TRANSPORTATION COMMUNICATIONS INTEROPERABILITY: PHASE 2 – RESOURCE EVALUATION

Final Report 569

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16. Abstract

Based on the Arizona Department of Transportation's (ADOT) previous SPR-561 'Needs Assessment' study, this report continues the efforts to enhance radio interoperability between Department of Public Safety (DPS) Highway Patrol officers and ADOT field personnel. Ideally, any DPS officer should be able to communicate with any ADOT highway worker in the rural areas. The SPR 561 project recommended two pilot programs: (a) testing of secondary VHF radios to be installed in several squads of DPS patrol cars, and (b) testing of dispatch console interties, or 'crosspatching,' by regional DPS dispatchers and by ADOT's Phoenix Traffic Operations Center.

This report outlines the implementation and evaluation aspects of the radio interoperability pilot program, to include evaluation of user needs, suggested deployments, development of training and evaluation plans, and defining a practical evaluation period for assessment of the programs. User needs were developed through a series of stakeholder meetings and follow-up discussions and interviews to identify critical areas. Previous attempts at interoperability were reviewed and analyzed to determine successes and challenges. A train-the-trainer plan was developed to support an on-going program such that refresher courses would be available, as well as opportunities to train new employees. The evaluation plan identifies the feedback methods used for the program, which included field interviews, dispatch log sheets, and interoperability field reports. Data reduction was performed to determine response times, message latency, any follow-up meetings needed, level of confusion, frequency of use, and user perception. An evaluation period of seven months was sufficient to support the analysis of radio interoperability.

Of three final recommendations from this successful pilot program, the key point is to deploy secondary car-to-car VHF radios in all highway patrol units in the rural areas of the state for direct contact with ADOT personnel. The dispatch console crosspatch resource is also in place as a tool for special events, incidents, or joint operations such as forest fires or winter storms. Ongoing training, testing, and feedback comprise a third key element.

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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 persquare 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 (or "t")	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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ACRONYMS AND ABBREVIATIONS

ACIC	Arizona Crime Information Center
ACU-1000	A portable device developed by Raytheon used for crosspatching of otherwise non-interoperable wireless communications systems.
ADOT	Arizona Department of Transportation
AIRS	Arizona Interoperable Radio System
AMPS	Advanced Mobile Phone System
ANSI	American National Standards Institute
ATRC	Arizona Transportation Research Center
AVL	Automatic Vehicle Location
bps	Bits per second
CAD	Computer-Aided Dispatch
CDMA	Code-Division Multiple Access
CDPD	Cellular Digital Packet Data
CFR	Code of Federal Regulations
CSMA	Carrier Sense Multiple Access
CTCSS	Continuous Tone Coded Squelch System
DEMA	Department of Emergency and Military Affairs
DPS	Department of Public Safety (Highway Patrol)
EIA	Electronics Industries Association
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
FAS	Frequency Assignment Subcommittee
FCC	Federal Communications Commission
FDMA	Frequency-Division Multiple Access
FHWA	Federal Highway Administration
FM	Frequency Modulation
FMCSA	Federal Motor Carrier Safety Administration
GHz	Gigahertz
GIS	Geographic Information System
GOS	Grade of Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
GVW	Gross Vehicle Weight
HAAT	Height Above Average Terrain
HAGL	Height Above Ground Level
HP	Highway Patrol
HazMat	Hazardous Materials
ID	Identification number
I	Interstate Highway
I-D	Infrastructure Dependent
I-I	Infrastructure Independent
IRAC	Interdepartment Radio Advisory Committee
Kbps	Kilobits per second
kHz	Kilohertz

ACRONYMS AND ABBREVIATIONS

LMR	Land Mobile Radio
MDC	Mobile Data Laptop Computer
MDT	Mobile Data Terminal
MHz	Megahertz
ms	Millisecond
MVD	Motor Vehicle Division
NASTD	National Association of State Telecommunications Directors
NCIC	National Crime Information Center
NIJ	National Institute of Justice
NMDOT	New Mexico Department of Transportation
NPR	National Performance Review
NPSPAC	National Planning Safety Planning Advisory Committee: an FCC-sponsored group which coordinates channels in the upper 800 MHz public safety spectrum (821-824 MHz and 866-869 MHz)
NTIA	National Telecommunications & Information Administration
OES	Office of Emergency Services
OpCom	DPS Operational Communications Dispatch
PC	Personal Computer
PCS	Personal Communication Service
PL	"Private Line" - a Motorola tone coded squelch moniker
PSCC	Public Safety Communications Commission (State of Arizona)
PSWAC	Public Safety Wireless Advisory Committee
PSWN	Public Safety Wireless Network
PTT	Push-to-talk
RF	Radio frequency
RX	Receive (designated frequency, per Appendix A)
RSSI	Receiver Signal Strength Indication
SCADA	Supervisory Control and Data Acquisition
SMR	Specialized Mobile Radio
SONET	Synchronous Optical Network, an ANSI standard
SPS	Spectrum Planning Subcommittee
SR	State Route
TAC	Technical Advisory Committee
TDMA	Time-Division Multiple Access
TIA	Telecommunications Industry Association
TIA/EIA	Telecommunications Industry Association/Electronic Industries Alliance
TOC	Traffic Operations Center
TX	Transmit (designated frequency, per Appendix A)
UHF	Ultra High Frequency band
USGS	United States Department of the Interior, Geological Survey
VHF	Very High Frequency band

EXECUTIVE SUMMARY

BACKGROUND

A previous Arizona Department of Transportation (ADOT) research project, (SPR 561 – *Transportation Communications Interoperability: Phase 1, Needs Assessment)* provided a road map to better radio communications for ADOT and its core partners in the State, primarily the ADOT Motor Vehicle Division (MVD) and the Department of Public Safety (DPS) Highway Patrol. Five pilot projects were recommended, of which three were internal ADOT actions. However, Pilot Projects 4 and 5 would require significant external support and guidance to implement. These involved interoperability between ADOT crews and the DPS Highway Patrol officers on the State's rural highways.

