system monitoring. - Through September 2004, one ramp had been used 31 times and the other had been used 25 times. - 7% of CVO survey respondents reported having used ADOT's instrumented truck escape ramps more than once or once.
D2. Emergency Roadside Callboxes	ADOT staff is generally familiar with emergency roadside callboxes. 59% of DPS survey respondents reported being aware of ADOT's emergency roadside callboxes. The figures were 59% for public from rural Arizona ZIP codes, and 58% for public from urban Arizona ZIP codes.	- Flagstaff Department of Public Safety (DPS) Operational Communications (OpComm) center received about 1130 calls from US 93 callboxes between July 2003 and June 2004, or 282 calls per box (four boxes). About 18% of received calls involved actual requests for emergency services. - The Tucson DPS OpComm center received 1314 calls from I-19 callboxes between July 2003 and June 2004, or 110 calls per box (12 boxes). - 9% of public survey respondents from rural Arizona ZIP codes reported having used ADOT's emergency roadside callboxes more than once or once. The figure was 5% for public from urban Arizona ZIP codes.
D3. Motorist Assist Patrols (MAPs)	ADOT staff is generally familiar with motorist assist patrols. 9% of DPS survey respondents reported being aware of ADOT's motorist assist patrol. The figures were 23% for public from rural Arizona ZIP codes, and 22% for public from urban Arizona ZIP codes.	- The US 93 MAP operator has logged 522 "assists" over about four and a half years, or about 124 assists per year. Assists include direct aid to motorists in trouble as well as removal of roadway obstacles and other activities. - 5% of public survey respondents from rural Arizona ZIP codes reported having been aided by ADOT's motorist assist patrol more than once or once. The figure was 3% for public from urban Arizona ZIP codes.

Table 31 summarizes the costs and perceived and reported benefits associated with ADOT's emergency detection and response systems.

Table 31: Group D ITI – Costs and Benefits

ITI	Costs	Perceived and Reported Benefits
D1. Instrumented Truck Escape Ramps	The total system cost, including the site survey, installation, and equipment and materials, was $227,350.	-ADOT and the Department of Public Safety (DPS) can remotely assess and more effectively respond to ramp intrusions. ADOT/DPS personnel involved in incident management and ramp repair are safer due to public notification of intrusion. - Faster ramp repairs and lower incidence of truck brake failures due to speed warnings benefits everyone. - Commercial Vehicle Operators (CVO) involved in ramp intrusions benefit from faster and more effective responses by ADOT and DPS.
D2. Emergency Roadside Callboxes	- The original design and installation costs for the four-callbox system on US 93 totaled $27,380, or $6,845 per callbox. A concurrent project absorbed some of the true costs of the installation. Average annual cellular communi-cations costs for the whole system are about $4,070. The Kingman District's maintenance agreement with the equipment vendor costs $2,800/year for the whole system. - Recent upgrades to the I-19 system, including a cement slab around the base of the pole and a teletype (TTY) keyboard, cost about $60,000 per site. Annual cellular communications costs for the whole system range from about $3,000 to about $7,000.	- ADOT's sponsorship of the callboxes is a good way of building public confidence and appreciation. Some calls alert ADOT and DPS to incidents that require their attention. It is believed that with factors like the recently improved callbox signing on US 93 and growing public familiarity, the number of non-emergency calls will diminish over time, which will reduce DPS's workload. - Among the public, it is recognized that callboxes have a role to play despite the popularity and ubiquity of cell phones. Some people don't have cell phones at all, or forget to bring it with them, or have one that runs out of battery power or whose coverage area does not extend to certain areas.
D3. Motorist Assist Patrols (MAPs)	The current rural MAP represents less than 1% of the total US 93 project construction cost. The MAP bid item totaled $150,000 for a patrol to run full time (eight hours) during weekday nights during a 30-month time frame.	- ADOT benefits from the positive public perception of the program. DPS benefits by having a knowledgeable person (the MAP operator) assess the situation, identify needed resources, and apply first aid if needed. Some incidents require no DPS response at all. - The MAP operator at times provides direct mechanical and first aid assistance to the public.

Table 32 summarizes the key issues and operational status/element-specific system performance measures associated with ADOT's emergency detection and response systems.

Table 32: Group D ITI – Key Issues and Operational Status

ITI	Key Issues	Operational Status/ Element-Specific Performance Measures
D1. Instrumented Truck Escape Ramps	- ADOT's policy for truck escape ramp construction is designed to minimize legal liability. - Double occupations have occurred on one of the SR 68 escape ramps on two different occasions. Such events highlight the need for efficiency and effectiveness in responding to ramp intrusion events.	- 49% of Department of Public Safety (DPS) survey respondents reported strongly or moderately agreeing that instrumented truck escape ramps contribute to travel safety. The figure was 63% for Commercial Vehicle Operators (CVO). - 51% of CVO survey respondents reported strongly or moderately agreeing that instrumented truck escape ramps contribute to cost savings.
D2. Emergency Roadside Callboxes	- Districts with callboxes reported no significant vandalism problems. - Remote areas outside regular DPS patrol areas need callboxes the most, but cellular coverage is often poor in such areas. Booster antennas help but may not be enough. - DPS policy is to make three attempts to reach members of a stranded motorists' family when tow service is requested. - Some hang-up calls are believed to be intentional; others are people who are caught by surprise when they are greeted with a 911 operator. - Closer callbox spacing is desirable. Suggestions for additional areas of coverage included non-interstate highways, locations with poor cellular coverage and locations where breakdowns frequently occur.	- 64% of DPS survey respondents reported strongly or moderately agreeing that emergency roadside callboxes contribute to travel safety. The figures were 65% for public from rural Arizona ZIP codes and 59% for public from urban Arizona ZIP codes. - 69% of DPS survey respondents reported strongly or moderately agreeing that emergency roadside callboxes result in emergency help arriving quicker. The figures were 58% for public from rural Arizona ZIP codes and 46% for public from urban Arizona ZIP codes.

Table 32: Group D ITI – Key Issues and Operational Status/Element-Specific Performance Measures (cont'd)

ITI	Key Issues	Operational Status/ Element-Specific Performance Measures
D3. Motorist Assist Patrols (MAPs)	- The MAP program reduces the workload of DPS officers, who can then proceed with enforcement activities - Motorists think very positively of MAPs. - In addition to patrolling the area, MAP effectiveness depends heavily on word of mouth. - Communications dead spots exist. - There may be some advantages to making the MAP operator a state employee (which is not now the case). - MAPs currently operate at night, but similar benefits would be derived from running a daytime patrol. - The MAP operator is unarmed but at times encounters illegal activities (such as human/ drug smuggling). Spotlights are an invaluable aid for assessment of this and other situations. - Suggestions for additional rural MAP locations included areas where breakdowns frequently occur: I-10 between Tucson and Phoenix, I-17 between Phoenix and Flagstaff, and desert highways such as SR 85 and SR 86.	- 61% of DPS survey respondents reported strongly or moderately agreeing that MAPs contribute to travel safety. The figures were 62%/56% for public from rural/urban Arizona ZIP codes. - 58% of DPS survey respondents reported strongly or moderately agreeing that MAPs result in emergency help arriving quicker. The figures were 51% for public from rural Arizona ZIP codes and 48% for public from urban Arizona ZIP codes.

Table 33 summarizes the performance evaluation of ADOT's emergency detection and response systems, based on universal performance measure composite scores.

Table 33: Group D ITI – Evaluation Based on Universal Performance Measures

ITI	Composite Goal Area Scores				Composite Overall Score (Overall / Group Rankings)
	Safety	Mobility	Costs	Reliability/ Usefulness	
D1. Instrumented Truck Escape Ramps	80	40	72	58	250 (10 of 18 / 1 of 3)
D2. Emergency Roadside Callboxes	53	60	48	63	224 (14 of 18 / 3 of 3)
D3. Motorist Assist Patrols (MAPs)	60	60	72	58	250 (10 of 18 / 1 of 3)

9. STUDY FINDINGS - OTHER ITI

This section offers a review of the various other innovative ITS systems or applications by individual ADOT Districts around the state of Arizona. Some, but not all of these ITS concepts would represent new solutions to local or regional concerns.

Operations Centers (Other than in Phoenix and Tucson)

The Holbrook District currently has an operations center located in Holbrook. The Flagstaff District has an operations center located in Flagstaff; it is open 7:00 AM to 5:00 PM Monday through Friday and as needed in emergencies.

Opinions vary widely between Districts in their desire to have independent, full-featured operations centers locally. The "24/7" availability of the Phoenix TOC is generally considered extremely beneficial, particularly in view of the limited operations schedule of the Districts (generally 8:00 AM to 5:00 PM). At the same time, a number of local ADOT staff mentioned a desire to increase local traffic operations and communications capabilities; however, no clear indication of desired features was provided to the Consultant. The overall impression gained through district interviews is that if the local districts were provided with sufficient staffing, a self-sufficient local TOC would be welcomed by most districts.

Snow Desks

When required (during winter storms), the Kingman, Flagstaff and Holbrook Districts operate "snow desks" to coordinate the Districts' snow plowing and other winter storm activities. The snow desk will normally remain open as long as any snow plows are still being operated. The ADOT TOC Operations Manual (12:39) provides the following operational guidelines to TOC operators:

1. DPS or ADOT personnel usually report snow and ice problems to the TOC.

2. The operator will advise on-duty DPS and ADOT personnel in the affected area that snow removal is being done.

3. If a call-out is necessary, refer to the district procedure for guidance.

4. The snow desk will notify the TOC when snow removal assignments have been completed.

Truck-Mounted Message Boards

Many maintenance organizations in ADOT Districts operate truck-mounted electronic message boards. These boards offer two lines of text and are found useful by most maintenance staff, due to the flexibility with which they can be moved about, compared

to the less mobile and flexible trailer-mounted portable VMS. The drawbacks of these truck-mounted signs are a smaller total message length and lesser board brightness, again compared to the trailer-mounted VMS.

Visibility Sensors

Visibility sensors are now part of the standard RWIS equipment. Generally, districts with significantly varying winter weather conditions (Kingman, Flagstaff, Prescott, Holbrook) and those experiencing dust storms (Safford) value this type of sensor as it allows their staff to detect potentially unsafe driving conditions. For example, the Safford District desires better visibility sensors, deployed over a wider range of locations. Districts equipped with remote cameras (also part of standard RWIS equipment), utilize them for visual verification of approximate weather conditions. A wider deployment of high-quality visibility sensors would result in more reliable estimates of actual visibility along the highways. The Tucson and Yuma Districts feel they have little or no need for these devices as they do not frequently experience severe reductions in visibility due to dust storms or severe precipitation or fog conditions. However, the Yuma District said that a potential application of visibility sensors would be to monitor I-10 near the Hope City truck stop for blowing dust.

Temperature Sensors on Snowplows

Northern ADOT Districts use air temperature and pavement (road surface) temperature sensors mounted on snow plows to assess the need for chemical anti-icing/de-icing during adverse weather. The Districts would prefer relying on the pavement sensors that are integral to the deployed RWIS stations; however, these units typically fail within the first year after installation and are considered unreliable by every District where they have been implemented.

Variable Speed Limit Systems

The Flagstaff District reported having researched variable speed limits. A software program to implement variable speed limits was developed and bench-tested, and it was determined that the system was capable of working. However, due to a number of factors including liability concerns, the effort was put on hold indefinitely. The Safford District expressed an interest in using variable-speed limit signs in school zones and long construction areas. However, enforcing the lower speeds could require special legislation. The District is aware of variable speed limits based on congestion levels being used successfully elsewhere.

10. GAP ANALYSIS

A gap analysis was conducted to determine any differences between the 2004 state of deployment envisioned in the 1998 Statewide ITS Strategic Plan and the actual 2004 state of deployment. This analysis was conducted primarily on the basis of needs. Members of the TAC scored a list of unmet needs prepared by the Consultant. While most TAC members were not involved in the in-depth needs review done as part of earlier statewide planning efforts, this cursory review at least helped to update the status and priorities of current needs.

The 1998 ITS Statewide Strategic Plan identified 76 concise rural ITS needs statements (see Appendix A). The Consultant first judged whether any of these needs statements had been fully met. It was judged that most needs had not been fully met, although significant progress has been made on addressing many needs. See Appendix M for a summary of progress toward meeting needs and remaining unsatisfied needs.

Second, the Consultant reviewed stakeholder feedback to determine whether any additional needs statements were warranted. A number of new needs statements reflective of stakeholder feedback were added to the list of unmet needs.

Third, the Consultant divided the unmet needs into eight categories to facilitate consideration of unmet need priorities by TAC members:

A. **CVO Regulation** (Seven unmet needs)
B. **Monitoring/Surveillance/Data Collection** (20 unmet needs)
C. **Public Outreach** (Eight unmet needs)
D. **System Maintenance** (Three unmet needs)
E. **Vehicle Systems** (Three unmet needs)
F. **Emergency Detection and Response** (22 unmet needs)
G. **Information – What, Where, How It Is Provided** (34 unmet needs)
H. **Information – Types Provided** (34 unmet needs)

Next the Consultant prepared a table or matrix for the TAC members to assign each unmet need an "A," "B," or "C" priority. See Appendix B.

Following receipt of TAC member priorities, the Consultant scored the unmet needs by assigning a score of 3 for each person who considered the need an A priority, 2 for each B and 1 for each C. Not all TAC members assigned a priority level to every need; this was treated as a null response. A composite score (taking the ratio of the actual and highest possible sum of the response values into account) was calculated.

The result of this exercise can be thought of as a means of filtering the findings from Section 4 and focusing attention on the highest priorities. In short, the needs priorities identified by the TAC aided in the formulation and prioritization of the project recommendations as given in Chapter 11.

Appendix N provides a table listing unmet needs in priority order per TAC feedback. The table includes a tally of the number of people assigning A, B and C priority to the needs, composite need score and overall and within-group ranking. Table 34 lists the five top-ranked needs (many needs received equivalent scores).

Table 34: Needs Ranking by the Technical Advisory Committee

ID	Unmet Needs	Rank
D02	Need improved maintenance for Variable Message Signs (VMS)	1
G12	Need for information to be timely, reliable, accessible, and clear	
H04	Need accurate winter road closure information	
B01	Need improved work zone safety	2
D01	Need improved maintenance for Road Weather Information System (RWIS) stations	3
F06	Need improved incident notification and response times	
F07	Need to improve emergency response times	
F14	Need emergency roadside callboxes in locations where cellular coverage is poor	
G01	Need to make traveler information available to the public	
G03	Need real-time traveler information	
G22	Need improved inter-agency communications	
H11	Need advanced information on flooded areas	
H22	Need clear and timely alternate route information	
H31	Need real-time traffic conditions detection	
F10	Need motorist assist patrols in remote areas	4
F21	Need more means to communicate with motorists in remote areas	
G24	Need to improve information sharing between agencies	
G26	Need ability to exchange weather and roadway condition information between agencies	
G29	Need to coordinate roadway closure information between agencies	
H02	Need detour and road closure information	
H09	Need advanced warning of dust storms	
H10	Need advanced work-zone information	
H19	Need weather conditions information	
H20	Need advanced information on flash flooding conditions	
H21	Need advance warning of inclement weather	
D03	Need improved maintenance for PrePass	5

Some suggested guidelines for formulating this needs list and other information from this report into an action plan include:

1. As this needs review may not have been as in-depth as needed for a foundation for further action planning, consider conducting a more thorough needs review.
2. Place ranked needs into overall "A," "B" and "C" categories based on rankings assigned by individuals. These categories could correspond to updated "short-term,"

"mid-term" and "long-term" planning horizons, perhaps the periods from 2005-2007, 2008-2013, and 2014 and beyond.

3. Determine which existing ITS elements will help best address needs within each planning horizon. Also consider ITS elements not yet deployed but commercially available.
4. Update the Statewide ITS Strategic Plan.

11. CONCLUSIONS AND RECOMMENDATIONS

11.1 CONCLUSIONS

Conclusions were drawn based on findings and focused on project objectives, which are repeated here:

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 Strategic Plan's vision.

Objective 1: Measure Performance and Document Benefits

This study identified universal and element-specific performance measures. Both types of measures are valuable means of evaluating ITS element performance.

One question addressed by the performance evaluation and documentation of benefits is, "Are any of ADOT's rural ITS elements underdeployed?"

Based on positive impacts on performance evaluation goal areas and in some cases, level of interest by non-user Districts, a number of ITS elements are good candidates for expanded deployment. Considering ADOT's ITS program as a whole:

- Existing ADOT plans to deploy more RWIS, remote cameras and VMS statewide are fitting as these systems have a strong positive impact.
- ADOT efforts to improve and promote 511 and az511.com (e.g., via static 511 signs) will broaden these important systems' user base.
- Based on benefits and level of interest expressed by non-user Districts, good candidates for expanded deployment are: shoulder-mounted VMS, highway advisory radio, 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.

Another question addressed by the performance evaluation is, "Are any of ADOT's deployed systems underperforming? If so, why?" This study concludes that many of ADOT's deployed systems are functioning quite well. It was found that ADOT is providing many services that contribute to safety, mobility and cost reduction, and that ADOT works steadily to improve system reliability and usefulness.

Six ITS elements were identified as underperforming in terms of potential versus actual benefits to rural Arizona. The following lists the ITS elements along with actions ADOT can take to improve performance:

- Road weather information systems – improve communications and sensor reliability;

- 511 - improve voice recognition and navigation;
- az511.com – improve content presentation/quality and provide low-graphics format for users with low-bandwidth (dial-up) Internet access;
- Highway advisory radio – improve quality (both in terms of transmission/reception and in terms of content);
- PrePass – improve compliance by CVOs; and
- Emergency roadside callboxes – reduce hang-ups and driver misunderstanding.

More detail about these suggested ADOT actions is provided in the recommendations section.

Objective 2: Identify and Document Operating and Maintenance Costs and Issues

The O&M costs tabulated earlier (see Tables 10, 17, 24 and 31) demonstrate that a substantial O&M funding commitment to deployed ITS elements is required. One District expressed that getting operations and maintenance arrangements set up and working smoothly is so critical that they are against further deployments in their District until that point in time. This is a reasonable concern since past failures to maintain equipment have led to numerous issues for ADOT.

The practice of requiring RTEOs to provide maintenance for VMS has drawbacks such as insufficient funding, training, parts inventory, and manpower. The Western RTEO has suggested that a statewide VMS maintenance team be put in place. Lacking that, the RTEOs need improved funding and training.

Some equipment vendors do not always provide the hoped-for level of support, or do so at a high price. ADOT's RWIS stations have been plagued with technical glitches and lack of vendor support to correct them. A recent contract will outsource RWIS maintenance; other ITS elements may also benefit from such alternative arrangements.

Objective 3: Determine Travelers' Perceptions and Reactions to Rural ITS Elements

Combining CVO and public survey results, Table 35 summarizes the percentage of respondents indicating awareness and frequent or rare usage of these elements.