Pilot Project 4 would install secondary very high frequency-band (VHF) radios in DPS patrol cars, which use standard UHF (ultra high frequency) radios, so as to communicate directly with ADOT units on their statewide VHF network. Pilot Project 5 would test the use of dispatch console interties between the DPS Flagstaff and Tucson Operational Communications sections (OpCom) and ADOT's Traffic Operations Center (TOC), to link any possible combination of ADOT and DPS channels together over the entire State.

To carry out the two recommended pilot projects in the field would require significant funding to provide VHF-band mobile radios for DPS patrol cars on a full-squad basis, and for the dispatch console inter-tie hardware and programming, in addition to the cost of performing the interoperability evaluation study itself. Although some of the DPS squad supervisors previously had surplus VHF radios in their own patrol vehicles, the key aspect of Pilot Project 4 was to deploy identical ADOT-compatible VHF radios into all of the patrol-officer vehicles in each selected squad.

ADOT's SPR 569 research funding provided a sufficient equipment budget for deploying a small-scale basic version of the two SPR 561 field test concepts. A total of 65 ADOT-configured VHF radios would be needed, as well as the regional dispatch console cross-patching systems. Partner funding was sought to expand the base-level deployment on a wider scale, to increase the potential field activity data and thus reduce the duration of the evaluation period; ADOT Homeland Security funds were used to reach the field test goal.

In mid-2005, ADOT's Arizona Transportation Research Center (ATRC) initiated this SPR 569 project in two stages. The consultant's initial 6-month design phase produced a deployment plan and evaluation program for the two pilot projects. This design was acceptable to all parties and a follow-on field hardware implementation and 7-month evaluation project was initiated, which involved close monitoring of DPS and ADOT joint interoperable field tests of the car-to-car and crosspatch concepts.

Prior to the research, the project's Technical Advisory Committee (TAC) provided guidance that the study should focus on the ADOT Flagstaff and Safford District areas.

The primary method of researching user needs was focus group interviews conducted in the Flagstaff, Phoenix, and Tucson areas. Two separate meetings were held during August and September of 2005. Widespread stakeholder participation included ADOT Engineers, Maintenance Supervisors, Construction Supervisors, Hazmat and MVD representatives, and members of the Technical Advisory Committee. DPS stakeholders and participants included Sergeants, Lieutenants, Commanders, Dispatch Supervisors, and telecommunications technical personnel.

These focus groups were continued as the evaluation phase progressed in 2006, with a series of three meetings held in both Tucson and Flagstaff during the study period. These discussions reviewed the interoperability incidents that were being reported on the field activity forms, and discussed possible needed changes or adjustments to the interoperability plans. As an example, minor changes in the calling procedures from an ADOT field worker to a DPS officer were implemented late in the project evaluation.

METHODOLOGY & USER NEEDS

Through initial stakeholder meetings in late 2005, and in follow-up discussions and interviews, the needs of DPS and ADOT stakeholders in two critical areas of the State were well defined. The TAC defined these critical areas of interoperability needs as those sections of I-40 and I-17 in ADOT's Flagstaff District, and along I-10 from Benson east to New Mexico in the Safford District. The I-40 / I-17 area is critical for DPS and ADOT interoperability for snow and ice control operations, and the associated accidents caused by weather conditions. To the south, I-10 is defined as critical because of high traffic volumes, blowing dust, highway flooding, and occasional ice storms.

Ideally, any DPS officer should be able to communicate directly with any ADOT highway worker in these rural areas. For most pilot project communications, including accident coordination or law enforcement operations, field personnel were instructed to initiate immediate direct communications. However, for snowplowing operations, the supervisors for both agencies were to first make contact with each other to construct a plan, prior to the patrolman and plow operator having direct communications.

After the focus group meetings held in Flagstaff, Phoenix, and Tucson, it was determined that a test involving four DPS officer squads in the Flagstaff-Williams areas would be involved, and also four in the Benson-Willcox-Sierra Vista-Bisbee areas. These formal interoperability tests took place beginning May 1, 2007, after completion of hardware installation and testing, and after training of all personnel concerned was accomplished.

In the initial phase, three DPS Highway Patrol squads in the Flagstaff area, and two in the Benson-Willcox area were equipped with mid-level cost-effective Kenwood VHF mobile radios. For four months, they practiced interoperability with ADOT via direct radio-to-radio communications. Meanwhile, one DPS Highway Patrol squad in the Williams area, and two others in the Bisbee and Sierra Vista areas, were trying interoperability via dispatcher crosspatching only. However, after four months, these squads using only

dispatch crosspatching were also given VHF radios, and all squads were then capable of using either mode of interoperability for further comparative purposes.