Table 35: CVO and Public Respondents' Awareness and Usage of ITS Elements

ITS Element	Awareness	Usage	Difference
Variable Message Signs	82%	84%	+2%
az511.com	72%	61%	-11%
511 traveler information	67%	39%	-28%
Highway Advisory Radio	56%	33%	-23%

Respondents ranked information dissemination systems, both by level of awareness and by usage as: VMS, az511.com, 511 and HAR. An interesting pattern is seen in how many of the people that know about the ITS systems are using them. The figures are almost identical for VMS, while the usage drops off quite a bit for az511.com, 511 and

HAR. This seems to indicate a lower level of "customer satisfaction" for those systems than for VMS.

The same ranking holds almost perfectly in perceptions of these systems' contributions to safety, mobility and cost savings. Table 36 summarizes these survey results. The percentages provided are a sum of respondents who strongly or moderately agree that the ITS elements contribute to the goal area.

Table 36: ITS Element Contribution to Goal Areas – Public and CVO Perception

	Goal Area		
ITS Element	**Safety**	**Mobility**	**Cost Savings**
Variable Message Signs	69%	65%	50%
az511.com	59%	60%	45%
511 traveler information	37%	35%	39%
Highway Advisory Radio	29%	26%	45%

A large majority of CVO respondents were aware of PrePass (79%) and instrumented truck escape ramps (59%). A majority of CVO respondents strongly or moderately agree that PrePass and instrumented truck escape ramps contribute to safety (63%) and cost savings (strongly agree - 60%, moderately agree - 51%).

More than half (59%) of public respondents were aware of emergency roadside callboxes; less than a quarter (22%) were aware of the motorist assist patrol (MAP). However, a large majority agree that callboxes and MAPs contribute to safety (strongly - 61% and moderately - 57%). It should be noted that there is quite good awareness of these systems given their very limited deployment on highway segments with relatively low Annual Daily Traffic (ADT). In 2002, the ADT on I-19 in the vicinity of the emergency roadside callboxes was 28,348; on US 93 in the vicinity of the callboxes and MAPs it was 6,008.

Objective 4: Extent of ADOT Adherence to the 1998 Statewide ITS Strategic Plan's Vision

The ADOT vision statement for the statewide rural ITS planning program (which guided the 1998 Statewide ITS Strategic Plan) is: "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 provides national leadership in 511 innovation, and the Kingman District, more than any other, has implemented innovative speed detection/warning devices, license plate readers, shoulder-mounted VMS, HAR, instrumented truck escape ramps, emergency roadside callboxes, and motorist assist patrols.

Operational statewide: ADOT has succeeded at deploying and keeping rural ITS elements operational across the state.

Safer/efficient: Rural ITS elements are perceived to 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.

11.2 RECOMMENDATIONS

Recommendations were formulated based on findings and focused using the unmet needs priorities identified by the TAC.

A. Surveillance and Data Collection Systems

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 ad-hoc changes to standard data polling frequencies of the RWIS sensors and cameras.
2. Consider portable PAD/other non-intrusive technology for conducting 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.

B. Information Fusion and Dissemination Systems

1. Upgrade HCRS program to allow verification of 511 audio and to interface with HAR.
2. For 511, expand marketing, improve VRAS and provide more user-friendly menu options.
3. For az511.com, offer data in low-bandwidth format and 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 (by private sector partners).
6. For VMS maintenance, consider improved RTEO funding and training or a specialized statewide team, and add catwalk extensions to VMS 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 HAR applications at the Mexican border for delay and traveler information.

C. Traffic Control/Commercial Vehicle Electronic Clearance Systems

1. For portable traffic signals, consider hard-wiring power or having 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 compliance, communications and system self-diagnostics.
3. Consider expanding use and coverage area of 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 quantifying the benefits considered in this study in monetary terms.
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.
4. Create opportunities for Districts to share practical rural ITS ideas and experiences.

11.3 SUMMARY

In conclusion, this research project has met its goals and objectives. In this, the first unified effort to evaluate ADOT‘s deployed ITS statewide in Arizona:

- A comprehensive, practical, goal-based evaluation methodology was established to measure the performance and effectiveness of ADOT’s rural ITS program, 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 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 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 gaining more 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.
  - It was found that 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 well-focused information in hand 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 services ADOT provides to highway users, including traveler information, electronic clearance and emergency support.

12. APPENDICES

A. RURAL ITS NEEDS, USER SERVICES, MARKET PACKAGES AND PROJECTS FROM THE 1998 STATEWIDE ITS STRATEGIC PLAN

B. UNMET NEEDS SCORING MATRIX

C. LIST OF DISTRICT INTERVIEWS

D. DISTRICT QUESTIONNAIRE

E. FOLLOW-UP QUESTIONS TO DISTRICTS AND TO REGIONAL TRAFFIC ENGINEERING OFFICES

F. MVD AND NEIGHBORING STATE DOT SURVEY INSTRUMENTS

G. DPS, CVO AND PUBLIC SURVEY INSTRUMENTS

H. MAPS OF GROUP A ITI DEPLOYED AND PLANNED

I. UNIVERSAL PERFORMANCE MEASURE SCORES

J. MAPS OF GROUP B ITI DEPLOYED AND PLANNED

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M. PROGRESS TOWARD MEETING NEEDS / REMAINING UNSATISFIED NEEDS

N. UNMET NEEDS – PRIORITIES, SCORES AND RANKINGS

O. REFERENCES AND BIBLIOGRAPHY

APPENDIX A

RURAL ITS NEEDS, USER SERVICES, MARKET PACKAGES AND PROJECTS FROM THE 1998 STATEWIDE ITS STRATEGIC PLAN

NEEDS FROM 1998 STATEWIDE ITS STRATEGIC PLAN (LISTED IN PRIORITY ORDER)

1. Need ability to exchange weather and roadway condition information between agencies
2. Need to improve information sharing between agencies
3. Need clearinghouse for information
4. Need improved inter-agency communications
5. Need to make public aware of snow plowing schedules and locations
6. Need visibility monitoring and reporting
7. Need bridge condition information
8. Need to coordinate roadway closure information between agencies
9. Need advanced warning of highway junctions
10. Need advanced warning of unsafe roadway conditions
11. Need advanced work-zone information
12. Need to communicate in advance availability of services to the public
13. Need for information to be timely, reliable, accessible, and clear
14. Need detour and road closure information
15. Need more means to communicate with motorists in remote areas
16. Need roadway closure information for streets outside of the ADOT roadway network
17. Need clear and timely alternate route information
18. Need accurate winter road closure information
19. Need icy road detection
20. Need weather conditions information
21. Need advanced information on flooded areas
22. Need roadway conditions information
23. Need remote communications with VMS
24. Need to prevent collisions with wildlife
25. Need advanced warning of animal crossings
26. Need to know status of at-grade railroad crossings
27. Need advanced warning of congestion
28. Need to accurately determine incident locations
29. Need advanced warning of rural intersections
30. Need mayday systems
31. Need road closures due to forest fires to be included in general road closure database
32. Need adaptive signal timing
33. Need to share ADOT video data with other agencies
34. Need detection of vehicles violating road closures
35. Need roadside communications in rural areas
36. Need in-vehicle emergency notification devices
37. Need advanced information on flash flooding conditions
38. Need real-time traffic conditions detection
39. Need traveler information regarding Nogales POE status
40. Need surveillance of POE traffic
41. Need toll free access to update and receive current roadway and weather conditions information
42. Need information on detours/road closures to be disseminated outside Arizona
43. Need advanced traveler information
44. Need advance warning of inclement weather
45. Need advanced traveler/tourism information at POE in Nogales
46. Need mass media to report up-to date, correct roadway conditions

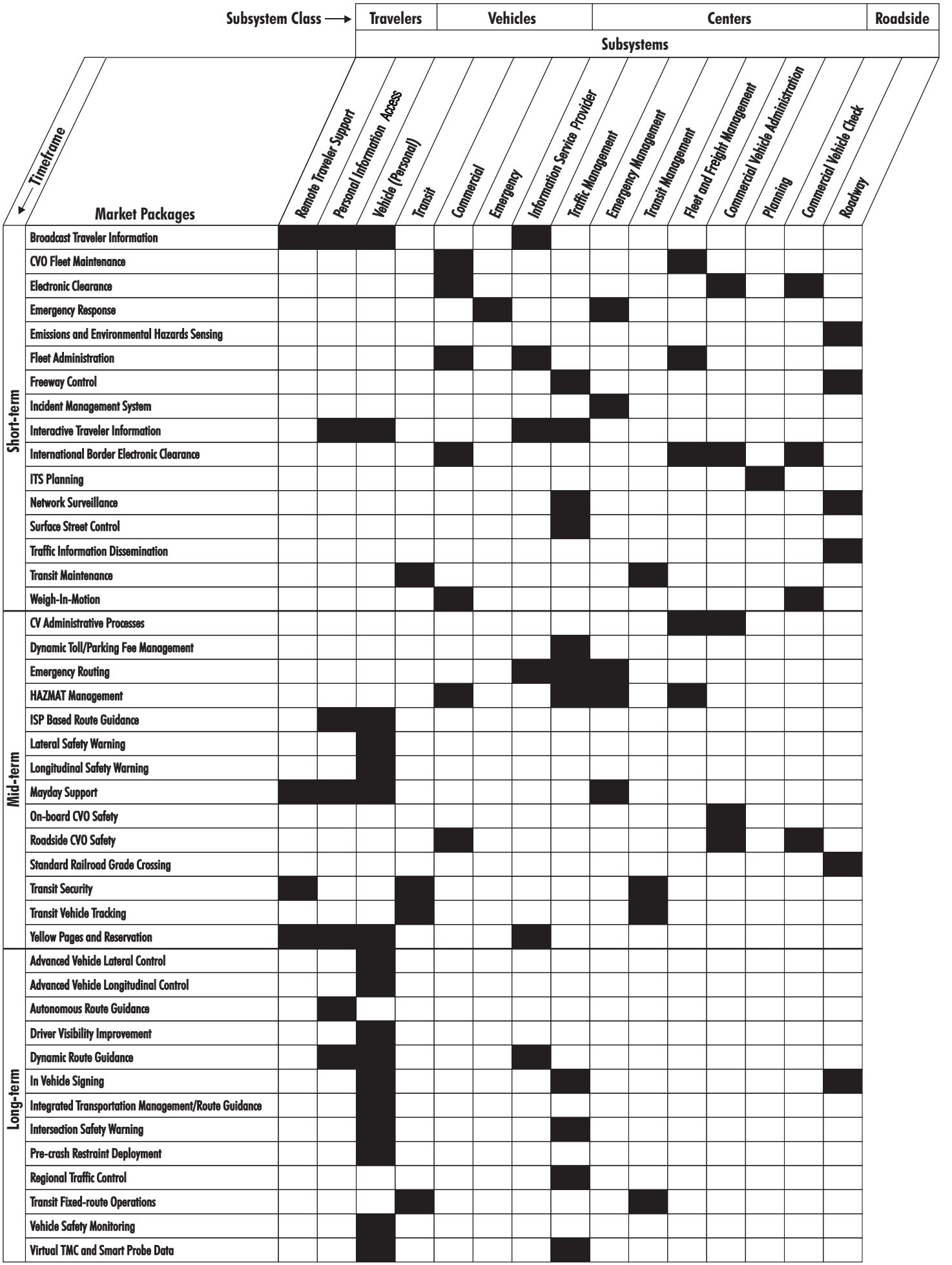
47. Need to determine locations for information kiosks
48. Need rest area security
49. Need traveler information at national/state parks
50. Need better directions to tourist attractions
51. Need tourism/traveler information at rest stops
52. Need warning of falling rocks
53. Need to make traveler information available to the public.
54. Need improved work zone safety
55. Need ability to monitor and display traffic speeds to motorists to deter speeding
56. Need to monitor drivers' condition
57. Need improved incident notification and response times
58. Need HAZMAT incident management
59. Need to standardize EMS response procedures
60. Need to improve emergency response times
61. Need coordination with statewide emergency management system
62. Need improved dispatch and communications for EMS vehicles
63. Need transit availability information
64. Need expeditious way to collect fees at state and national parks
65. Need 24 hour tourist information
66. Need tourist information
67. Need multi-lingual tourist information
68. Need to include POE in the information exchange loop
69. Need to improve coordination between maintenance/construction crews to avoid overlapping of efforts
70. Need commercial vehicle tracking
71. Need information regarding CVOs entering United States
72. Need HAZMAT vehicle tracking
73. Need for collision avoidance systems for CVOs
74. Need ability to weigh trucks in a safe and quick manner
75. Need to enforce CVO weight restrictions
76. Need information on emergency parking areas for CVOs

USER SERVICES FROM 1998 STATEWIDE ITS STRATEGIC PLAN (IN RECOMMENDED DEPLOYMENT TIME FRAMES)

Short-Term (1999 - 2001)	**Mid-Term (2002 – 2007)**	**Long-Term (2008 and beyond)**
• En-Route Driver Information • Pre-Trip Travel Information • Commercial Fleet Management • Traffic Control • Portable Traffic Management • Traveler Services Information • Commercial Vehicle Electronic Clearance	• Incident Management • Emergency Vehicle Management • Emergency Notification and Personal Security • Road Maintenance and Management • Hazardous Material Incident Response • Public travel security • Public transportation management	• Route Guidance • Economic Development/Tourism • Safety Readiness • Economic Development/Business Viability • Highway Rail Intersection

MARKET PACKAGES FROM 1998 STATEWIDE ITS STRATEGIC PLAN
(IN RECOMMENDED DEPLOYMENT TIME FRAMES)

Short-Term (1999 - 2001)	**Mid-Term (2002 – 2007)**	**Long-Term (2008 and beyond)**
• Broadcast Traveler Information • CVO Fleet Maintenance • Electronic Clearance • Emergency Response • Emissions and Environmental Hazards Sensing • Fleet Administration • Freeway Control • Incident Management System • Interactive Traveler Information • International Border Electronic Clearance • ITS Planning • Network Surveillance • Surface Street Control • Traffic Information Dissemination • Transit Maintenance • Weigh-In-Motion	• CV Administrative Processes • Dynamic Toll / Parking Fee Management • Emergency Routing • HAZMAT Management • ISP Based Route Guidance • Lateral Safety Warning • Longitudinal Safety Warning • Mayday Support • On-Board CVO Safety • Roadside CVO Safety • Standard Railroad Grade Crossing • Transit Security • Transit Vehicle Tracking • Yellow Pages and Reservation	• Advanced Vehicle Lateral Control • Advanced Vehicle Longitudinal Control • Autonomous Route Guidance • Driver Visibility Improvement • Dynamic Route Guidance • In-Vehicle Signing • Integrated Transportation Management / Route Guidance • Intersection Safety Warning • Pre-Crash Restraint Deployment • Regional Traffic Control • Transit Fixed-Route Operations • Vehicle Safety Monitoring • Virtual TMC and Smart Probe Data


Subsystem Class
Travelers
Vehicles
Centers
Roadside
Subsystems
Timeframe
Market Packages
Remote Traveler Support
Personal Information Access
Vehicle (Personal)
Transit
Commercial
Emergency
Information Service Provider
Traffic Management
Emergency Management
Transit Management
Fleet and Freight Management
Commercial Vehicle Administration
Planning
Commercial Vehicle Check
Roadway
Short-term
Broadcast Traveler Information
CVO Fleet Maintenance
Electronic Clearance
Emergency Response
Emissions and Environmental Hazards Sensing
Fleet Administration
Freeway Control
Incident Management System
Interactive Traveler Information
International Border Electronic Clearance
ITS Planning
Network Surveillance
Surface Street Control
Traffic Information Dissemination
Transit Maintenance
Weigh-In-Motion
Mid-term
CV Administrative Processes
Dynamic Toll/Parking Fee Management
Emergency Routing
HAZMAT Management
ISP Based Route Guidance
Lateral Safety Warning
Longitudinal Safety Warning
Mayday Support
On-board CVO Safety
Roadside CVO Safety
Standard Railroad Grade Crossing
Transit Security
Transit Vehicle Tracking
Yellow Pages and Reservation
Long-term
Advanced Vehicle Lateral Control
Advanced Vehicle Longitudinal Control
Autonomous Route Guidance
Driver Visibility Improvement
Dynamic Route Guidance
In Vehicle Signing
Integrated Transportation Management/Route Guidance
Intersection Safety Warning
Pre-crash Restraint Deployment
Regional Traffic Control
Transit Fixed-route Operations
Vehicle Safety Monitoring
Virtual TMC and Smart Probe Data

PROJECTS FROM 1998 STATEWIDE ITS STRATEGIC PLAN
(IN RECOMMENDED DEPLOYMENT TIME FRAMES)

Phase I: Short-term Market Packages (1999 - 2001)

Broadcast Traveler Information

- Provide interface to public broadcast media for use and distribution to viewers/listeners including AM/FM radio broadcasters, TV, cable TV, and cellular service providers for Traffic Alerts. Provide FM Traveler Advisory Radio. The FM subcarrier information broadcast would provide data to Radio Data System (RDS) subsystem of FM radio stations and allow transmission of corridor conditions to in-vehicle route guidance systems. Request for a Partnership Proposal (RFPP) is recommended as a viable method to begin implementing these solutions.

- Expand traveler/driver information dissemination to neighboring states to prepare travelers before they enter Arizona. New Mexico, Nevada, California, and Utah are key states to receive this information.

CVO Fleet Maintenance

- In-vehicle devices such as automatic vehicle identification (AVI) and automatic vehicle location (AVL) are needed to support electronic vehicle clearance. The current ADOT program to install electronic clearance stations at most of Arizona's ports of entry, combined with an effort to encourage the trucking industry to use to this technology, will increase the number of trucks with AVI, AVL, and electronic credentials exchange technology.

- Automated vehicle status, mileage, and fuel reporting are features currently implemented by a number of private fleets, and should be considered by ADOT to provide more efficient and timely vehicle maintenance capabilities for its vehicle fleets.

Electronic Clearance

- Additional ports of entry with PrePass technology would provide automated bypass of vehicles meeting selected criteria and provide weigh-in-motion (WIM) to identify potentially overweight vehicles. All POEs should include weigh-in-motion and AVI readers. Digital Short Range Communications (DSRC) continues to be the recommended means of communications between the vehicle and the POE.

Emergency Response

- It is recommended that ADOT evaluate placing free-standing call boxes along some of the remote rural routes in Arizona. The effectiveness of the call box technology is time proven and has been used in southern Arizona on I-19 as well as in other states, notably California.

- Cellular telephones with automatic distress calling function and with GPS are some of the desired features of personal portable communications devices that are available to travelers. This technology is being implemented and marketed solely by private industry. It is recommended that ADOT's and other agencies' EMS-related planning efforts closely observe the direction in which this industry is headed in order to adjust their EMS practices accordingly.

- Provide computer-aided dispatching (CAD) for police, fire, search and rescue, HAZMAT response teams, and the Department of Public Safety, with automated route selection. The

potential benefits of providing CAD monitoring workstations to other agencies (ADOT, media) should be evaluated.

- Emergency phones at rest areas and transit stops with free direct dial capability will benefit the security of travelers at these facilities.

- CCTV and audio monitoring of rest areas and border crossings could provide police or security agencies with the ability to monitor the security of these public areas.

- Increase motorist service patrols along remote rural routes, and equipment vehicles with two-way radios, cellular telephones, and GPS.

- Traffic signal pre-emption would allow DPS, fire, ambulance, and other emergency response vehicles to request signal pre-emption along their direction of travel. This would require the installation of both in-vehicle devices (such as strobe lights currently used by some fire departments) and pre-emption equipment at the traffic signals.