OBSTACLES TO INTEROPERABILIITY TESTING & EVALUATION

The success or failure of most radio interoperability projects hinges on the quality of training provided to the users, including continued refresher training, and continuous system testing. Familiarity with the system on an on-going basis is critical to success. A "train-the-trainer" plan was implemented, whereby the project consultants trained ADOT field supervisors and console operator supervisors, as well as DPS OpCom trainers and supervisors and field Sergeants. These people then took the training information back to their field staffs. Continued weekly testing of radios in the field, and of console patching at least monthly, was recommended. New employees were to be trained within 30 days of their assignment into the pilot test areas, or to dispatch communications.

Evaluation of the efficiency and effectiveness of the two pilot projects depended upon the quality and quantity of the feedback to the research team. The reporting methods were:

- Field interviews conducted bi-monthly.
- Special dispatch log incident summaries.
- ADOT field worker / DPS officer Field Reports submitted monthly.

Data reduction was performed on the raw data to determine:

- Response times.
- Message latency.
- Number of field meetings required.
- Level of confusion.
- Frequency of use of interoperability technology.
- User perception of interoperability tools.

By May 1, 2006, DPS had the mobile radio and console hardware in place to begin the testing. The field testing period was to run through the end of November (7 months), with regular monitoring of the process. Three field meetings were held in both Flagstaff and Tucson to ensure that the program was running smoothly. Users were asked to send radio interoperability field report forms to the consultant on a continuing basis. After the end of the field testing, another month was used to complete data reduction, accept any final field evaluation forms, and finalize the draft summary report.

EVALUATION RESULTS

Most of the evaluation forms received for analysis were from field users rather than console dispatch operators. As the evaluation period took place during the summer

months, most of the evaluation forms came from the users in the southern region. Typical incidents cited in the forms included accidents, flooding, dust storms, and road closures. There were over 40 car-to-car field user evaluation forms submitted, but only two dispatch operator forms were returned. Limited evaluation forms were received from the northern region, as there were few opportunities for radio interoperability during the evaluation period (the early winter of 2006 was a very dry period, with almost no snow). This was evident in the field user review meetings held in Flagstaff, where participants indicated a general lack of circumstances to employ interoperable communications.

The results of the evaluation, as verified by user-submitted incident evaluation forms and interviews, varied based on the interoperability method used. Overall the general user satisfaction level for Pilot Project 4, direct car-to-car communications, was exceptionally high. Through comments received during the field review meetings and written field reports, the VHF radio user satisfaction expressed was on the order of 90%. The varying replies to the evaluation form included comments regarding improved response times to incidents, reduced confusion, better coordination between the agencies, and ease of use.

Initial contacts were successful over 90% of the time. Use of radio interoperability was found not to distract responders from their primary focus; as none of the evaluation forms indicated that it interfered significantly with their regular tasks or functions. Over 85% of the responders indicated that there were absolutely no communication problems with radio interoperability. The project's TAC considered this a very good success rate.

One major surprise of Pilot Project 4, the direct car-to-car communications evaluation, was the extent of usage of the VHF radios by DPS to communicate with other law enforcement and local public safety agencies in their operating area. This was an unexpected major benefit. Between 50% and 75% of the interoperable communications that DPS initiated were with other law enforcement agencies, not ADOT. These agencies included sheriffs' offices, local police departments, Hazmat teams, and park rangers.

With the Pilot Project 5 test, dispatch console crosspatching, a much different result was noted. The opportunities for the intended application for console crosspatching did not arise during the evaluation period. These would be events of long duration occurring over a wide area, such as snowstorms and large forest fires. Only two incidents were noted where a console crosspatch was successfully used, and one of the occasions was a testing opportunity. This lack of use of the crosspatch is due to the evaluation period occurring during the summer months, and a milder than average fire season. The small number of responses for crosspatch communications is not indicative of failure of the test, but only shows the limited number of opportunities for use in the evaluation period.

PROJECT 569 OPERATIONAL RECOMMENDATIONS & COST SUMMARY

Pilot Project 4, direct car-to-car interoperability, proved so successful and popular with DPS and ADOT personnel that continued statewide implementation, outside of Maricopa County, is recommended. All participants from field officers up through regional commanders and supervisors agree that the project had proven the concept, and support

its expansion. The TAC representative for the ADOT Safety and Health Emergency Response Section stated, "This is very important. We need to make this happen."

For statewide DPS implementation outside of Maricopa County, the expansion of Pilot Project 4 will involve the procurement of an additional 440 radios with an approximate cost of $660,000. This deployment will have to be funded by DPS, to expand beyond the limits of the ADOT research study. Legislative appropriation is one means of obtaining the necessary funding, although alternative resources such as law enforcement grants should first be explored. This interoperability expansion would not replace the Arizona Interoperable Radio System (AIRS) or a future statewide Public Safety Communications Commission (PSCC) radio network, which is still at least 5 years and $100 million in the future, but it is an efficient solution to augment AIRS.

The VHF radios offer the possibility of expanding radio interoperability to neighboring states' highway departments and highway patrols also, including Utah and New Mexico, and to other Arizona local agencies still using legacy VHF analog radio systems.

Expansion of Pilot Project 4 would further enhance not only safety for ADOT workers and the motoring public, but also for individual DPS highway patrol officers. Any level of additional support made available through interoperable communications will clearly enhance the officers' safety. The perceived level of benefit, for such a low cost and effort to address this crucial interagency communications issue, is exceptionally high.