- Coordination of emergency management policy and efforts among Arizona emergency management and other agencies.

Emissions and Environmental Hazards Sensing

- Visibility sensors at dust storm areas could provide motorist information on adverse driving conditions due to blowing dust. Installation should be considered at: (1) locations where recorded accidents have persistently occurred due to blowing dust, and (2) locations where the ADOT Districts deem it advantageous. These sensors should be capable of detecting low visibility conditions due to other elements as well, including smoke, rain, and snow. CCTV cameras can be used to visually verify local environmental conditions and the impact they are having on traffic. Those installations should have the capability to get information quickly to the public. Currently, portable VMS are used to warn drivers of blowing dust conditions. These sensors should be coordinated with the appropriate set of VMS in the area. Locations with blowing dust should be researched and catalogued.

  Visibility sensors may be mounted as stand-alone devices or on other roadside installations, if appropriate. The sensors should be programmed to notify the responsible TOC of critical visibility conditions.

- Weather alert systems with flash flood sensors could help a number of areas throughout the state that suffer from violent flash floods each year. Sensors with alert capabilities could be installed to provide early warning of flooded routes.

- Road Weather Information Systems (RWIS), combined with National Weather Service data; could provide updates of weather conditions on ADOT roadways. Through in-pavement sensors, these stations could also provide the current chemical content on the roadway surface. The RWIS could be used to activate snow and ice control measures. RWIS should be considered for locations (1) with elevations over 4000 feet, (2) where predictive information would be beneficial, (3) where, historically, Districts deemed it advantageous to have local weather conditions information, (4) at key point where initial icing occurs, and (5) in locations other than Northern Arizona to track storms. RWIS locations can be more effectively selected using thermal mapping.

RWIS and other weather monitoring sensor stations should be equipped with automated alarms to notify responsible personnel (e.g. via a pager) of events that require action.

- Still-frame video cameras at RWIS stations could use the communications link used by the RWIS to transmit compressed images of the local conditions (weather or traffic).

Fleet Administration

- Computer Aided Dispatching at fleet management centers could provide private commercial carriers with more efficient deliveries. Knowing where commercial vehicles are and having direct computer links to each operator would provide for more efficient service.

- Coordinated scheduling for ADOT and other maintenance crews, including coordinated snow plowing schedules should be implemented. The coordination of roadway and roadside maintenance between ADOT crews and local municipal teams currently relies on verbal notification. This information should also be made available to travelers.

- Data exchanges between ADOT and public and commercial fleet management centers could provide ADOT with valuable information (fleet centers collect a great deal of up-to-date information through their daily operation). Some of this information should be made available to other fleet centers and to the traveling public.

Freeway Control

- Traffic Management Center (TMC)-to-TMC wireline or high-bandwidth wireless communications for traffic data, information exchange, and control of traffic control measures.

- Improved "truck route" signing. Many routes lack adequate signing on whether or not they can be used by trucks. Improved signing, especially beneficial during detours, is recommended.

Incident Management System

- Incident location determination technologies - ADOT should vigorously continue to study the technologies and solutions that are available to improve the incident location process. ADOT has begun this effort through a pilot Mayday study being conducted for the US 93 corridor (from Wickenburg to the Nevada border).

- Incident management strategies for rural routes should include the use of VMS and media notification to detour traffic to other routes.

- Common communications channels for agencies within Arizona should include standardized radio frequencies for inter-agency communications and high-capacity data channels.

- Common communications channels (wireless and landline) with DOTs in California, Nevada, New Mexico, Utah, and Colorado could help facilitate inter-state coordination and information exchange through high-speed/high-capacity communications links.

- Coordinate roadway closures/alternate routes by providing real-time information about roadway closures.

Interactive Traveler Information

- Highway Closure and Restrictions System (HCRS)—ADOT continues to deploy HCRS throughout the state. The system includes consolidation of roadway conditions and hazards reports from District Traffic Operations Centers and preparation of this information for distribution to the public. The system provides a statewide central data repository of real-time traveler information. The HCRS is used to gather information about construction locations, traffic-related maintenance activities, weather-related road closures, roadway weather information, and traffic accident information collected from different authorized agencies.

  It is recommended that the HCRS provide a number of additional features, including:

  - Marked alternate routes that are suitable for trucks;
  - Multi-lingual tourist information (via its web access); and
  - Storing and displaying of coordinated scheduling for ADOT and other maintenance crews, including snow plowing schedules.

  Public users can access HCRS information via the Voice Remote Access System (VRAS), Information Kiosk System, and Internet web pages (www.azfms.com). The Internet version of the HCRS user interface provides a geographical lookup of traveler information, which is updated automatically at approximately five-minute intervals. It is intended that the system provide HCRS client services to city and county traffic agencies, transit operators, utilities, Bureau of Land Management, US Forest Service, Hoover Dam Authority, the National Guard, Palo Verde Nuclear Power Plant, Tribal Authorities, and other participating organizations statewide.

- Voice Remote Access System (VRAS) provides an interface to the HCRS using cellular/DCS service to provide traffic reports. The project has been deployed statewide by ADOT and the information is accessible through a dial-up number (1-888-411-ROAD). Once a user dials the 1-888-411-ROAD Travel Information Line, a computerized voice provides information about:

  - Current and planned road closures and restrictions
  - Alternate routes and detours to handle road closures
  - Current incident locations and status
  - Current traffic flow levels
  - Traffic diversions planned to handle special events
  - Weather condition information derived from roadway weather systems

- Road Closure and Restrictions System (RCRS) is an information collection and dissemination system similar to the already operational Highway Closure and Restriction System. The RCRS is currently in development stages by ADOT. While the HCRS provides information for the Arizona highways, the RCRS will cover local (municipal) roads and streets, thus completing the informational roadway coverage in the state.

  - Strategically located information kiosks could provide information about weather, roadway conditions, incidents, transit station locations and schedule information, and various tourist information. They could also be used to promote Arizona to out-of-state visitors. Recommended implementation is through private/public partnerships, based on

the I-40 model. Suggested locations include rest areas, ports of entry, truck stops and commercial centers, tourist information centers, chambers of commerce, restaurants, and hotels/motels.

- It is recommended that ADOT seek to partner with cable TV providers to deliver tourist and traffic information and combine it with yellow pages-type information for delivery at such locations as hotels/motels, other businesses, and private homes. Public access channels on cable TV, especially those already used by local agencies, can broadcast a congestion map. As a minimum, such broadcasts can be delivered during the morning and afternoon peak hours.

- Cellular traveler information services could be provided by contracting with a private partner to deliver information to the traveling public via Personal Digital Assistants (PDAs) with communications interfaces and similar portable devices.

  Note: Several kiosks deployed during this project and their effectiveness was limited. Based on this fact, ADOT decided to implement other technologies for rural travelers.

International Border Electronic Clearance

- CVO tracking for NAFTA corridors. Enhanced tracking capabilities of international CVO traffic should be part of the electronic clearance equipment recommended for deployment at Arizona's border crossings.

- CCTV surveillance at ports of entry to consistently monitor traffic conditions. Ports of entry routinely experience congestion. Video monitoring of border crossings on both sides of the border should become part of traffic management at Arizona's border with Mexico.

ITS Planning

- ITS data collection and processing for transportation planning would require a planning function of a regional TOC/TMC, agency-to-agency communications (two-way-landline communications), and computer equipment for data processing.

- Central on-line, GIS-based database of traffic information collected from automatic traffic recording stations, traffic engineering study data, freeway management detector stations, and other sources. This data can then be easily provided to planning and operations organizations.

Network Surveillance

- CCTV cameras should be located at major problem areas (locations where more than 10 accidents occur per year within a one mile radius) and where major traffic congestion occurs.

- CCTV at ports of entry is recommended as an integral part of POE traffic management.

- CCTV at strategically located traffic interchanges would provide early incident detection.

- System detectors (loop, acoustic, and video) should be installed at strategic locations along the state's highway network for early incident detection. These detectors should be connected to traffic monitoring stations (manned or automated). See next item.

- Vehicle detection stations with remote communications could determine volumes and speed of traffic and identify sudden changes of traffic conditions for incident detection. Detectors should be located: (1) where ADT > 70,000, (2) where congestion has been known to occur, (3) where CCTV is installed, (4) within cities, (5) near and at ports of entry, (6) at commercial centers, and (7) where levels of service (LOS) at peak time is LOS "D" or worse. Consider using real time data from ATRs (appropriately modified) for incident detection.

- Systems detecting work zone intrusions (vehicle detection with remote alert capability) should be evaluated and installed as needed. These systems could alert the maintenance crews if an unauthorized vehicle has entered a closed-off area.

- A toll-free telephone number could be set up to collect information from motorists. Many incidents are first witnessed by passing-by traffic. A telephone number (other than "911") should be available for motorists to provide information on such incidents.

- Vehicle speed monitoring and display stations are roadside speed detectors with electronic display boards that could communicate to the passing drivers the current speed of their vehicles.

Surface Street Control

- Traffic signal systems to synchronize traffic signal timing within cities and towns could provide better traffic progression and reduce potential congestion. Generally, a signal system provides benefits where four or five signals are grouped together. Where city and ADOT signals are involved, it is recommended that a system to coordinate all the signals be implemented.

- New traffic signals, where warranted, should be installed. Consideration should be given to additional traffic monitoring equipment (CCTV, system loops) at new traffic locations, as needed.

Traffic Information Dissemination

- Portable variable message signs with remote communications could provide important messages on a seasonal basis. For those locations, such signs should be equipped with remote communications which would allow updated advisory messages to be posted remotely.

- Small, scrolling LED-type information displays could be co-located with kiosks or installed as a partial alternative to a kiosk's functionality.

- Variable message signs are electronic signs to communicate corridor traffic status, weather information, and to advise alternate routes. ADOT has already installed a number of rural VMS, primarily in northern and southeastern parts of the state. Placement criteria suggested by the stakeholders include: (1) before highway junctions, (2) ahead of an exit onto an alternate route, and (3) ahead of the first exit into a city. It is recommended that the following additional criteria, developed through the ADOT ITI effort, be used for VMS placement as conditions dictate: (1) on all interstates within five miles of a border or port of entry, (2) two miles before areas of mandatory snow chain usage, (3) at rest areas, and (4) in advance of other trouble spots or other locations as deemed necessary by the ADOT District Engineer. Finally, the placement of VMS near Arizona's borders should be coordinated with neighbor states (California, Utah, New Mexico).

The recommended message set for the VMS should include messages capable of notification of: (1) maintenance activities, (2) construction activities, (3) accidents, (4) unique roadway conditions, (5) adverse or potentially adverse weather conditions, (6) road closures, (7) suggestion of alternate routes, and (8) pollution advisories.

- To ensure delivery of the correct, intended messages to the motorists, those variable message signs with remote communications should be accompanied by a CCTV camera, capable of delivering the image of the VMS to the TOC.

- Web-based tourist and traveler information systems could provide traffic conditions information (including road closure), weather, and yellow pages. ADOT's initiative to deliver up-to-date traveler information via the web should be continued and coordinated with other public and private agencies interested in this medium.

- Information clearinghouse(s) for weather, traffic conditions, roadway conditions, and tourist information should include a centralized detour/alternate route database (including highway-rail intersections) with route planning algorithms, and be available via telephone, the Internet, and kiosks.

- Inter-agency information exchange and cooperation. Systems and policies should be put in place to allow for exchange of information affecting the traveler between public agencies.

Transit Maintenance

- Automated mileage, vehicle status, and fuel reporting. The vast majority of transit vehicles in rural Arizona are privately owned. Many rural transit providers benefit from the transit program administered by ADOT. Those providers should evaluate using these technologies to ultimately prolong the life of equipment and improve service.

Weigh-in-Motion

- Locations should be provided for enforcement officers to pull trucks over for the purposes of weighing, verifying credentials, and performing safety inspections. These locations should have WIM and AVI screening devices, and should be located on routes that are or can be used to circumvent the ports, and in locations established by the Motor Vehicles Division, the Department of Public Safety, and local maintenance forces. WIM scales should also be placed at all Arizona ports of entry.

  WIM scales are used to weigh vehicles without stopping. In addition to their role in law enforcement, they provide data for pavement design, the Strategic Highway Research Program, ADOT Structures Section, Transportation Planning Group (Data Section), and information on percentage of overweight vehicles.

Phase II: Mid-term Market Packages (2002 - 2007)

Commercial Vehicle Administrative Processes

- State agencies should expand their collection, review, and processing of CVO safety data capability. Increased use of electronic purchase of credentials, and improved other processing/reporting capabilities, as well as agency-to-agency communications, and infrastructure-to-roadside communications should be explored. It is Arizona's intention to become a participant in the Commercial Vehicle Information Systems and Networks (CVISN) program when funding becomes available under the TEA-21 legislation. Present CVO activities will be correlated towards this goal.

Dynamic Toll/Parking Fee Management

- Parking fee collection systems at tourist attractions should be evaluated to improve parking and fare collection operations.

Emergency Routing

- Highway-rail intersections should be equipped with signal preemption status notification for emergency vehicles. Rural emergency vehicles should be notified, while en-route, of an impending railroad crossing closure if that crossing is along their selected route.

- Expansion of rural E911 could improve response time to emergencies in rural areas.

- Coordinated emergency services dispatch among all involved agencies within a region and across regions could greatly help emergency response time in rural areas of the state. Technologically advanced, coordinated dispatching, coupled with appropriate jurisdictional agreements, is likely to improve the emergency services to motorists on rural highways.

HAZMAT Management

- AVL, two-way communications, collision detection sensors, automated incident notification, and CVO RF intelligent tags for HAZMAT warning are recommended to improve emergency response to incidents involving hazardous materials.

- Other technologies to improve HAZMAT management include agency-to-agency communications, infrastructure-to-vehicle two-way communications, Computer-Aided-Dispatching, HAZMAT tracking, inter-agency location, and route database sharing.

Information Service Provider-Based Route Guidance

- The majority of the technologies required to provide this service reside in the vehicle and include stored map databases, processors with routing software, AVL devices, wireless transceivers for data updates, and in-vehicle displays. Updates for the in-vehicle system are provided by information clearinghouses and contain traffic, roadway, weather, and yellow pages information. These information clearinghouses may also include route-planning algorithms, with calculated routes sent to the traveler via two-way radio or cellular communication links. ADOT and other agencies participating in information dissemination should partner with private service providers to include their information in this service.

Lateral Safety Warning

- Safety sensors (including collision sensors). As with most in-vehicle devices, the deployment of various safety sensors is largely in the private domain. It is recommended that ADOT consider using these technologies in their fleet vehicles.

Longitudinal Safety Warning

- Wildlife roadway crossing deterrents could help reduce the number of accidents involving deer and elk crossing rural routes in Arizona. Measures to reduce these types of incidents, such as the installation of roadside equipment to deter wildlife, should be considered.

- Wildlife warning signs could provide information to the traveling public of seasonal migration of elk/deer crossing public roadways. These should be located where 10 or more kills have occurred within a year, or where non-local traffic varies. VMS could be evaluated for effectiveness in reducing wildlife and livestock kills; use of portable VMS may be more effective. If VMS is selected for this purpose, wildlife warnings could be coordinated with the overall VMS system; however, it is not recommended that permanent VMS be installed for the sole purpose of providing wildlife warnings.

Mayday Support

- Coordinated corridor Mayday systems with automated route planning could allow stranded vehicles to notify emergency response units of an incident including location and vehicle description. One criterion for corridor selection for Mayday is average time between cellular phone owners (provide Mayday services if greater than 10 minutes, or approximately 4,000 ADT). These technologies are being developed by car manufacturers.

- Expanded cellular coverage could provide a better means for notification of emergencies. It is desired to have 100% coverage on all interstates and highways in Arizona. A study of cellular coverage in Arizona revealed numerous coverage gaps, especially along remote routes. Private/public partnerships should be considered to improve cellular coverage.

On-board CVO Safety and Roadside CVO Safety

- The deployment of these market packages is controlled by private fleets, with some cooperation from ADOT, which operates the roadside (i.e. POE-installed) RF scanners and databases. These technologies include: audio warning systems, deployable pre-crash safety systems, in-vehicle driver monitoring sensors, roadside data processing devices, and electronic tags (RF) – including AVI. ADOT's role could also include logging the quantity and operation of the trucks' safety equipment upon passage through the POE and thus encourage the CVO to install such devices.

Standard Railroad Grade Crossing

- Passive and active railroad crossing signs should be considered for all locations where railroad crossings are at grade within the Highways of National Significance. This technology still needs to be evaluated.

Traffic Information Dissemination (continued)

- Highway Advisory Radio (HAR) should be considered for at least the interstate routes in Arizona, at locations permitting the selection of an alternate route. Stations at interchanges could reach motorists in each direction to provide critical traffic information.

Transit Security

- Audio and video monitoring of transit stops are recommended to improve security. These monitoring devices should be manned by a private security agency, police or DPS.

Transit Vehicle Tracking

- Automatic transit vehicle location (AVL) and identification (AVI), coordinated transit dispatch, and improved transit routing are recommended to help increase transit efficiency and ridership in rural Arizona.

Note: Off-the-shelf, low-cost, Internet-based fleet dispatch solutions, requiring minimal installation and support, are currently available.

Yellow Pages and Reservations

- Coordinated yellow pages and reservations processing via kiosk, telephone, Internet, interactive TV, Personal Computer, and PDA could be made available alongside the publicly available traveler information (provided by ADOT) to increase usage at the base services. Once improved, in-vehicle data access and display devices and two-way communications become more prevalent in the private vehicle, the dissemination of these services should be extended to these vehicles as well.

Phase III: Long-term Market Packages (2008 and Beyond)

Advanced Vehicle market packages, including Advanced Vehicle Lateral Control (lateral collision avoidance sensors, lateral position sensors or lane control), Advanced Vehicle Longitudinal Control (longitudinal collision avoidance sensors, speed control devices), and Driver Visibility Improvement (on-board display hardware such as heads-up display, sensor systems such as infrared sensors) are likely to become widely used in the near future. Many of these types of equipment are being operationally tested or are available today. It is recommended that ADOT participate in the deployment of these technologies by providing test vehicles for operational tests and by installing proven devices in their own fleet vehicles.

Autonomous Route Guidance and Dynamic Route Guidance constitute yet another set of market packages whose deployment depends largely on the private sector. Technologies used include portable processors with GIS software and graphical user interface, in-vehicle data processing and display devices, GPS, and stored map databases. Similar to the Advanced Vehicle market package, ADOT should fill the role of the promoter of these technologies, which will include making appropriate data and communications interfaces (such as FM subcarrier) available to private providers.

Emergency Response

- Interconnected local and wide area networks (LANs and WANs) in rural communities could be used to promote jurisdictional connectivity. The results would be better coordination of emergency notification, dispatch, and other related services.

In Vehicle Signing

- Heads-up and dash-mounted displays and other in-vehicle information delivery technologies are gaining popularity. ADOT should be ready to provide traveler information in a format that would be suitable for distribution to such devices with a minimal amount of conversion.

Integrated Transportation Management/Route Guidance

- In-vehicle data processing and display devices, GPS, stored map databases, GIS software with GUI, and infrastructure-to-vehicle communications (e.g. cellular or mobile satellite phone).

- Traffic, roadway, weather, and yellow pages information clearinghouse, infrastructure-to-vehicle communications

Intersection Safety Warning

- Signal control at the traffic management subsystem level to provide signal priority for emergency and other vehicles. Traffic signal control systems and signal coordination are required to provide this service.

Pre-Crash Restraint Deployment

- These are vehicle sensors (detecting lateral and longitudinal distances, weather and roadway conditions) combined with processors equipped with algorithms to determine collision probability and to activate the deployment of a pre-crash safety system. These detection systems should be supplemented by additional sensors for weather and roadway conditions and roadway geometry. A processor in the vehicle could assimilate this information and determine the probability of a collision with the other vehicle or obstacle. If the collision

probability is high, it would deploy a pre-crash safety system either to avoid the accident or to reduce the accident severity. The deployment of these and other in-vehicle devices and systems depends on the car manufacturers and market response to these products. Their use is highly recommended for ADOT and other agency fleets when they become available and affordable.

Regional Traffic Control

- TMC-to-TMC wireline communications, traffic coordination between local and regional jurisdictions.

Transit Fixed-Route Operations

- Two-way, wide-area wireless communications, and display devices could improve two-way communications (including improved coverage) between the transit vehicle and the dispatching center to provide higher quality, real-time bus schedule information. Information displays combining the route and vehicle data are recommended for the transit center to facilitate coordination.

- Transit centers should be equipped with automated route planning and vehicle scheduling algorithms, infrastructure-to-infrastructure communications for current schedule dissemination, CAD software, and computer hardware.

Vehicle Safety Monitoring

- Sensors monitoring steering, braking, acceleration, emissions, fuel economy, engine performance, etc.; on-board processors and display devices; audio warning devices.

Virtual TMC and Smart Probe Data

- In-vehicle processing and audio and video (display) devices for information delivery to the driver.

- Multi-TMC roadway management functions related to weather conditions; traffic, roadway, and weather information clearinghouse; and infrastructure-to-infrastructure communications

MISCELLANEOUS PROJECTS

The following projects did not fit directly into any of the pre-defined market packages offered by the National Architecture, but are included in this *Strategic Plan* due to their importance to improving rural Arizona's transportation system as expressed by stakeholders.

- Improved sign management and signing program for ADOT and municipalities. These programs are recommended based on input from the stakeholders. Signs on a number of rural routes are old and deteriorated or missing altogether. The quantity of multilingual signs, especially near tourist attractions, should be increased.

- Traveler education on available information types and sources would greatly increase the effectiveness of a traveler information program. Traveler information systems can only be successful if they are being used. Educating the travelers on the availability and use of information should become part of ADOT's and private partners' programs.

- Driver education on benefits and capabilities of ITS. The ADOT Driver License Manual should include information on ITS as it is a document that is read by every driver at least once. This information could also be mailed along with the registration renewal packet.

- Automated vehicle guidance systems could greatly help ADOT maintenance activities. ADOT is currently in the process of evaluating in-vehicle navigational aids installed in a snow-plow as part of a field operational test being conducted jointly with CALTRANS. Improved winter road maintenance is an important function for ADOT maintenance crews in northern Arizona, and has significant bearing on the quality of travel, including safety, on the I-40 corridor as well as other major Arizona routes with snowfall.

APPENDIX B

UNMET NEEDS SCORING MATRIX

NEED CATEGORY A: CVO REGULATION

Need	Level of Importance
A01. Need surveillance of POE traffic	
A02. Need information regarding CVOs entering United States	
A03. Need to enforce CVO weight restrictions	
A04. Need ability to weigh trucks in a safe and quick manner	
A05. Need ability to weigh trucks on the highway mainline (not just the ramp)	
A06. Need commercial vehicle tracking	
A07. Need HAZMAT vehicle tracking	

NEED CATEGORY B: MONITORING / SURVEILLANCE / DATA COLLECTION

Need	Level of Importance
B01. Need improved work zone safety	
B02. Need more extensive network of RWIS stations	
B03. Need denser network of RWIS stations	
B04. Need visibility monitoring and reporting	
B05. Need icy road detection	
B06. Need rest area security	
B07. Need adaptive signal timing	
B08. Need ability to monitor and display traffic speeds to motorists to deter speeding	
B09. Need to deter speeding on roadways with frequent curves	
B10. Need to deter speeding near areas with a transition in the speed limit	
B11. Need to deter speeding near areas with frequent falling rock	
B12. Need to deter speeding near areas with frequent bad weather	
B13. Need to deter speeding near areas with wildlife crossings	
B14. Need to prevent collisions with wildlife	
B15. Need to know status of at-grade railroad crossings	
B16. Need portable non-intrusive detection to enhance employee safety during traffic data collection	
B17. Need improved monitoring of construction areas	
B18. Need improved monitoring of mountain passes	
B19. Need improved monitoring of areas prone to flash flodding	
B20. Need improved monitoring of areas prone to dust storms	

NEED CATEGORY C: PUBLIC OUTREACH

Need	Level of Importance
C01. Need improved public understanding of rural ITS	
C02. Need improved driver education	
C03. Need outreach to school children	
C04. Need clearer emergency roadside callbox instructions posted at callboxes	
C05. Need bilingual emergency roadside callbox instructions posted at callboxes	
C06. Need improved signing for emergency roadside callboxes	
C07. Need signing indicating callbox locations and distances	
C08. Need more prominent signing at callbox locations	

NEED CATEGORY D: SYSTEM MAINTENANCE

Need	Level of Importance
D01. Need improved maintenance for RWIS stations	
D02. Need improved maintenance for VMS	
D03. Need improved maintenance for PrePass	

NEED CATEGORY E: VEHICLE SYSTEMS

Need	Level of Importance
E01. Need for collision avoidance systems for CVOs	
E02. Need to monitor drivers' condition	
E03. Need expeditious way to collect fees at state and national parks	

NEED CATEGORY F: EMERGENCY DETECTION AND RESPONSE

Need	Level of Importance
F01. Need coordination with statewide emergency management system	
F02. Need to standardize EMS response procedures	
F03. Need information on emergency parking areas for CVOs	
F04. Need detection of vehicles violating road closures	
F05. Need HAZMAT incident management	
F06. Need improved incident notification and response times	
F07. Need to improve emergency response times	
F08. Need more motorist assist patrols	
F09. Need motorist assist patrols in areas where breakdowns frequently occur	
F10. Need motorist assist patrols in remote areas	
F11. Need motorist assist patrols in deserts	
F12. Need more emergency roadside callboxes	
F13. Need emergency roadside callboxes in areas where breakdowns frequently occur	
F14. Need emergency roadside callboxes in locations where cellular coverage is poor	
F15. Need emergency water stations co-located at emergency roadside callboxes locations	
F16. Need emergency roadside callboxes based on communications technology not subject to cellular coverage limitations	
F17. Need in-vehicle emergency notification devices	
F18. Need improved dispatch and communications for EMS vehicles	
F19. Need mayday systems	
F20. Need to accurately determine incident locations	
F21. Need more means to communicate with motorists in remote areas	
F22. Need roadside communications in rural areas	

NEED CATEGORY G: INFORMATION – WHAT, WHERE, HOW IT IS PROVIDED

Need	Level of Importance
G01. Need to make traveler information available to the public.	
G02. Need in-vehicle traveler information	
G03. Need real-time traveler information	
G04. Need advanced traveler information	
G05. Need traveler information at national/state parks	
G06. Need more means to communicate with motorists in remote areas	
G07. Need more overhead VMS in quickly growing areas	
G08. Need more overhead VMS on roads frequently requiring or providing detours	
G09. Need more overhead VMS in long gaps between existing VMS	
G10. Need more overhead VMS near the international border crossing	
G11. Need clearinghouse for information	
G12. Need for information to be timely, reliable, accessible, and clear	
G13. Need improvement in remote verification of VMS messages	
G14. Need to provide visitors to az511.com website the option of a text-based / less graphics-intensive interface	
G15. Need toll free access to update and receive current roadway and weather conditions information	
G16. Need better 511 voice interface	
G17. Need weather information to be provided on 511.	
G18. Need municipal street information to be provided on 511	
G19. Need improved intra-agency communications	
G20. Need to include POE in the information exchange loop	
G21. Need to improve coordination between maintenance/construction crews to avoid overlapping of efforts	
G22. Need improved inter-agency communications	
G23. Need to carry out recommendations of Radio Interoperability study	
G24. Need to improve information sharing between agencies	
G25. Need better coordination with local jurisdictions on special events	
G26. Need ability to exchange weather and roadway condition information between agencies	
G27. Need improved information sharing with regards to flash flooding	
G28. Need to share full RWIS data with the National Weather Service	
G29. Need to coordinate roadway closure information between agencies	
G30. Need information on detours/road closures to be disseminated outside Arizona	
G31. Need to share ADOT video data with other agencies	
G32. Need remote communications with VMS	
G33. Need mass media to report up-to date, correct roadway conditions	
G34. Need to work more closely with cellular providers to close coverage gaps.	

NEED CATEGORY H: INFORMATION - TYPES PROVIDED

Need	Level of Importance
H01. Need roadway conditions information	
H02. Need detour and road closure information	
H03. Need road closures due to forest fires to be included in general road closure database	
H04. Need accurate winter road closure information	
H05. Need roadway closure information for streets outside of the ADOT roadway network	
H06. Need more detailed detour information	
H07. Need more accurate and timely detour information	
H08. Need advanced warning of unsafe roadway conditions	
H09. Need advanced warning of dust storms	
H10. Need advanced work-zone information	
H11. Need advanced information on flooded areas	
H12. Need warning of falling rocks	
H13. Need advanced warning of congestion	
H14. Need advanced warning of highway junctions	
H15. Need advanced warning of animal crossings	
H16. Need advanced warning of rural intersections	
H17. Need bridge condition information	
H18. Need to make public aware of snow plowing schedules and locations	
H19. Need weather conditions information	
H20. Need advanced information on flash flooding conditions	
H21. Need advance warning of inclement weather	
H22. Need clear and timely alternate route information	
H23. Need greater District support for development of integrated alternate route information system	
H24. Need tourist information	
H25. Need 24 hour tourist information	
H26. Need tourism/traveler information at rest stops	
H27. Need multi-lingual tourist information	
H28. Need advanced traveler/tourism information at POE in Nogales	
H29. Need better directions to tourist attractions	
H30. Need transit availability information	
H31. Need real-time traffic conditions detection	
H32. Need traveler information regarding Nogales POE status	
H33. Need information on emergency parking areas for CVOs	
H34. Need to communicate in advance availability of services to the public	

APPENDIX C

LIST OF DISTRICT INTERVIEWS

Meeting (Location)	Date / Time	ADOT Attendees	Other Attendees
Kingman District – Interview in Person (Kingman)	May 10, 1:30 PM-3:00 PM	DISTRICT: Four ATRC: One	ITS ENGINEERS: Two
Kingman District – Interview in Person (Kingman)	May 11, 6:15 AM – 7:30 AM		CONTRACTOR: One ITS ENGINEERS: Two
Yuma District – Interview by Phone (Flagstaff)	June 24, 8:15 AM-9:00 AM	DISTRICT: Six	ITS ENGINEERS: Two
Flagstaff District – Interview In Person (Flagstaff)	June 24, 1:00 PM-3:30 PM	DISTRICT: Five NORTHERN REGIONAL TRAFFIC ENGINEERING: One ATRC: One	ITS ENGINEERS: Two
Yuma District – Interview in Person (Yuma)	July 15, 1:00 PM-3:30 PM	DISTRICT: Nine ATRC: One	ITS ENGINEERS: One
Kingman District – Interview in Person (Kingman)	July 20, 1:00 PM-2:30 PM	DISTRICT: One	ITS ENGINEERS: Two
Prescott District – Interview in Person During Staff Meeting (Prescott)	July 27, 9:00 AM-Noon	DISTRICT: 20 WESTERN REGIONAL TRAFFIC ENGINEERING: Five ATRC: One	ITS ENGINEERS: Two
Tucson District – Interview in Person (Tucson)	August 3, 9:00 AM-11:30 AM	DISTRICT: Four BAJA REGIONAL TRAFFIC ENGINEERING: One ATRC: One	DPS: One City of Tucson: Two ITS ENGINEERS: Two
Globe District – Interview in Person (Globe)	August 4, 1:00 PM-4:00 PM	DISTRICT: Five ATRC: One	DPS: One ITS ENGINEERS: Two

Safford District – Interview in Person (Willcox)	August 5, 8:00 AM – 11:00 AM	DISTRICT: Seven TTG: One ATRC: One	DPS: One NEW MEXICO DOT: One ITS ENGINEERS: Two
Phoenix Construction District (PCD) – Interview in Person (Phoenix)	August 6, 9:00 AM – 11: 00 AM	PCD: Three TTG: One ATRC: One	DPS: One ITS ENGINEERS: Two
Phoenix Maintenance District – Email about Questionnaire*	August 10	DISTRICT: One	ITS ENGINEERS: One
Holbrook District – Email to DE about Questionnaire**	August 11	DISTRICT: One	ITS ENGINEERS: One
All Districts except Holbrook – Email with Final Round of Questions	August 11	DISTRICTS: Nine	ITS ENGINEERS: One
Holbrook District – Interview in Person	August 12, 10:00 AM – Noon	DISTRICT: Nine ATRC: One	ITS ENGINEERS: Two
Phoenix Maintenance District – Two Interviews by Phone	August 16	DISTRICT: Two	ITS ENGINEERS: One

* The Phoenix Maintenance District (PMD) was invited to attend the August 6 Meeting in Phoenix, but no one from PMD was able to attend; the Consultant requested PMD questionnaire participation via email.

** The DE was unable to attend the August 12 Holbrook District Interview in person; the Consultant requested DE participation via email.

APPENDIX D

DISTRICT QUESTIONNAIRE

District Questionnaire
SPR-570: Rural ITS in Arizona

The following questions are designed to help gather information from ADOT District staff on the availability, use, benefits, and concerns related to deployed Intelligent Transportation System devices and systems in Arizona. These questions pertain to your District only. If other ITS devices or system are deployed in the District, please provide what information is available on their use, benefits, and costs (or how we can obtain it).

(1) Overhead Variable Message Signs (OH-VMS)

a) How many VMS in your district?
b) Where are they typically located (i.e., what criteria are used to select sign locations)?
c) Where are the VMS in your district located?
d) What are the types of events that cause a message to be posted?
e) Have the VMS been ever used to post Amber Alert messages?
f) Are messages posted by the district or by the Phoenix TOC?
g) How many folks in the district are authorized to post / change VMS messages?
h) Do other agencies ever request that a specific message be posted? If so, which agencies? If so, what types of messages?
i) How often do you post new messages?
j) Are any of the VMS equipped with other instrumentation, e.g. remote cameras or traffic detectors?
k) Can you offer any accounts / stories of the effect(s) that a VMS message might have had on the highway traffic?
l) What benefits / problems with the VMS have you received comments on by people outside of ADOT?
m) What do you see as the main benefits of the VMS?
n) What are the main problems or concerns with the VMS?
o) Does the district have a sufficient number of VMS?
p) What is the typical cost to install a VMS in your district?
q) What does it cost to operate a VMS in your district on a monthly or yearly basis?
r) What does it cost to maintain the VMS in your district on a monthly or yearly basis?
s) Who maintains the VMS in your district?

(2) Shoulder Mounted Variable Message Signs (SM-VMS – these are the smaller VMS mounted on a semi-permanent basis on the shoulder)

a) How many SM-VMS are in your district?
b) If none, do you see a need for these in your district?
c) What is their main purpose / reason they were deployed?
d) Where are they typically located?
e) What are the types of events that cause a message to be posted?
f) How many messages per day / week /month?
g) Can you offer any accounts / stories of the effect(s) that a SM-VMS message might have had on the highway traffic?
h) What do you see as the main benefits of the SM-VMS?
i) What are the main problems or concerns with the SM-VMS?
j) What is the typical cost to install a SM-VMS in your district?
k) What does it cost to operate a SM-VMS in your district?
l) What does it cost to maintain the SM-VMS in your district?

(3) Portable Trailer Mounted Variable Message Signs (PTM-VMS)

a) How many PTM-VMS are in your district?
b) If none, is there an unfulfilled need for PTM-VMS in your district?
c) How many PTM-VMS units in your district can be updated remotely (i.e., by cellular telephone)?
d) For what purposes are the PTM-VMS used?
e) What are the benefits of PTM-VMS to the district?
f) What operations / maintenance issues / problems do you have with PTM-VMS?
g) What benefits / problems with the PTM-VMS have you received comments on by people outside of ADOT?
h) Who operates the PTM-VMS?
i) Any anecdotes about PTM-VMS message compliance / non-compliance through roadwork zones? (If no ADOT stories, can you recommend a contractor who we could talk to?)

(4) Road Weather Information Systems

a) How many RWIS stations are in your district?
b) If none, is there an unfulfilled need for RWIS in your district?
c) What type of data do you obtain / can you obtain from the RWIS stations?
d) What is the RWIS data used for?
e) Who at the district uses the RWIS data?
f) Do you receive requests for RWIS data from other agencies (e.g. NWS)
g) Are any of the RWIS equipped with other instrumentation such as remote cameras? Which ones / how many?
h) What are the main benefits of RWIS to your district? To the public?
i) What are the main problems (if any) with your RWIS?
j) What is the typical cost to install an RWIS station in your district?
k) What does it cost to operate an RWIS station in your district?
l) What does it cost to maintain an RWIS station in your district?
m) Do you have any statistics on use of pavement snow / ice treatment?
n) Do you have any statistics on snow plow mileage?
o) Which of the following features / sensors of RWIS stations do you consider the most (least) useful / reliable? (Wind speed and direction, barometric pressure, precipitation, visibility sensor, remote camera, pavement sensor)

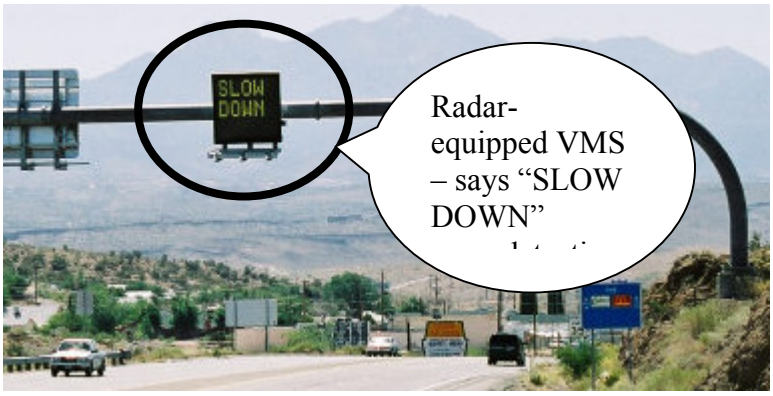
(5) Highway Condition Reporting System

a) How many folks at the district are authorized to enter data into HCRS?
b) How long does it take to train HCRS users?
c) Do you perceive HCRS as beneficial? If so, what are its major benefits?
d) What are the main problems (if any) with HCRS? In particular, what is your perception of system availability?
e) What does it cost on an annual or monthly basis in staff time to enter HCRS data?