Optional accessories could be included in this expansion, such as weatherproof in-grille speakers for the VHF mobile radios and/or portable radio extender units. Grille-mounted speakers are inexpensive, at approximately $50. The portable radio extender units would allow DPS UHF hand-held radios to communicate through their vehicles directly with ADOT units, but this would cost approximately $1,500 per each unit.

It is not recommended that portable VHF radios be purchased for use by each DPS officer, because of their limited range and the added weight on the officer's utility belt. However, one VHF portable radio could be made available for each squad in the squad office for specialized applications including, but not limited to, long-term special events.

As for Pilot Project 5, the expansion of crosspatching is recommended on a very limited scale. Building on the Flagstaff and Tucson DPS dispatch console links, similar links should be constructed at the Phoenix DPS OpCom center. This will allow crosspatching between ADOT and DPS field units through the Phoenix DPS dispatch center, including the ADOT 800 MHz talk groups in Maricopa County. The cost of this expansion is quite minimal; approximately $3,500 based on DPS estimates. This will enable interoperable communications between DPS and ADOT, both within Maricopa County and statewide.

Expansion of crosspatching capability beyond the limited steps detailed in the previous paragraph would be very expensive and of questionable utility; no further expansion over that crosspatch capacity is recommended.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

A previous study, the ADOT-ATRC SPR 561 "Needs Assessment" Project (Phase I)[1], identified key interoperability needs between ADOT and its core partners. That 2004 study made five Pilot Project recommendations to ADOT and DPS to improve radio transportation communications interoperability. This Phase II project, which was divided into two parts, Design and Evaluation, focuses on two of the original recommendations that are specific to radio interoperability between ADOT and DPS:

- **Pilot Project 4**: Install low-cost secondary VHF mobile radios in DPS patrol vehicles on I-40, all of which have the DPS standard UHF radio systems.
- **Pilot Project 5**: Add dispatch console gateways to link DPS channels to ADOT's VHF and 800 megahertz (MHz) maintenance radio systems.

The earlier Phase I recommendations, apart from Pilot Projects 4 and 5, dealt primarily with improving radio interoperability internally within ADOT in the Phoenix Metro area, improving interoperability with ADOT's Motor Vehicle Division enforcement units, and improving ADOT's VHF radio interoperability among multiple agencies along the I-40 corridor and in other parts of the State. Implementation actions taken internally were:

- Expand VHF infrastructure-independent interagency interoperability agreements and policies along the Interstate 40 corridor.
- Reprogram MVD radios with ADOT VHF statewide channels and set-up emergency after-hours access to the TOC dispatch center for MVD.
- Install "hard" cross-links on the TOC console between specific 800 MHz maintenance talk-groups, and adjacent district VHF maintenance channels.

The initial phases of this SPR 569 project recommended and summarized deployment plans for Pilot Project 4 and Pilot Project 5. Technical Memoranda that separately discussed User Needs, Deployment Planning, Training Plans, and Evaluation Plans were previously prepared to complement this Final Report.

The technical objectives of the Resource Evaluation Project's design phase were to:

- Identify and prioritize User Needs between ADOT and DPS in implementation of Pilot Project 4 and Pilot Project 5.
- Identify and prioritize locations, units, squads, and vehicles in which radios will be deployed for Pilot Project 4.
- Provide Equipment and Installation Specifications for the required radio and antenna equipment for Pilot Project 4.

- Develop Equipment Installation Procedures.
- Provide a System Design and Interconnection Diagram for Pilot Project 5.
- Provide Equipment Specifications for Pilot Project 5.
- Identify a procurement mechanism for the deployment.
- Provide detailed Estimates of Cost for the proposed deployment.
- Identify a Maintenance Plan for the proposed equipment.

Additional related operational objectives were to:

- Develop policies and procedures for use of the car-to-car and crosspatch interoperability tools.
- Define protocols for communicating using the interoperability tools.
- Recommend procedures for ongoing testing and training to enhance, exercise, and maintain the skills of ADOT and DPS personnel responsible for using each interoperability tool.
- Define policies, procedures, and protocols for use of the radio interoperability technology to be presented to the field and dispatch staff during Phase B after the hardware is installed, so that the training is fresh in the minds of the users at the time that the hardware becomes available.

In addition, a final objective of the initial phase of the project was to devise an Evaluation Plan, including development of evaluation materials to be disseminated to dispatch operators and field staff. The evaluation phase was recommended to take place during a 7- to 9-month period of time, and it was to be divided into two parts for comparative purposes. Part 1 would allow certain DPS squads VHF radio car-to-car interoperability, whereas several other squads will have only access to, and evaluation of console crosspatch interoperability. In Part 2, those DPS squads would continue to evaluate console crosspatching as well as direct radio car-to-car interoperability.

These goals and objectives were closely monitored during the evaluation phase of the project, and data was extracted from the field reporting forms which would confirm or deny the hypothesis generated supporting the goals. These are discussed extensively in Sections 6 and 7.