(6) 511 System

a) Is there sufficient cellular coverage in your district to allow access to the 511 system?
b) In your opinion, do many drivers in / through your district use the 511 system?
c) Do any of your staff ever / routinely use the 511 system?
d) What is your perception of 511 system availability via phone? via Internet?
e) Can you offer any accounts / stories of people using the 511 system?
f) Do you find the 511 website as useful / less / more useful than the telephone access?

(7) Speed Detection Devices



a) How many permanent / temporary speed detection devices in your district?
b) If none, do you see a need for them in your district?
c) Where are they typically located?
d) How do they operate? What is their set up?
e) What are the main benefits of your speed detection installations?
f) Have you noticed / documented any reduction in accident quantity or severity since the speed detector was installed?
g) What are the main problems?
h) How long does it take to recognize, diagnose and repair problems?
i) Do you have any statistics or estimate of device downtime?
j) Were any detectors installed and then taken down? If so, for what reason?
k) What does it cost to install one speed detector?
l) What does it cost to operate one speed detector?
m) What does it cost to maintain one speed detector?

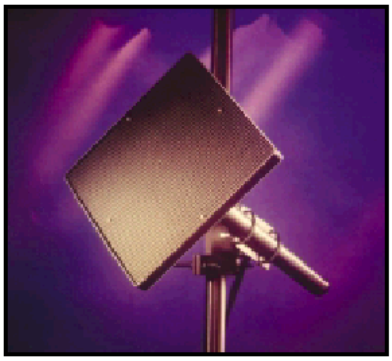
(8) Highway Advisory Radio (HAR)

a) How many HAR stations in your district?
b) If none, would your district benefit from HAR?
c) Where are they located?
d) What are they typically used for? Do you use HAR only in construction zones?
e) How many new messages per day / week / month are recorded? (Or – how often are the messages typically updated, on average?)
f) How many folks at the district operate the HAR? (update messages)
g) Do you perceive HAR as an effective means of delivering traveler information / warnings?
h) What are the main benefits of HAR in your district?
i) What are the main problems with HAR in your district?
j) Can you offer any stories or accounts of the HAR having benefited the general public or ADOT / other agency drivers?
k) What does it cost to install a HAR station?
l) What does it cost to operate a HAR station?
m) What does it cost to maintain a HAR station?

(9) Emergency Roadside Callboxes

a) How many callboxes in your district?
b) If none, would you like to have callboxes in your district?
c) Who answers the calls? Is it the DPS? Who at DPS?
d) Do you have statistics on the number of qualified emergency calls from the callboxes?
e) Any statistics on the actual number of dispatches to answer a call from the callboxes?
f) Is ADOT staff ever dispatched to assist the callers?
g) Do you perceive the callboxes as beneficial? Specifically, do they increase motorist safety with regards to secondary accidents?
h) What does it cost to install a callbox?
i) What does it cost to operate a callbox?
j) What does it cost to maintain a callbox?
k) Who maintains the callboxes in your district?
l) Who pays for the installation, operation, and maintenance?
m) Do you have any statistics or estimate of reduction in incident detection & response time due to emergency callboxes?

(10) Passive Acoustic Detectors or other traffic detectors



a) Are there any remote traffic detectors in your district? What type?
b) If none, would your district benefit from remote detectors?
c) Where are they installed and why?
d) Are any detectors mounted on the overhead VMS?
e) Do you collect and store data from the detectors?
f) How do you use the detector data?
g) What are the main benefits of using remote traffic detectors in your district?
h) Any problems?
i) What does it cost to install a remote traffic detector?
j) What does it cost to operate a remote traffic detector?
k) What does it cost to maintain a remote traffic detector?

(11) Remote Cameras (36 TOTAL in the state; exclusive of the FMS CCTV)

a) How many remote cameras in your district?
b) What kind / type of cameras are installed in your district?
c) If none, do you think your district would benefit from remote cameras?
d) Where are they located? How is their location chosen?
e) Are any cameras mounted on the overhead VMS?
f) What are the main benefits of having access to remote cameras?
g) What are the problems?
h) Can you provide any accounts of positive / negative feedback on the use of the remote cameras in your district?
i) What does it cost to install a remote camera in your district?
j) What does it cost to operate?
k) What does it cost to maintain?

(12) Instrumented Truck Escape Ramps

a) Are there any truck escape ramps in your district?
b) If none, do you see a need for instrumenting any of the truck escape ramps in your district?
c) Are any of them instrumented to detect / confirm occupancy (e.g. with vehicle detectors, remote cameras, and shoulder mounted VMS)?
d) How many detections per month occur?
e) Do you have any statistics on ramp occupation response time and ramp clearance time?
f) Can you offer any anecdotes of the benefits of the truck escape ramp instrumentation in your district?
g) What does it cost to instrument a truck escape ramp?
h) What does it cost to operate?
i) What does it cost to maintain?

(13) PrePass Sites / Tags (MVD)

a) Are there any PrePass sites in your district?
b) Where are they located?
c) Do you have statistics on how many trucks use PrePass to bypass the inspection site?
d) Does PrePass allow you to do "more with less?" (i.e., are the personnel you have at the site used more efficiently)?
e) Can you offer any anecdotes of your own or feedback from commercial drivers on the benefits of PrePass?

(14) License Plate Readers

a) Are there any license plate readers installed in your district now? (Or – were there any in the past?)
b) If none, do you see a need for license plate reader stations in your district?
c) Do you have any statistics on the use of the license plate readers in your district (detection rate, reduction in work zone travel delays, % downtime)
d) What does it cost to install a license plate reader station?
e) What does it cost to operate?
f) What does it cost to maintain?

(15) Motorist Assistance Patrols (MAP)

a) Are there any MAPs in your district? How many?
b) If not, is there a need for motorist assistance patrols / vehicles on the highways in your district?
c) Who provides this service?
d) Who pays for the service?
e) Do you have statistics on the number of assists provided over a period of time (e.g. last 2-3 years)?
f) Can you offer any accounts on the value / benefits / problems associated with the MAP in your district?
g) Does MAP reduce the occurrence of secondary accidents? Any anecdotes?
h) What is the cost of operating a MAP in your district?
i) Do you have any statistics or estimate of reduction in incident detection & response time due to MAPs?
j) Do you have any statistics on tow truck calls?

(16) Portable Traffic Signals

a) Does your district use portable traffic signals?
b) If not, do you see a need for these devices in your district?
c) How many do you own?
d) Do you rent the portable traffic signals?
e) What is the cost to acquire / rent one?
f) If the district does not own or rent, do you require the contractor to use them? In what circumstances?
g) Can you provide any accounts of the beneficial use of these devices? Any problems?
h) In your opinion, do portable traffic signals improve driver comprehension? Do they provide cost savings over using flaggers?

(17) What other ITS elements have been tried, or are in use, in your District?

(18) Can you offer information on **any general statistics** such as costs of infrastructure repairs due to crashes and safety of maintenance personnel? Over time, a well designed system of ITS elements should contribute to improvement in statistics such as these, though the contribution of individual elements may be difficult to isolate.

(19) Can you offer some information on **any general feedback or impressions you might have received on the performance and benefits of the district's ITI?** We are interested in the perceptions of the neighboring state DOTs, the DPS, the driving public, and the trucking industry.

APPENDIX E

FOLLOW-UP QUESTIONS TO DISTRICTS AND TO REGIONAL TRAFFIC ENGINEERING OFFICES

FOLLOW-UP QUESTIONS TO DISTRICTS
(Questions addressed to contacts at all but the Holbrook District on August 11, 2004)

1. For any of the ITS in your district, please provide information on any additional issues/problems that you may have thought of recently.
2. For any of the ITS in your district, are there additional features or capabilities that would improve user friendliness, control, troubleshooting / diagnosis of problems, etc.
3. For any of the ITS in your district, what funding sources are used to install and maintain them? What sources should be used?
4. For any of the ITS in your district, can you provide average operation and maintenance costs? Who receives the bills?

FOLLOW-UP QUESTIONS TO REGIONAL TRAFFI C ENGINEERING OFFICES
(Questions addressed to contacts at the Northern, Western, and Baja Regional Traffic Engineering Offices and at the Phoenix Maintenance District on August 17, 2004)

1. Please provide a brief summary of the most common maintenance issues that arise with the ITS equipment that you deal with.
2. What kinds of maintenance problems do you handle completely in-house? What kinds of problems require vendor support?
3. How much total staff do you have?
4. How many of your staff get involved in maintenance and repair of ITS equipment?
5. To what degree do your region's ITS-involved staff "specialize?" Do you have anyone devoted just to ITS, or just to one type of ITS equipment?
6. Do you feel you can provide the level of maintenance support for ITS expected by the districts with the resources you currently have?
7. Describe your region's needs related to ITS maintenance support in each of the following areas:
    a. Funding
    b. Staffing
    c. Spare parts
    d. Equipment / tools
    e. Other
8. What more could you be doing maintenance-wise if you had more resources?
9. Are there any software tools, policies or procedures you might suggest to make ITS maintenance more cost effective?

APPENDIX F

MVD AND NEIGHBORING STATE DOT SURVEY INSTRUMENTS

MVD Questionnaire
SPR-570: Rural ITS in Arizona

Your Name: _____

Port of Entry: _____

Days of Week / Hours of Operation: _____

Questions about PrePass Sites

a) Do you have statistics on how many trucks use PrePass to bypass the inspection site?
b) Does PrePass allow you to do "more with less?" (i.e., are the personnel you have at the site used more efficiently)?
c) Can you offer any anecdotes of your own or feedback from commercial drivers on the benefits of PrePass?
d) Have you had any issues / problems with driver compliance?
e) Have you had any issues / problems with the equipment? Any system downtime? What part of the system is most / least reliable? How long do repairs typically require?
f) Do you incur any power or communications costs with the system equipment?
g) Any other comments?

Neighboring DOT Questionnaire
SPR-570: Rural ITS in Arizona

The Arizona Department of Transportation (ADOT) is evaluating the performance of ITS devices and system in use in rural Arizona. Feedback from states neighboring Arizona who have a stake in ADOT's Rural ITS Program is an important part of this study. The following questions are designed to help gather information on ADOT's key rural ITS elements from neighboring state DOT's.

Your contact information:

Name: _____
Job Title: _____
State / Agency: _____
Email: _____
Phone: _____

(1) Overhead Variable Message Signs (OH-VMS)

t) Are there any ADOT-owned VMS within your state's boundaries?
u) Are there any VMS owned by your state DOT within Arizona?
v) Does your agency ever request that a specific message be posted on ADOT-owned signs? If so, which signs and what types of messages?
w) Can you offer any accounts of the effect(s) that a message on an ADOT-owned VMS might have had on highway traffic entering your state?
x) Can you offer any accounts of the effect(s) that a message on a VMS owned by your state might have had on highway traffic entering Arizona from your state?
y) What benefits / problems with ADOT's VMS do you perceive?
z) Can you suggest any improvements to ADOT's VMS system in terms of location, control, user friendliness, additional features (such as cameras & traffic detectors), etc.?

(2) Road Weather Information Systems

a) What weather information resources does your agency make use of?
b) Are you familiar with ADOT's RWIS stations? (http://www.az511.com/hcrsweb/hcrsweb.jsp, "Weather sensor" icons)
c) Do you ever make use of any of ADOT's RWIS sensor information? (Wind speed and direction, barometric pressure, precipitation, visibility sensor, remote camera, pavement sensor)
d) Do you perceive ADOT's RWIS as beneficial? What if anything might be done to make them more beneficial?

(3) Highway Condition Reporting System (HCRS)

a) Are you familiar with ADOT's HCRS?
b) Do you perceive ADOT's HCRS as beneficial? If so, what are its major benefits?
c) What if anything might be done to make ADOT's HCRS more beneficial?
d) What are the main problems (if any) with ADOT's HCRS?

(4) 511 System

a) Are you familiar with ADOT's 511 traveler information by telephone service? (Available from within Arizona at 511, and from outside Arizona at 1.888.411.ROAD).
b) Are you familiar with ADOT's 511 traveler information website (www.az511.com)?
c) Does your agency ever make use of ADOT's 511 traveler information by phone? by Internet?
d) Does your agency receive phone calls for information about travel into Arizona? How are such calls handled?

(5) Highway Advisory Radio (HAR)

a) Do you perceive HAR as an effective means of delivering traveler information / warnings?
b) Might HAR be useful for delivering information to traffic crossing between your state and Arizona?
c) Does your state currently operate any HAR stations near your state's border with Arizona?
d) What benefits might be derived from increased use of HAR near your state's border with Arizona? Any potential problems?

(6) PrePass Sites / Tags (MVD)
Sites at California/Arizona Border: Yuma, Ehrenberg, Topock; Sites at Nevada/Arizona Border: Kingman; Sites at Utah/Arizona Border: St. George; Sites at New Mexico/Arizona Border: Sanders, San Simon

a) Does your agency make use of the "PrePass" system for electronic clearance of commercial vehicles at New Mexico ports of entry? If so, what benefits does it provide?
b) Does your agency make use of any alternative system for electronic clearance of commercial vehicles at New Mexico ports of entry? What system(s)?
c) Does your agency have any need for compatibility with Arizona's electronic clearance systems?

APPENDIX G

DPS, CVO AND PUBLIC SURVEY INSTRUMENTS

(see Chapter 3 for discussion)

DPS Survey Instrument
(Size as distributed was 8.5” by 11” with no margins)

SURVEY - MOTORIST RESOURCES IN RURAL ARIZONA	INFORMATION RESOURCES				EMERGENCY ASSISTANCE		
Tell Us How We Are Doing! ADOT wants your feedback on the motorist information and assistance resources that they provide **in rural parts of Arizona.** Your District Office ZIP code: _____	**Electronic Message Boards (Variable Message Signs)**	**Highway Advisory Radio**	**511 Road Conditions by Phone**	**ADOT Highway Conditions Website**	**Roadside Emergency Phones**	**Nighttime Motorist Assist Patrols**	**"Smart" Truck Ramps (WB Hwy 68 only)**
I am aware that ADOT provides this resource.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
I use this resource **[O]**ften, **[R]**arely, **[N]**ever.	O R N	O R N	O R N	O R N	O R N	O R N	
I know someone who uses (has used) this resource.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
The information provided by this resource…	*1 - Strongly disagree 5 - strongly agree (circle your answer)*						
… is easy to understand.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
… is accurate.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
… is provided in time to be useful.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
… saves time / prevents delay en route.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
… helps motorists adjust travel plans.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5			
This resource makes travel safer.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
With this resource, emergency help arrives quicker.					1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
I consider these resources the most useful to drivers:	☐	☐	☐	☐	☐	☐	☐
I would like having more of this resource in rural Arizona.	Yes No	Yes No			Yes No	Yes No	Yes No

Additional comments:

Return by FAX:
623-321-0213 (main fax number)
602-943-2377 (alternative fax number)

Return by mail:
ITS Engineers - SPR570
2432 W Peoria Ave, Suite 1119
Phoenix, AZ 85029

Thank You!

CVO Survey Instrument – Postcard Version

(Size as distributed was 4.25" by 5.5" with no margins)

SURVEY: COMMERCIAL VEHICLE RESOURCES IN RURAL ARIZONA | INFORMATION RESOURCES | OTHER RESOURCES

Tell Us How We Are Doing!
The Arizona Department of Transportation (ADOT) wants your feedback on the information and other commercial vehicle resources that they provide **in rural parts of Arizona.**

Your Home State: _____

Please circle your answers to the survey questions.

	1 Electronic Message Boards	2 Highway Advisory Radio	3 511 Road Conditions by Phone	4 Highway Conditions Website	5 "Smart" Truck Escape Ramps (Westbnd. Hwy. 68)	6 Electronic Clearance at State Border
I am aware that ADOT provides this resource.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
I use this resource **[O]**ften, **[R]**arely, **[N]**ever.	O R N	O R N	O R N	O R N	O R N	O R N
I know someone who uses (or has used) this resource.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
The information provided by this resource…	*1 - Strongly disagree*			*5 - Strongly agree*		
… is easy to understand.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
… is accurate.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
… is provided in time to be useful.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
… saves time / prevents delay en route.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
… helps me adjust travel plans.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
This resource makes my travels safer.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
This resource reduces my operating costs.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
With this resource, emergency help arrives quicker.					1 2 3 4 5	
The resource most helpful to me is (check one or more):	☐	☐	☐	☐	☐	☐
I would like having more of this resource in rural Arizona.	Yes No	Yes No			Yes No	Yes No

Thank You!

1 ACCIDENT AHEAD 2 RIGHT LANES BLOCKED

2 TRAFFIC ALERT WHEN FLASHING TUNE TO 1640 AM

3 511

4 www.az511.com

5 RUNAWAY TRUCK RAMP / RAMP OCCUPIED

6 PrePass

To tell us more, visit ***www.az511.com***. *You may also send comments* ***via e-mail*** *to* ***ruralsurvey@itsengineers.com*** ***or via mail*** *to the address shown on the reverse side.* ***Please indicate your home state in any mail or e-mail.*** *Please return this survey by* ***August 27, 2004*** *(no postage necessary).*

Public Survey Instrument – Postcard Version

(Size as distributed was 4.25" by 5.5" with no margins)

SURVEY: MOTORIST RESOURCES IN RURAL ARIZONA | INFORMATION RESOURCES | EMERGENCY ASSISTANCE

Tell Us How We Are Doing!
The Arizona Department of Transportation (ADOT) wants your feedback on the motorist information and assistance resources that they provide in rural parts of Arizona.

Your Home ZIP Code: _____

Please circle your answers to the survey questions.

	1 Electronic Message Boards	2 Highway Advisory Radio	3 511 Road Conditions by Phone	4 Highway Conditions Website	5 Roadside Emergency Phones	6 Nighttime Motorist Assist Patrols
I am aware that ADOT provides this resource.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
I use this resource [O]ften, [R]arely, [N]ever.	O R N	O R N	O R N	O R N	O R N	O R N
I know someone who uses (or has used) this resource.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
The information provided by this resource...	*1 - Strongly disagree*			*5 - Strongly agree*		
... is easy to understand.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
... is accurate.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
... is provided in time to be useful.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
... saves time / prevents delay en route.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
... helps me adjust travel plans.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5		
This resource makes my travels safer.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
With this resource, emergency help arrives quicker.					1 2 3 4 5	1 2 3 4 5
The resource most helpful to me is (check one or more):	☐	☐	☐	☐	☐	☐
I would like having more of this resource in rural Arizona.	Yes No	Yes No			Yes No	Yes No

Thank You!

1 ACCIDENT AHEAD 2 RIGHT LANES BLOCKED

2 TRAFFIC ALERT WHEN FLASHING TUNE TO 1640 AM

3 511

4 www.az511.com

5

6

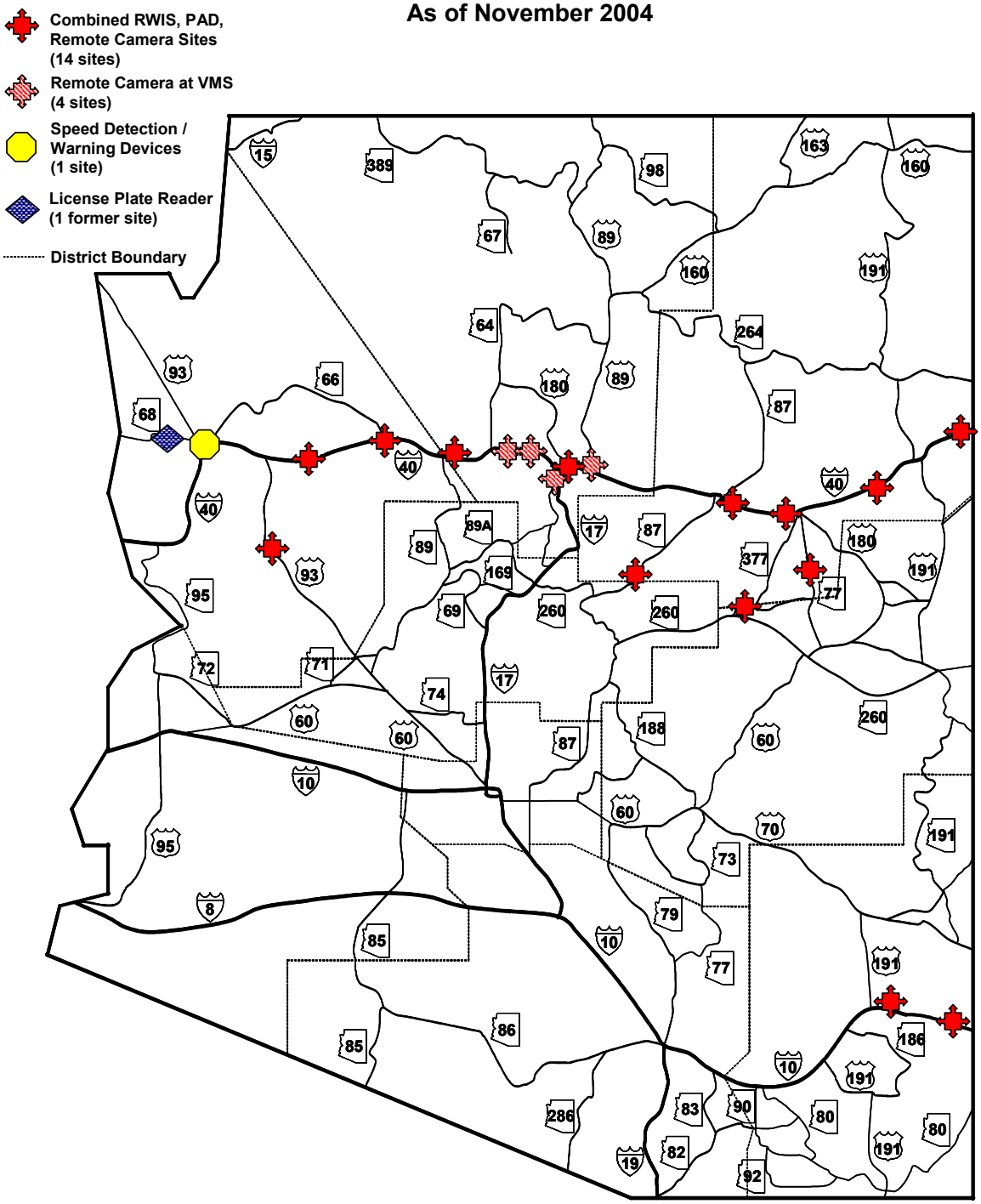
To tell us more, visit ***www.az511.com***. *You may also send comments* ***via e-mail*** *to* ***ruralsurvey@itsengineers.com*** ***or via mail*** *to the address shown on the reverse side.* ***Please indicate your home ZIP code in any mail or e-mail.*** *Please return this survey by* ***August 27, 2004*** *(no postage necessary).*

APPENDIX H

MAPS OF GROUP A ITI DEPLOYED AND PLANNED

STATEWIDE LOCATIONS OF GROUP A ITI (SURVEILLANCE / DATA COLLECTION SYSTEMS)

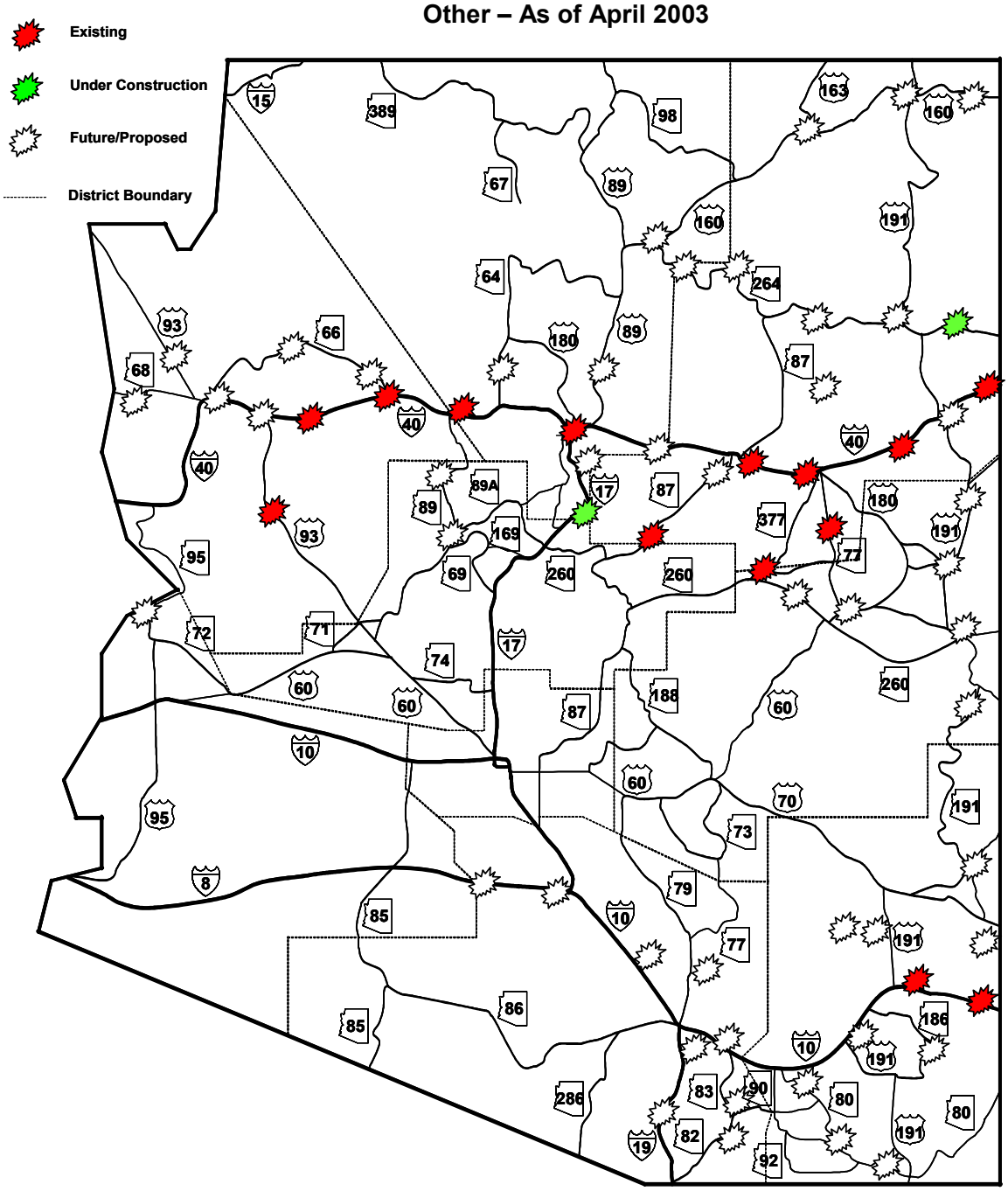
As of November 2004



ROAD WEATHER INFORMATION SYSTEMS

Existing – As of November 2004

Other – As of April 2003

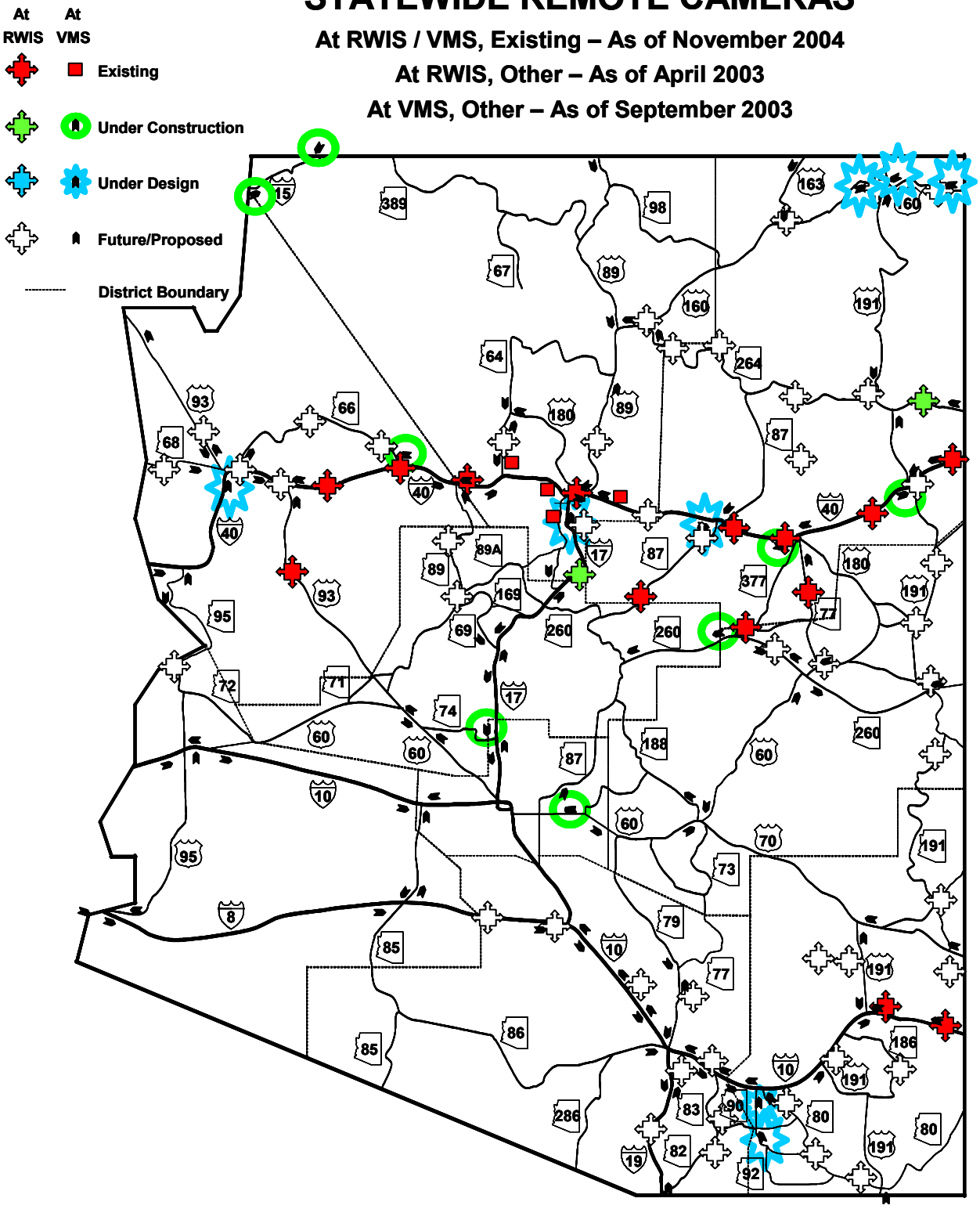


STATEWIDE REMOTE CAMERAS

At RWIS / VMS, Existing – As of November 2004

At RWIS, Other – As of April 2003

At VMS, Other – As of September 2003



APPENDIX I

UNIVERSAL PERFORMANCE MEASURE SCORES

Scores for Universal Performance Measures Related to ADOT and Partners

Goal Areas→	Improve Safety	Reduce Costs			Improve System Reliability and Usefulness			
Goals	Improves ADOT employee and / or partner safety	Reduces infrastructure construction costs	Reduces infrastructure maintenance / operations costs	Reduces workload of AODT and / or partners	Is quickly replaced or repaired and returned to service	Has (A) widespread/(B) frequent use by ADOT and / or partners	Unfamiliar ADOT Districts and / or partners are interested	ADOT partners depend on or have interest in it
GROUP A: SURVEILLANCE AND DATA COLLECTION SYSTEMS								
A1. RWIS	2	1	4	4	2	3 / 3	2	4
A2. PAD/OTD	1	1	1	2	2	2 / 1	2	1
A3. RC	2	3	4	4	2	3 / 3	3	3
A4. SDWD	5	5	4	4	3	2 / 4	1	3
A5. LPR	2	3	2	4	3	1 / 1	1	2
GROUP B: INFORMATION FUSION AND DISSEMINATION SYSTEMS								
B1. HCRS	3	3	3	3	4	5 / 5	1	1
B2. 511	3	3	3	4	4	4 / 2	3	2
B3. az511.com	3	3	3	4	4	4 / 2	3	3
B4. OH-VMS	5	5	5	5	4	5 / 3	- - -	5
B5. SM-VMS	4	4	4	5	4	2 / 4	2	4
B6. PTM-VMS	4	4	4	5	4	5 / 3	- - -	5
B7. HAR	4	4	4	5	4	3 / 2	3	3
GROUP C: TRAFFIC CONTROL / COMMERCIAL VEHICLE ELECTRONIC CLEARANCE SYSTEMS								
C1. PTS	5	5	3	5	3	2 / 2	2	1
C2. CVEC	4	5	5	5	2	5 / 4	- - -	1
C3. EPIC	4	5	5	5	3	3 / 5	- - -	4
GROUP D: EMERGENCY DETECTION AND RESPONSE SYSTEMS								
D1. ITER	4	1	4	5	4	1 / 5	1	4
D2. ERC	2	1	2	3	4	2 / 5	2	4
D3. MAP	3	4	3	5	4	1 / 5	2	5

NOTE: A score of 1 indicates ITS element has little positive impact on goal; a score of 5 indicates ITS element has great positive impact on goal. Dashes indicate items for which no score is applicable or necessary.

Scores for Universal Performance Measures Related to Commercial Vehicle Operators

Goal Areas→	Improve Safety	Improve Rural Mobility	Reduce Infra-structure and User Costs	Improve System Reliability and Usefulness		
Goals	Improves commercial vehicle operator safety	Improves commercial vehicle mobility	Reduces trucking costs	Is familiar to commercial vehicle operators	Is used frequently by commercial vehicle operators	Is useful to commercial vehicle operators
GROUP A: SURVEILLANCE AND DATA COLLECTION SYSTEMS						
A1. RWIS	2	2	2	- - -	- - -	- - -
A2. PAD/OTD	1	1	1	- - -	- - -	- - -
A3. RC	2	2	2	- - -	- - -	- - -
A4. SDWD	5	3	3	- - -	- - -	- - -
A5. LPR	2	2	2	- - -	- - -	- - -
GROUP B: INFORMATION FUSION AND DISSEMINATION SYSTEMS						
B1. HCRS	3	3	3	- - -	- - -	- - -
B2. 511*	3	3	3	3	2	4
B3. az511.com*	3	3	4	3	2	4
B4. OH-VMS*	5	5	5	5	5	5
B5. SM-VMS*	4	4	4	5	5	5
B6. PTM-VMS*	4	4	4	5	5	5
B7. HAR*	4	4	4	4	3	4
GROUP C: TRAFFIC CONTROL / COMMERCIAL VEHICLE ELECTRONIC CLEARANCE SYSTEMS						
C1. PTS	5	5	5	- - -	- - -	- - -
C2. CVEC*	4	5	5	4	4	4
C3. EPIC	4	5	5	- - -	- - -	- - -
GROUP D: EMERGENCY DETECTION AND RESPONSE SYSTEMS						
D1. ITER*	5	2	5	3	1	4
D2. ERC	2	2	2	- - -	- - -	- - -
D3. MAP	2	2	2	- - -	- - -	- - -

* The asterisk marks ITS elements about which questions were included on the CVO survey. The survey did not distinguish between VMS types.

NOTE: A score of 1 indicates ITS element has little positive impact on goal; a score of 5 indicates ITS element has great positive impact on goal. Dashes indicate items for which no score is applicable or necessary.

Scores for Universal Performance Measures Related to the General Public

Goal Areas→	Improve Safety	Improve Rural Mobility	Reduce Infra-structure and User Costs	Improve System Reliability and Usefulness		
Goals	Improves general public safety	Improves general public mobility	Reduces general public travel costs	Is familiar to the general public	Is used frequently by the general public	Is useful to the general public
GROUP A: SURVEILLANCE AND DATA COLLECTION SYSTEMS						
A1. RWIS	2	2	2	- - -	- - -	- - -
A2. PAD/OTD	1	1	1	- - -	- - -	- - -
A3. RC	2	2	2	- - -	- - -	- - -
A4. SDWD	5	3	3	- - -	- - -	- - -
A5. LPR	2	2	2	- - -	- - -	- - -
GROUP B: INFORMATION FUSION AND DISSEMINATION SYSTEMS						
B1. HCRS	3	3	3	- - -	- - -	- - -
B2. 511*	3	3	3	4	2	3
B3. az511.com*	3	3	3	4	4	4
B4. OH-VMS*	5	5	5	5	5	5
B5. SM-VMS*	4	4	4	5	5	5
B6. PTM-VMS*	4	4	4	5	5	5
B7. HAR*	4	4	4	3	2	2
GROUP C: TRAFFIC CONTROL / COMMERCIAL VEHICLE ELECTRONIC CLEARANCE SYSTEMS						
C1. PTS	5	5	5	- - -	- - -	- - -
C2. CVEC	2	3	3	- - -	- - -	- - -
C3. EPIC	2	3	3	- - -	- - -	- - -
GROUP D: EMERGENCY DETECTION AND RESPONSE SYSTEMS						
D1. ITER	3	2	3	- - -	- - -	- - -
D2. ERC*	4	4	4	3	1	4
D3. MAP*	4	4	4	1	1	4

* The asterisk marks ITS elements about which questions were included on the general public survey. The survey did not distinguish between VMS types.