1.2 RESEARCH METHODS AND OBJECTIVES

This project's Technical Advisory Committee (TAC) provided initial guidance that the study should focus on the ADOT Flagstaff and Safford District areas. The primary method of confirming local-level user needs was focus group interviews with personnel from the Flagstaff, Phoenix, and Tucson regions. Two separate group meetings were held in August and September of 2005. Widespread stakeholder participation included ADOT District Engineers, Maintenance Supervisors, Construction Supervisors, HazMat representatives, MVD representatives, ATRC staff, and members of the research TAC.

The DPS stakeholders and participants included Sergeants, Lieutenants, Commanders, Dispatch Supervisors, and technical personnel.

The focus groups included a brief introduction to the goals and objectives of the project, followed by a structured discussion of interoperability questions addressed to all parties in attendance.

These focus groups were continued as the evaluation phase progressed in 2006, with three meetings each of both the Tucson and Flagstaff groups during the evaluation period. These discussions reviewed the interoperability incidents that were being reported on the form sheets, and discussed possible needed changes or adjustments to the interoperability plans. As an example, minor changes in the calling procedures from an ADOT field worker to a DPS officer were implemented late in the project evaluation.

1.3 STUDY PARTICIPANTS

The project communications interoperability team consisted of the Safford and Flagstaff ADOT Districts, the Arizona Department of Public Safety, and the Federal Highway Administration (FHWA). DPS cooperated with a number of local agencies during the Pilot Project 4 evaluation that did not officially participate in the project. These agencies included county and city public works departments, county sheriffs, local police and fire departments, ambulance service providers, neighboring states, and others.

1.4 INTENDED IMPLEMENTATION AND USE OF RESEARCH RESULTS

This project was initiated to implement effective radio interoperability between ADOT and DPS field forces in the Safford and Flagstaff Districts. It was expected to directly support expanded future communications deployments for both ADOT and DPS, in order to better coordinate local and regional incident response and command.

1.5 REPORT ORGANIZATION

The report is divided into two major components: design and evaluation. Chapters 2 through 5 identify the project design, and Chapters 6 and 7 present the project activities, findings and recommendations. Following this introduction, this report is organized as follows:

- **Chapter 2: User Needs Inventory** – This chapter focuses on the varying interoperability needs based on the different regions, including potential benefits and challenges, and presents the training needs for the project.
- **Chapter 3: Deployment Plan** – This chapter presents the study deployment recommendations for Pilot Project 4 and Pilot Project 5.
- **Chapter 4: Training Plan –** This chapter details the training plan, including identifying staff to be trained and providing the training materials.

- **Chapter 5: Evaluation Plan** – This chapter outlines the project evaluation period, including the measures of effectiveness, data collection period, data collection methods, and data reduction and analysis.
- **Chapter 6: Field Evaluation** – This chapter presents the project evaluation, including the incidents reported by the project participants identifying incident details and user observations.
- **Chapter 7: Recommendations** – This chapter summarizes the evaluation period and makes explicit recommendations for future radio interoperability implementation.

1.6 ACKNOWLEDGEMENTS

The consultant gratefully acknowledges the support and participation of the many ADOT and DPS personnel who participated in the TAC meetings for this project, and the efforts of the many unnamed field personnel from both agencies who took the time to complete evaluation forms and attend meetings to bring this project to a successful conclusion.

Key personnel in this project included Lonnie Hendrix and Tim Wolfe of the ADOT Homeland Security Taskforce, who along with the Flagstaff and Safford Districts served as the program and project champions. Steve Owen was the Project Manager for this *Transportation Communications Interoperability: Phase 2 – Resource Evaluation*. A Technical Advisory Committee, with strong participation from the field units as listed below, gave guidance and outstanding support to the consultant team.

Technical Advisory Committee / Stakeholders

Team Member	Agency
Central Region	
Lonnie Hendrix	ADOT Central Maintenance-Homeland Security Taskforce
Tim Wolfe	ADOT Transportation Technology Group (sponsor)
Manny Agah	ADOT Traffic Operations Center
Linda Anestasi	ADOT Traffic Operations Center
Lori Elzy	ADOT Motor Vehicle Division – Enforcement
Scott Grissom	ADOT Motor Vehicle Division – Enforcement
Jeff Page	ADOT Safety & Health
John Hauskins	ADOT Phoenix Maintenance District
Curt Knight	Arizona Department of Public Safety / Public Safety Communications Commission
Alan Hansen	Federal Highway Administration
Debbie Henry	DPS OpCom – Phoenix
Donna Contreras	DPS OpCom – Phoenix
Scott Tillman	DPS Wireless Services Bureau – Phoenix
Steve Golisch	DPS Wireless Services Bureau – Phoenix

Team Member	Agency
Southern Region	
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Steve Puzas	ADOT Safford District
Cdr. David Denlinger	DPS Southern Region
Cdr. Larry Scarber	DPS Southern Region
Sgt. Brian Preston	DPS District 9
Sgt. Jeff Mitchell	DPS District 9
Lt. Steve Roethle	DPS District 9
Ptlmn. Martin Tapia	DPS District 9
Mike Bishop	DPS OpCom – Tucson
Celina Murrieta-Gonzales	DPS OpCom – Tucson
Felix Gabino	DPS Wireless Services Bureau – Tucson
Northern Region	
John Harper	ADOT Flagstaff District
Kent Link	ADOT Flagstaff District
Carl Burkhalter	ADOT Flagstaff District
Dennis Johnson	ADOT Flagstaff District
Danny Russell	ADOT Flagstaff District
JoAnn Wamble	ADOT Flagstaff District
Nola Cardani	DPS OpCom – Flagstaff
Suzanne Holbert	DPS OpCom – Flagstaff
Dennis McLouth	DPS Wireless Services Bureau – Flagstaff
Cdr. Bill McCance	DPS Northern Region
Sgt. Jeff Brownlee	DPS District 2
Sgt. Rod Wigman	DPS District 2
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2. USER NEEDS INVENTORY

2.1 BACKGROUND

The existing approach for intercommunication between ADOT and DPS field personnel during weekday work hours was via telephone. DPS would call the local district office to request ADOT assistance, and the district office then would dispatch the appropriate resources. This method was used both in northern and southern Arizona. Generally, response time was fairly good, but some opportunities for improvement existed.

During nights and weekends the formal procedure for communication between ADOT and DPS was for DPS to call the TOC and for the TOC to identify the staff on callback duty to dispatch to the scene. DPS reported that there is some latency in the response time when this method is used. Differences in opinion regarding the amount of latency exist. ADOT hazardous materials staff reported excellent service from the TOC. To get a more rapid response than the formal dispatching method currently provides, it was not uncommon for DPS Sergeants to call ADOT maintenance supervisors on cell phones.

The proposed radio interoperability solutions are seen as a short- to mid-term approach while the Public Safety Communications Commission (PSCC) and the DPS develop and implement a long-term, $200 million-plus statewide interoperable radio system. ADOT anticipates using the current VHF radio frequencies for up to another 10 years.

2.2 GEOGRAPHIC FOCUS

User geographic needs for interoperable radio communications between ADOT and DPS were documented. The specific geographic focus of the project includes the:

- I-40 Corridor and Flagstaff areas: including I-40 and I-17 in Coconino County, as well as US-89 north to the Gap. This area is in the ADOT Flagstaff Maintenance District and DPS District 2. (See Appendices A and C.)
- I-10 Corridor between Benson and New Mexico: including surrounding areas which included Sierra Vista and Bisbee. This area is in the ADOT Safford Maintenance District and DPS District 9. Some slight overlap on the western boundaries of the Safford Maintenance District falls into DPS District 8. It was anticipated that DPS District 8 would not be a major participant in this research.
- A limited number of DPS vehicles in District 9 and some Sergeants in District 2 already had ADOT VHF radios installed in their patrol cars. The most remote areas of the state had the most widespread sharing of obsolete or surplus ADOT radios in key DPS vehicles, primarily those of patrol supervisors. For example, all officers in the Page area and most officers in the Fredonia area (working the I-15 corridor segment in Arizona) already had ADOT radios. Response to this type of interoperability has been generally favorable, with some issues related to call sign recognition when DPS officers are attempting to contact ADOT dispatchers.

2.3 INTEROPERABILITY METHODS

The sections below describe the two interoperability methods that are the focus of this research. The recommendations presented in this study should be useful prior to the transition to a statewide interoperable radio network, while DPS continues to operate on UHF frequencies and ADOT continues to operate on VHF frequencies outside of the metro Phoenix area. This time period is expected to be approximately 7 to 10 years.

2.3.1 VHF Radio Approach

ADOT VHF radios installed in DPS vehicles have a range of 5 to 10 miles in the car-to-car environment and up to 50 miles using repeaters. A benefit of this approach is that no dispatcher intervention is required, making for rapid set-up of car-to-car interoperability. A limitation would be that this is only good for the specific DPS vehicles that have dual radios installed. In addition, the officer must have turned on the ADOT radio and be in his vehicle to use it, in order for either agency to initiate an interoperable communication.

2.3.2 Crosspatch Approach

The crosspatch approach requires close coordination between two dispatchers and the requesting personnel for both setup and teardown of the interoperable channel crosspatch. A benefit of this approach is that it can be used anywhere statewide without additional hardware in the vehicles. Crosspatching channels, however, might cause information overload concerns and might be a relatively low priority for a busy dispatcher. Specific instructions were developed to affect a crosspatch. These instructions addressed the use of the DPS "Statewide" channel for crosspatching.

Extended use of crosspatching might also require additional dispatch consoles and staff, if crosspatches are expected to remain active for an extended period of time. An example of staffing a console for an interoperability channel was seen during the extensive 2002 Show Low forest fires. Use of crosspatches for very short durations was thought to be possible, but cumbersome. Prior to this study, DPS dispatchers viewed crosspatches as useful only when there was no other way to provide interoperability.

2.4 INTEROPERABILITY NEEDS

The research questions generated during the Design Phase of the project included:

Interoperability Functions and Benefits

- What are the most common radio interoperability needs for ADOT and DPS?
- How frequently is interoperability between ADOT and DPS needed?
- What are the peak times of need for radio interoperability?
- How many ADOT and DPS officers typically respond to situations requiring interoperability?

- What is the typical duration of events that require interoperability?
- Over what size of geographic area is interoperability required?

Potential Constraints and Limitations

- What obstacles are there to implementing a smooth interoperability project in your area using console crosspatching technology?
- What obstacles are there to implementing a smooth interoperability project in your area using mobile radio technology?

Interoperability Training Needs

- How much training is required to operate the interoperable radio system smoothly?
- How and when should such training be provided to the ADOT and DPS staff?
- What formats of training material would be most helpful?
- How frequently would you recommend exercising or testing each interoperable radio system?
- How often are radio manuals used?
- Who will provide the training?