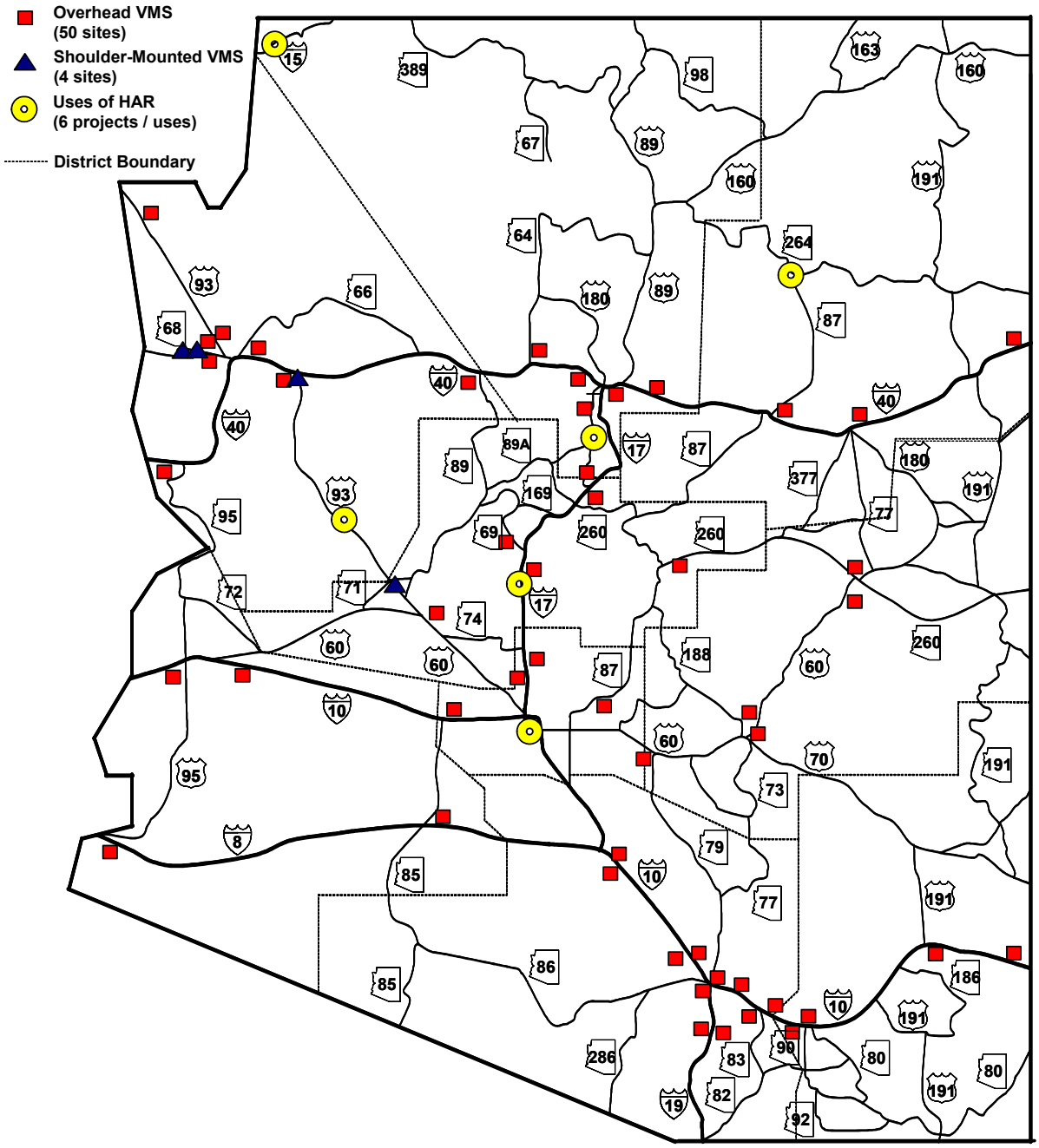
NOTE: A score of 1 indicates ITS element has little positive impact on goal; a score of 5 indicates ITS element has great positive impact on goal. Dashes indicate items for which no score is applicable or necessary.

APPENDIX J

MAPS OF GROUP B ITI DEPLOYED AND PLANNED

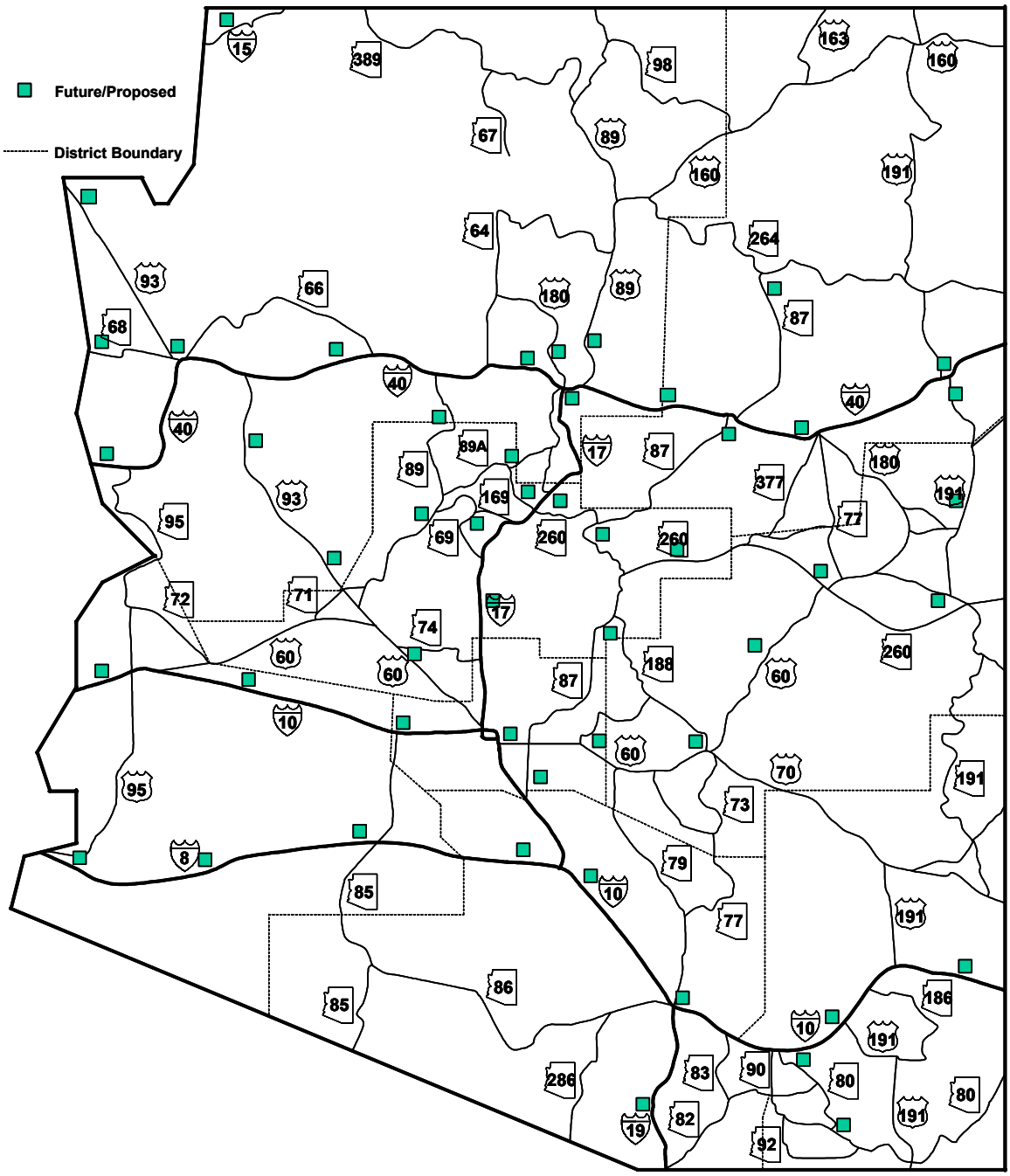
STATEWIDE LOCATIONS OF GROUP B ITI (INFORMATION FUSION AND DISSEMINATION SYSTEMS)

As of November 2004

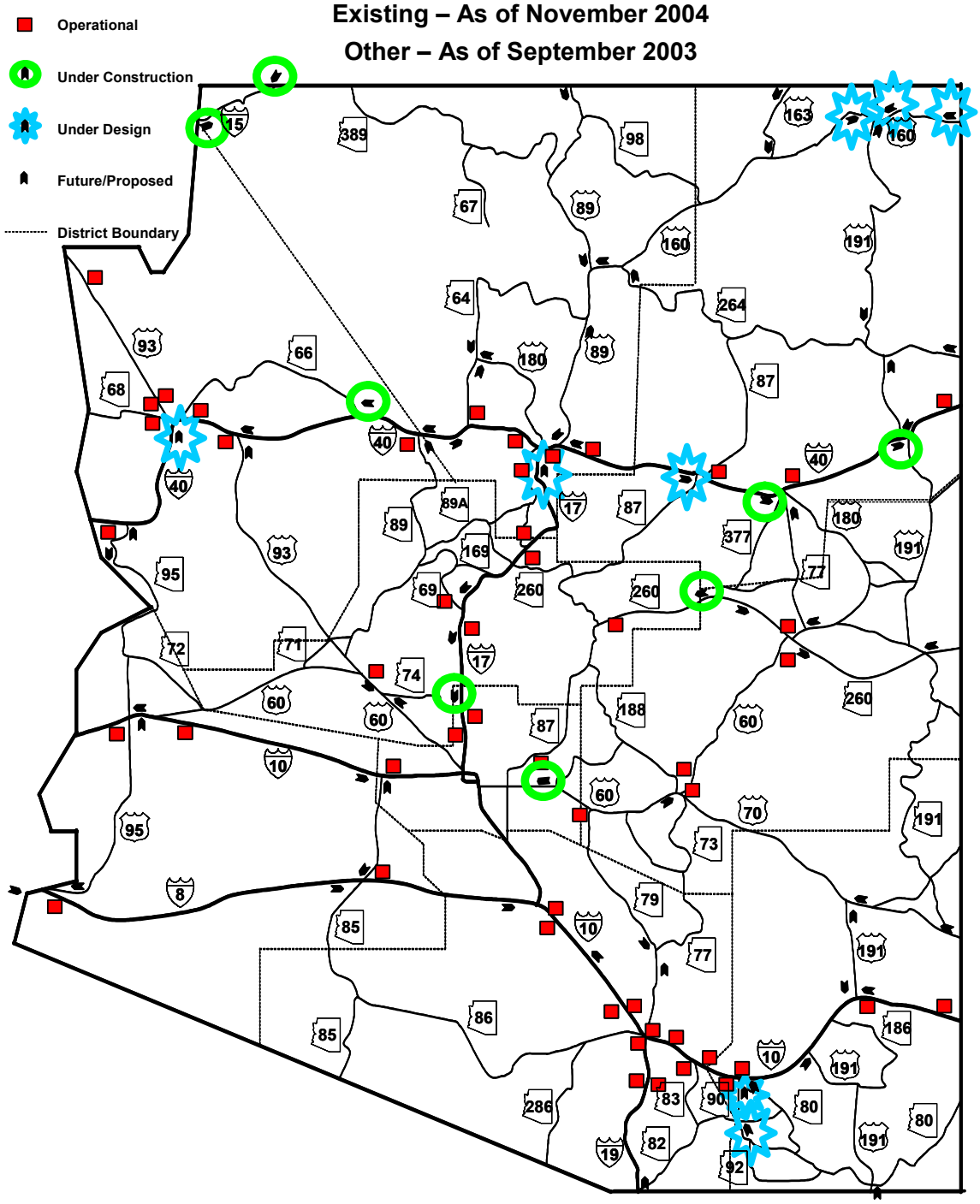


STATIC SIGNS FOR 511

As of November 2004



STATEWIDE VARIABLE MESSAGE SIGNS

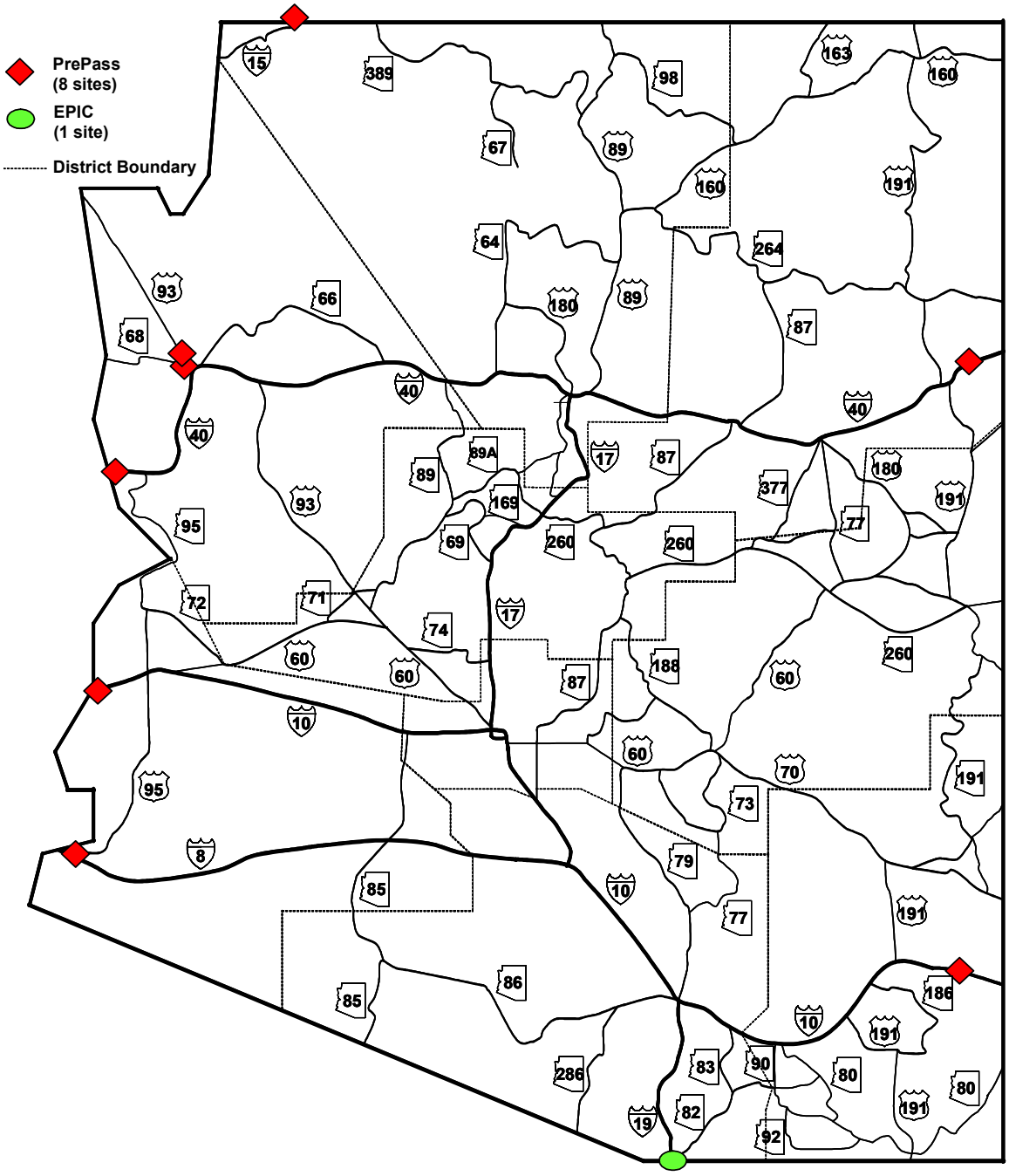


APPENDIX K

MAP OF GROUP C ITI DEPLOYED

STATEWIDE LOCATIONS OF GROUP C ITI (TRAFFIC CONTROL / COMMERCIAL VEHICLE ELECTRONIC CLEARANCE SYSTEMS)

As of November 2004

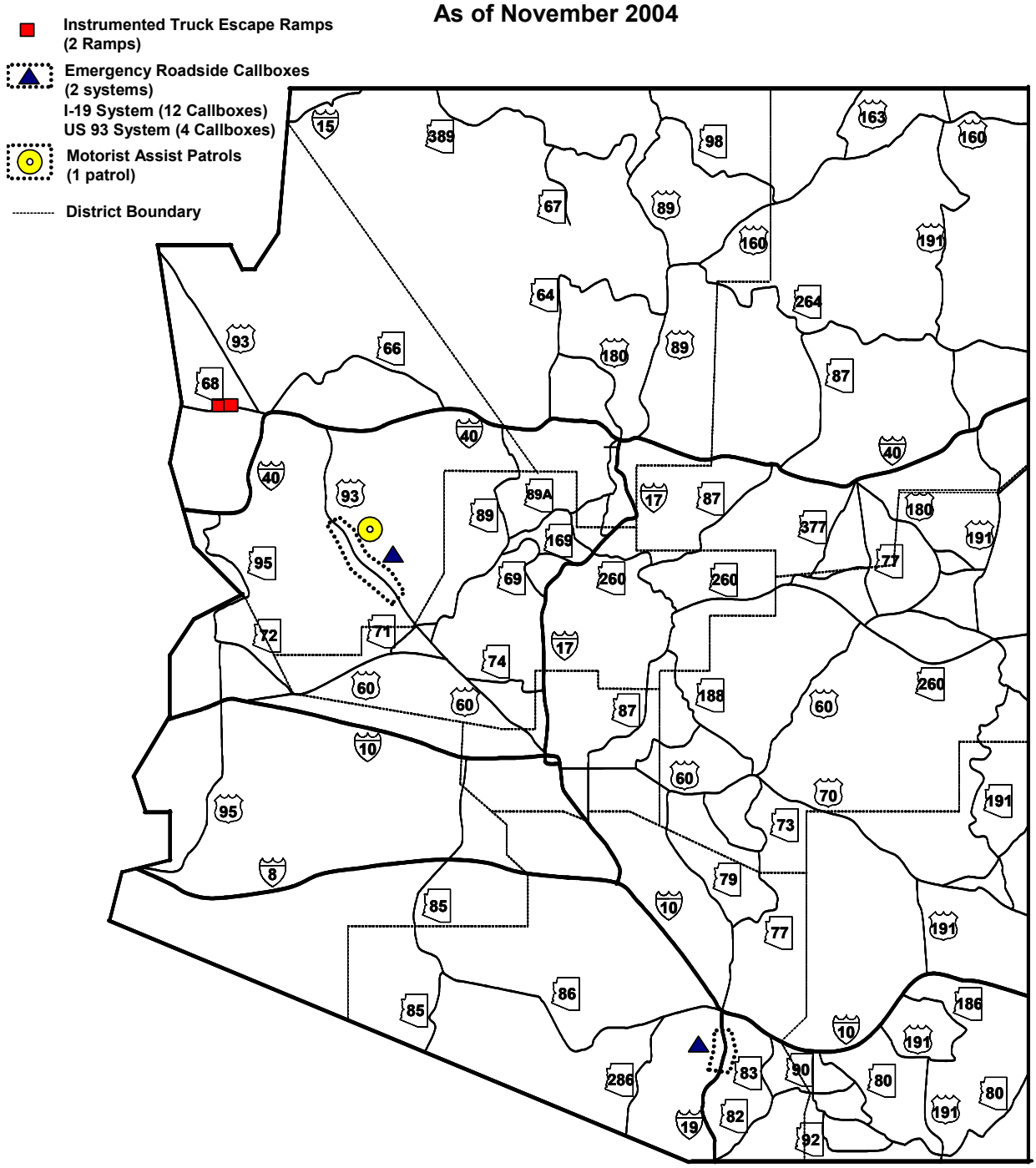


APPENDIX L

MAP OF GROUP D ITI DEPLOYED

STATEWIDE LOCATIONS OF GROUP D ITI
(EMERGENCY DETECTION AND RESPONSE SYSTEMS)

As of November 2004



APPENDIX M

PROGRESS TOWARD MEETING NEEDS / REMAINING UNSATISFIED NEEDS

ADOT Progress Toward Satisfying Prominent Rural ITS Needs		
Need IDs and Needs	**Progress**	**Remaining Unsatisfied Need**
14: Need detour and road closure information / 18: Need accurate winter road closure information / 8: Need to coordinate roadway closure information between agencies	ADOT regularly records closures in HCRS and posts road closure messages on various types of VMS. ADOT and DPS generally work hand in hand on decisions regarding roadway closures.	Detailed detour information not frequently provided. Detour information too often outdated, inaccurate, or not posted.
13: Need for information to be timely, reliable, accessible, and clear	ADOT continually strives to provide excellent quality of information via its information fusion and dissemination systems.	ADOT, working with its partners, will continue to make this a priority. More Better 511 voice interface needed.
60: Need to improve emergency response times / 57: Need improved incident notification and response times / 28: Need to accurately determine incident locations	ADOT's implementation of remote cameras, smart truck escape ramps, roadside callboxes, and motorist assistance patrols has helped improve emergency response times / incident notification and response times.	ITER and MAP have very limited deployment. MAP in particular is sorely needed in more locations. ERC and RC are more widespread but also cover very little of Arizona's rural roadways.
10: Need advanced warning of unsafe roadway conditions/ 21: Need advanced information on flooded areas / 37: Need advanced information on flash flooding conditions	ADOT's implementation of remote cameras, RWIS, HCRS, 511, and VMS has helped obtain and pass on information about unsafe roadway conditions to the public.	ADOT does not yet have much infrastructure in place that would enable them to issue timely flooding / flash flooding warnings. As weather-related warning systems are also the responsibility of regional bodies such as Counties, more collaboration and timely information sharing between those jurisdictions and ADOT should occur (see Need #1, next row).

ADOT Progress Toward Satisfying Prominent Rural ITS Needs		
Need IDs and Needs	**Progress**	**Remaining Unsatisfied Need**
1: Need ability to exchange weather and roadway condition information between agencies	Much ADOT and partner information is available via the Internet. Progress on entering of surface street information into HCRS is being made.	The NWS would like more in-depth information from ADOT's RWIS stations than is available on the Internet.
4: Need improved inter-agency communications / 2: Need to improve information sharing between agencies	ADOT has performed a radio interoperability study that has identified actions to improve interagency communications during emergencies.	Actions identified in the radio feasibility study still need to be carried out. Need more widespread coordination with local jurisdictions on special events and road / lane closures is needed.
41: Need toll free access to update and receive current roadway and weather conditions information	The 511 system addresses this need to a significant degree.	The 511 voice interface must continue to evolve to gain wider use. Weather info is not part.
15: Need more means to communicate with motorists in remote areas / 35: Need roadside communications in rural areas / 30: Need mayday systems	Cell phones are very common and address much of this need; CVO have good communications equipment and often pass on information; ADOT's roadside callbox systems also help.	Callbox installations cover very little of Arizona's rural roadways. Cellular-based ERC systems are subject to cellular provider coverage area limitations, which are severe in many parts of the state, often where dangerous driving conditions occur.
20: Need weather conditions information / 6: Need visibility monitoring and reporting	ADOT's RWIS installations address this need at least in part. Some Districts rely on NWS information available on the Internet.	Coverage provided by current RWIS network is limited. Much more could be done with a denser, more extended, and strategically developed network of RWIS stations. Dust storm detection using visibility sensors is a big need in areas that don't currently have RWIS.

ADOT Progress Toward Satisfying Prominent Rural ITS Needs		
Need IDs and Needs	**Progress**	**Remaining Unsatisfied Need**
17: Need clear and timely alternate route information	ADOT has performed an alternate route study. An end-user interface of an on-line system is under testing.	The ability to provide real-time information on alternate routes will take a sustained commitment from ADOT and its partners. The integrated alternate route information system under development has met with limited support from the Districts.
3: Need clearinghouse for information	ADOT's HCRS system addresses this need.	Some of the key information delivery systems envisioned in the Statewide Architecture (see Figure 1) have not been implemented. ADOT must continue to pursue its pioneering efforts in HCRS and 511 in order to ultimately meet the telematics industry half-way for the ultimate (and inevitable) objective of delivering real-time or near-real time roadway and traffic conditions information in-vehicle.

The following summarizes additional needs mentioned by the Districts and other stakeholders during the course of the study.

- Equipment maintenance is a big issue. While most devices appear to have satisfactory maintenance arrangements, four devices for which Districts and/or other ADOT organizations would like to see improved maintenance arrangements are RWIS, VMS, and commercial vehicle electronic clearance.

- The RTEO's are asked to provide maintenance support for RWIS but have no funding to do so and view it as their lowest priority. TTG has recently hired a contractor for RWIS maintenance support statewide.

- The license plate reader system used on the SR 68 project tended to break down. While penalties were assigned for times where data from the LPR showed travel times exceeding the acceptable maximum, no penalty was assigned for times where the system was inoperable. Future travel time specifications should assign a penalty for periods in which the system is inoperable for too long a period of time, perhaps 24 or 48 hours, or provide for alternative travel time estimation techniques.

- The RTEO's, although not adequately funded, generally do a good job of maintaining VMS. Regional support staff suggested that a statewide team of five to six people would be more effective at ITS support in terms of inventory / parts and expertise than the level of support that the RTEO's can provide currently.

- The Ports of Entry reported that it can be difficult to get vendor support when PrePass malfunctions occur.

- Portable PAD and other portable non-intrusive technologies may represent a safer way for traffic counts to be conducted when required for traffic signal warrants, corridor studies, etc.

- Remote cameras have the potential to help with a number of needs, such as verifying traffic conditions, confirming VMS messages, monitoring construction areas, monitoring rest areas, monitoring mountain pass conditions, and monitoring areas prone to flash flooding or dust storms.

- Judicious placement of Speed Detection / Warning Devices may contribute to lower crash rates on sections of road with switchbacks, transitions in speed limits, or hazardous environmental conditions (such as frequent falling rock or bad weather).

- The municipal street information available on the az511.com website does not yet seem to be available on the phone system.

- The public would like reliable and more specific alternate route information. Some would at least like ADOT to suggest a specific on- or off-ramp, which carries some risk for ADOT.

- The driving public wants the roadway / traffic conditions information to be reliable, accurate, timely, and relevant. In some cases other information resources exist to which the public will very readily gravitate if they feel they cannot rely on ADOT's information.

- There is a need for additional overhead VMS in quickly growing areas, in areas where improved detour information is needed, in areas with large gaps between existing signs, and near the international border crossing.

- The PrePass Ports of Entry all need mainline WIM. Some have WIM only on the exit ramp to the port.

- There is a need for improved public understanding of ITS and several ITI in particular, such as emergency callboxes. A large number of non-emergency calls and hang-ups result in a significant impact on DPS resources. It is believed much of this problem could be resolved through public education and improved written instructions at the callboxes, in both English and Spanish.

- There is a need for emergency callboxes and Motorist Assist Patrols in areas where breakdowns frequently occur. Areas where cellular coverage is poor may be good target areas for cellular- or radio-based callbox deployment if booster antennas are sufficient to overcome the coverage problem; ADOT may wish to consider other communications technologies with fewer limitations.

- Some of the public would like to receive az511.com website information with a lower "wow" factor. They just want the facts and would rather not deal with waiting for graphics-heavy pages to load up. A more text-based option would be helpful for those attempting to access the information via low-speed dial up connections or PDAs.

- There is a need for prevention and minimizing the impact of animal-vehicle crashes. As an example, the shoulder-mounted VMS that were installed on SR 260 to provide elk warnings have recently been removed as part of a realignment project; however, the potential for collisions remains.

APPENDIX N

UNMET NEEDS –
PRIORITIES, SCORES AND RANKINGS

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
G12. Need for information to be timely, reliable, accessible, and clear	9			27	100	1	1 of 34
H04. Need accurate winter road closure information	9			27	100	1	1 of 34
D02. Need improved maintenance for VMS	8			24	100	1	1 of 3
B01. Need improved work zone safety	9	1		29	97	4	1 of 20
F14. Need emergency roadside callboxes in locations where cellular coverage is poor	8	1		26	96	5	1 of 22
G01. Need to make traveler information available to the public.	8	1		26	96	5	2 of 34
G03. Need real-time traveler information	8	1		26	96	5	2 of 34
H11. Need advanced information on flooded areas	8	1		26	96	5	2 of 34
H22. Need clear and timely alternate route information	8	1		26	96	5	2 of 34
H31. Need real-time traffic conditions detection	8	1		26	96	5	2 of 34
D01. Need improved maintenance for RWIS stations	7	1		23	96	5	2 of 3
F06. Need improved incident notification and response times	7	1		23	96	5	1 of 22
F07. Need to improve emergency response times	7	1		23	96	5	1 of 22
G22. Need improved inter-agency communications	7	1		23	96	5	2 of 34
F10. Need motorist assist patrols in remote areas	7	2		25	93	15	4 of 22
F21. Need more means to communicate with motorists in remote areas	7	2		25	93	15	4 of 22
G24. Need to improve information sharing between agencies	7	2		25	93	15	5 of 34

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
G26. Need ability to exchange weather and roadway condition information between agencies	7	2		25	93	15	5 of 34
G29. Need to coordinate roadway closure information between agencies	7	2		25	93	15	5 of 34
H02. Need detour and road closure information	8		1	25	93	15	5 of 34
H09. Need advanced warning of dust storms	7	2		25	93	15	5 of 34
H10. Need advanced work-zone information	7	2		25	93	15	5 of 34
H19. Need weather conditions information	7	2		25	93	15	5 of 34
H20. Need advanced information on flash flooding conditions	7	2		25	93	15	5 of 34
H21. Need advance warning of inclement weather	7	2		25	93	15	5 of 34
D03. Need improved maintenance for PrePass	6	2		22	92	26	3 of 3
B05. Need icy road detection	7	3		27	90	27	2 of 20
F05. Need HAZMAT incident management	6	3		24	89	28	6 of 22
F09. Need motorist assist patrols in areas where breakdowns frequently occur	6	3		24	89	28	6 of 22
G06. Need more means to communicate with motorists in remote areas	7	1	1	24	89	28	8 of 34
G08. Need more overhead VMS on roads frequently requiring or providing detours	7	1	1	24	89	28	8 of 34
G13. Need improvement in remote verification of VMS messages	6	3		24	89	28	8 of 34
G19. Need improved intra-agency communications	7	1	1	24	89	28	8 of 34

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
G33. Need mass media to report up-to date, correct roadway conditions	6	3		24	89	28	8 of 34
G34. Need to work more closely with cellular providers to close coverage gaps.	6	3		24	89	28	8 of 34
H13. Need advanced warning of congestion	6	3		24	89	28	11 of 34
F01. Need coordination with statewide emergency management system	6	1	1	21	88	37	8 of 22
G23. Need to carry out recommendations of Radio Interoperability study	6	1	1	21	88	37	14 of 34
G32. Need remote communications with VMS	6	1	1	21	88	37	14 of 34
G09. Need more overhead VMS in long gaps between existing VMS	5	4		23	85	40	16 of 34
G16. Need better 511 voice interface	6	2	1	23	85	40	16 of 34
A04. Need ability to weigh trucks in a safe and quick manner	5	5		25	83	42	1 of 7
G04. Need advanced traveler information	4	4		20	83	42	18 of 34
C01. Need improved public understanding of rural ITS	5	3	1	22	81	44	1 of 8
C02. Need improved driver education	5	3	1	22	81	44	1 of 8
F08. Need more motorist assist patrols	6	1	2	22	81	44	9 of 22
F11. Need motorist assist patrols in deserts	5	3	1	22	81	44	9 of 22
F20. Need to accurately determine incident locations	5	3	1	22	81	44	9 of 22
G07. Need more overhead VMS in quickly growing areas	5	3	1	22	81	44	19 of 34
G17. Need weather information to be provided on 511.	4	5		22	81	44	19 of 34
G27. Need improved information sharing with regards to flash flooding	5	3	1	22	81	44	19 of 34

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
G30. Need information on detours/road closures to be disseminated outside Arizona	5	3	1	22	81	44	19 of 34
H08. Need advanced warning of unsafe roadway conditions	6	1	2	22	81	44	12 of 34
H12. Need warning of falling rocks	4	5		22	81	44	12 of 34
A07. Need HAZMAT vehicle tracking	5	4	1	24	80	55	2 of 7
B20. Need improved monitoring of areas prone to dust storms	6	2	2	24	80	55	3 of 20
G21. Need to improve coordination between maintenance/construction crews to avoid overlapping of efforts	5	1	2	19	79	57	23 of 34
G28. Need to share full RWIS data with the National Weather Service	5	2	2	21	78	58	24 of 34
G31. Need to share ADOT video data with other agencies	5	2	2	21	78	58	24 of 34
H01. Need roadway conditions information	6		3	21	78	58	14 of 34
H03. Need road closures due to forest fires to be included in general road closure database	5	2	2	21	78	58	14 of 34
H07. Need more accurate and timely detour information	6		3	21	78	58	14 of 34
A03. Need to enforce CVO weight restrictions	4	5	1	23	77	63	3 of 7
F02. Need to standardize EMS response procedures	3	4	1	18	75	64	12 of 22
G25. Need better coordination with local jurisdictions on special events	4	2	2	18	75	64	26 of 34
F13. Need emergency roadside callboxes in areas where breakdowns frequently occur	4	3	2	20	74	66	13 of 22
F16. Need emergency roadside callboxes based on communications technology not subject to cellular coverage limitations	5	1	3	20	74	66	13 of 22

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
H23. Need greater District support for development of integrated alternate route information system	3	5	1	20	74	66	17 of 34
B04. Need visibility monitoring and reporting	3	6	1	22	73	69	4 of 20
B17. Need improved monitoring of construction areas	5	2	3	22	73	69	4 of 20
B02. Need more extensive network of RWIS stations	4	3	3	21	70	71	6 of 20
B03. Need denser network of RWIS stations	4	3	3	21	70	71	6 of 20
G10. Need more overhead VMS near the international border crossing	4	2	3	19	70	71	27 of 34
H06. Need more detailed detour information	3	4	2	19	70	71	18 of 34
A02. Need information regarding CVOs entering United States	2	6	2	20	67	75	4 of 7
A05. Need ability to weigh trucks on the highway mainline (not just the ramp)	3	4	3	20	67	75	4 of 7
B14. Need to prevent collisions with wildlife	4	2	4	20	67	75	8 of 20
C03. Need outreach to school children	3	3	3	18	67	75	3 of 8
C08. Need more prominent signing at callbox locations	3	3	3	18	67	75	3 of 8
E01. Need for collision avoidance systems for CVOs	2	5	2	18	67	75	1 of 3
F22. Need roadside communications in rural areas	2	5	2	18	67	75	15 of 22
H15. Need advanced warning of animal crossings	3	3	3	18	67	75	19 of 34
H34. Need to communicate in advance availability of services to the public	2	5	2	18	67	75	19 of 34
F18. Need improved dispatch and communications for EMS vehicles	3	2	3	16	67	75	15 of 22
B07. Need adaptive signal timing	3	3	4	19	63	85	9 of 20

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
B19. Need improved monitoring of areas prone to flash flodding	2	5	3	19	63	85	9 of 20
F12. Need more emergency roadside callboxes	2	4	3	17	63	85	17 of 22
G02. Need in-vehicle traveler information	3	2	4	17	63	85	28 of 34
G11. Need clearinghouse for information	3	2	4	17	63	85	28 of 34
G15. Need toll free access to update and receive current roadway and weather conditions information	3	2	4	17	63	85	28 of 34
H17. Need bridge condition information	2	4	3	17	63	85	21 of 34
B12. Need to deter speeding near areas with frequent bad weather	1	5	3	16	59	92	11 of 20
B13. Need to deter speeding near areas with wildlife crossings	2	3	4	16	59	92	11 of 20
C05. Need bilingual emergency roadside callbox instructions posted at callboxes	2	3	4	16	59	92	5 of 8
F17. Need in-vehicle emergency notification devices	2	3	4	16	59	92	18 of 22
G05. Need traveler information at national/state parks	2	3	4	16	59	92	31 of 34
H05. Need roadway closure information for streets outside of the ADOT roadway network	3	1	5	16	59	92	22 of 34
H16. Need advanced warning of rural intersections	1	5	3	16	59	92	22 of 34
H26. Need tourism/traveler information at rest stops	1	5	3	16	59	92	22 of 34
F03. Need information on emergency parking areas for CVOs	2	2	4	14	58	100	19 of 22
B16. Need portable non-intrusive detection to enhance employee safety during traffic data collection	1	4	4	15	56	101	13 of 20

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
C07. Need signing indicating callbox locations and distances	2	2	5	15	56	101	6 of 8
G14. Need to provide visitors to az511.com website the option of a text-based / less graphics-intensive interface	2	2	5	15	56	101	32 of 34
G18. Need municipal street information to be provided on 511	3		6	15	56	101	32 of 34
G20. Need to include POE in the information exchange loop	1	4	4	15	56	101	32 of 34
H14. Need advanced warning of highway junctions	1	4	4	15	56	101	25 of 34
H18. Need to make public aware of snow plowing schedules and locations	1	4	4	15	56	101	25 of 34
H25. Need 24 hour tourist information	2	2	5	15	56	101	25 of 34
H30. Need transit availability information	3		6	15	56	101	25 of 34
A01. Need surveillance of POE traffic		6	4	16	53	110	6 of 7
B08. Need ability to monitor and display traffic speeds to motorists to deter speeding	1	3	5	14	52	111	14 of 20
B09. Need to deter speeding on roadways with frequent curves		5	4	14	52	111	14 of 20
C04. Need clearer emergency roadside callbox instructions posted at callboxes		5	4	14	52	111	7 of 8
F04. Need detection of vehicles violating road closures	1	3	5	14	52	111	20 of 22
H24. Need tourist information	1	3	5	14	52	111	29 of 34
H33. Need information on emergency parking areas for CVOs	2	1	6	14	52	111	29 of 34
B06. Need rest area security	1	3	6	15	50	117	16 of 20
B15. Need to know status of at-grade railroad crossings	1	3	6	15	50	117	16 of 20
C06. Need improved signing for emergency roadside callboxes		4	5	13	48	119	8 of 8

Unmet Needs Listed in Order of Composite Need Score

Unmet Needs	A's (3 pts.)	B's (2 pts.)	C;s (1 pt.)	Raw Composite Need Score	Composite Need Score	Overall Rank	Rank within Group
H32. Need traveler information regarding Nogales POE status	1	2	6	13	48	119	31 of 34
A06. Need commercial vehicle tracking		4	6	14	47	121	7 of 7
B18. Need improved monitoring of mountain passes	1	2	7	14	47	121	18 of 20
B11. Need to deter speeding near areas with frequent falling rock		3	6	12	44	123	19 of 20
E02. Need to monitor drivers' condition	1	1	7	12	44	123	2 of 3
F15. Need emergency water stations co-located at emergency roadside callboxes locations	1		7	10	42	125	21 of 22
F19. Need mayday systems	1		7	10	42	125	21 of 22
B10. Need to deter speeding near areas with a transition in the speed limit		2	7	11	41	127	20 of 20
E03. Need expeditious way to collect fees at state and national parks		2	7	11	41	127	3 of 3
H28. Need advanced traveler/tourism information at POE in Nogales	1		8	11	41	127	32 of 34
H27. Need multi-lingual tourist information		1	8	10	37	130	33 of 34
H29. Need better directions to tourist attractions		1	8	10	37	130	33 of 34

APPENDIX O

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