Deployment Planning Issues

- Which DPS squads should receive VHF radios and which squads should use console crosspatch interoperability?
- What different protocols and codes do ADOT and DPS personnel use in the field?
- Will your team be enthusiastic about new radio interoperability capabilities, or view them as additional work load?
- What criteria should be used to measure the success or lack of success of the two interoperability techniques being tested?
- What practical methods can be used to collect data?

Deployment Planning Tasks

- Identify and prioritize locations, units, squads, and vehicles in which radios will be deployed for Pilot Project 4.
- Provide Equipment and Installation Specifications for the required radio and antenna equipment for Pilot Project 4.
- Develop Equipment Installation Procedures.
- Provide a System Design and Interconnection Diagram for Pilot Project 5.
- Provide Equipment Specifications for Pilot Project 5.

- Identify a procurement mechanism for the deployment.
- Provide an Engineer's Opinion of Cost for the proposed deployment.
- Identify a Maintenance Plan for the proposed equipment.

Follow-up Research Conducted

Extensive follow-up research was conducted, both through telephone interviews and by reviews of technical and operations manuals provided by ADOT and DPS. Supplemental information and materials received during the follow-up research stage included:

- ADOT Flagstaff District Snow Manual including Radio Calls Signs.[2]
- DPS Radio Manual from DPS OpCom.[3]
- Statewide ADOT Radio Manual from DPS.[4]
- DPS Telecommunications Microwave and Radio Systems Manual.[5]
- The DPS Northern Region Commander and the Flagstaff District Commander clarified that interoperable communications need to be routed through supervisors for snow operations. Other interoperable communications may be initiated directly between the field personnel involved.
- Additional discussions with the ADOT Flagstaff District confirmed the approach.
- The DPS Administrative Sergeant in Flagstaff provided guidance regarding the geographic area covered by each squad, number of squad members, and squad numbering for DPS District 2.
- The DPS Administrative Officer in Sierra Vista provided similar guidance with regard to geographic areas, members, and squad numbering for DPS District 9.
- The DPS District 9 Lieutenant was contacted to confirm participation and support for the basic research concept.

The following sections describe a set of situations and scenarios during which interoperability was anticipated, and found to be useful. The scenarios are prioritized into high, medium, and low priority categories in terms of interoperability needs.

2.4.1 High Priority Interoperability Needs

Needs in this category involve imminent danger to life or property if immediate actions are not taken by appropriate response personnel. Although appropriate actions can be taken without the availability of an interoperable radio system, an interoperable system was postulated to make it easier to coordinate activities and improve response times.

Incident-Related Interoperability Scenarios

Incidents include traffic collisions, fires, hazardous materials spills, and other unplanned blockages of the roadway. DPS patrol officers and tow truck operators can rapidly clear the most common incidents involving passenger vehicles, unless fatalities are involved,

and such events typically would not trigger a need for radio interoperability. A typical DPS response to an accident is two officers, initially.

The most common interoperability need in the I-10 corridor is due to the more significant traffic collisions. Although winter weather operations provide the strongest justification for interoperability in the I-40 corridor, the second highest priority was for management of traffic collisions, particularly involving heavy vehicles.

ADOT currently responds to all hazardous materials (HazMat) situations and fatalities. Hazardous materials incidents tend to be relatively frequent in the Safford / Morenci area, near the mines.

The duration of the more significant events is typically four to five hours or more. ADOT plans to implement regional detours if the expected duration is likely to be four hours or more. It takes three to five hours to set up a regional detour. In many areas there are no good alternate routes available.

Interoperability for incident response was the top priority for the Safford District and DPS District 9. Incident response was the second highest priority for interoperability, after winter storms, in the ADOT Flagstaff District and DPS District 2.

The Snow Interoperability Scenario

The Flagstaff region's snow season can be from October through May, but more typically is December through February. The average storm duration is 17 hours. Ice and snow problems are more common in the I-40 corridor, but can also be a concern in the I-10 corridor. Icy bridges are a specific concern along I-10 for the Safford District. ADOT typically handles I-10 icing and snow issues without extensive coordination with DPS.

Interoperability for snow scenarios in the Flagstaff area was to be initiated between DPS Sergeants and the responsible ADOT maintenance supervisor working the area, because these individuals have knowledge of overall conditions and plow routing in the area. Once a plan is established, interoperable communications may be used by officers and plow drivers to coordinate operations. In the I-10 corridor, guidelines for which staff should communicate during a snow scenario are less rigid.

Snow situations are the highest priority for interoperability radio usage in the ADOT Flagstaff District and DPS District 2. Snow conditions on I-10 are less common, but radio interoperability would be considered a valuable tool in the ADOT Safford District and DPS District 9 to manage roadway-icing conditions.

The Dust Storm & Flood Interoperability Scenario

Dust storms are unique to the I-10 corridor and present a high priority need for radio interoperability. When conditions become unsafe, any officer has authority to shut down the road. In less severe dust situations, a joint ADOT and DPS response is sometimes

used to slow traffic down. Dust storms tend to occur two to three times per year. The peak season for dust is Spring, but Summer experiences its share of windstorms as well.

The Pursuit Interoperability Scenario

Radio interoperability appears essential for managing critical pursuits where DPS may request ADOT assistance to block roadways, although this has not been done to date due to lack of rapid and interoperable communications. Interoperable radios should also be used to warn staff in work zones that a pursuit is approaching the area so that workers on the roadway can be notified. At least two DPS patrol units, as well as a supervisor, typically would be involved in a pursuit.

2.4.2 Medium Priority Interoperability Needs

Needs in this category involve potentially hazardous road conditions and situations where interoperable communications offer greater convenience and effectiveness in managing the situation to prevent potential harm.

The Work Zone Interoperability Scenario

Work zones are often jointly staffed by DPS officers working under contract for traffic control purposes, to support and protect ADOT's construction inspection staff and the contractor's personnel. Work zones may have active traffic control for segments up to five miles long. Work zones may be ongoing and continuous. Interoperable radios may be useful and convenient in eliminating the need for face-to-face coordination meetings, and the time involved.

Port of Entry Interoperability

Ports of Entry operated by ADOT MVD, such as San Simon on I-10, could benefit from interoperable communications with DPS. Current communications between the port and DPS is via telephone (port staff calls DPS OpCom). Direct communications between the port and DPS would be used to rapidly report trucks that unlawfully bypass the port. This scenario may also be an issue on I-40 but was not identified as a concern during the I-40 focus group. This interoperability can be readily achieved by programming the MVD Southern Regional frequency into the ADOT VHF radios installed in the DPS vehicles.

2.4.3 Low Priority Interoperability Needs

Needs in this category involve infrequent needs or needs where other alternatives such as face-to-face communications are practical or preferred methods of making contact. Some examples of these types of needs would be infrequent joint holiday and special event operations and special enforcement details or task forces where traffic diversion is required. Activation of DMS messages could also be enhanced by radio interoperability.

2.5 POTENTIAL INTEROPERABILITY BENEFITS

Potential benefits that were anticipated from an effective interoperable radio system would include improved response times, shorter incident duration, and fewer mistranslated or garbled messages. Direct communication might also allow ADOT to provide a more effective initial response by knowing what heavy equipment and resources to bring to the scene. A more direct line of communication may result in more frequent calls and a better level of service. The tools might also offer a safety benefit by allowing DPS to warn workers of imminent hazards such as an approaching pursuit.

2.6 POTENTIAL INTEROPERABILITY CHALLENGES

Project focus group participants identified some potential challenges to enhanced radio interoperability. These challenges generally fall into the categories of differences in agency culture, technical challenges, procedural issues, and issues related to information overload. Users reported that the emphasis should be less on technology and more on policy and procedure.

2.6.1 Agency Culture

Both agencies generally have very limited resources in the I-10 and I-40 corridors and would value more ready access to resources offered by the other agency in times of need. DPS officers are very radio-centric and always carry a portable UHF radio while on duty. ADOT is less radio-centric and the radio may not be heard when a highway maintenance worker or supervisor is outside the truck. Most the ADOT trucks have external speakers to mitigate this shortcoming to some extent.

ADOT and DPS each have their own different protocols and unit identification methods. DPS sometimes may use proper names on the car-to-car channels. Difficulty with current interagency radio communication may be driven by lack of common terminology and identifiers.

A brief summary of potential concerns expressed in the focus groups is provided below:

2.6.2 Technical Challenges

The following technical challenges were identified:

- Dead spots would pose a problem.
- Differences in how the radio systems work would cause confusion.
- ADOT radios require users to select repeaters based on geographic area.
- DPS radios have common channel voting, so repeater operation is transparent to the users.

2.6.3 Procedural Challenges

The following procedural challenges were identified:

- District boundaries would pose a problem.
- Interoperable radio usage might contribute to additional workload.
- Establishing strong guidelines to avoid confusion caused by too much independent judgment in the field would be required.
- Planned and unplanned events may require different interoperability solutions.
- Switching from a primary channel might be an officer safety concern.
- Using an interoperable channel might not be worth the effort to communicate just a few messages for an incident.
- Some officers believe that it is more important to stay on your dispatcher's frequency than the ADOT frequency to convey four or five messages over the duration of a long accident.
- ADOT has many crews on the radio that have nothing to do with highway maintenance, but who use the same radio channels.
- DPS dispatchers need to be in charge of the channel to manage one-to-many communications.

2.6.4 Information Overload Concerns

The following concerns regarding information overload were identified:

- An interoperable radio system might provide more information than one can listen to at a single time.
- Officers may be out of the car and unable to hear the radio and putting separate speakers for the two radios outside the car would result in information overload.
- People often "talk over" each other on a radio channel.

2.7 CELLULAR TELEPHONES AS AN INTEROPERABILITY TOOL

Although ad-hoc usage of cellular telephones as an interoperability tool was discussed, cellular telephones are not seen as a substitute for the public safety radio network. Most cellular telephones do not offer the one-to-many communications offered by the public safety radio networks. Cell phones could be used for one-on-one communications between specific ADOT and DPS staff members who find that the cell phones are the best way to coordinate their activities.

2.8 TRAINING NEEDS

The project included development of training materials for initial interoperability training. Upon completion of the project, ADOT and DPS representatives would need to

take ownership of the training to keep the procedures current and offer it regularly in both refresher format and for new staff. ADOT currently has mandatory training and radio interoperability that could be added to this program. It was also noted that the most effective training scenarios would involve joint participation by ADOT and DPS staff at the same time. Assembling members of the focus groups might be an effective method to train the trainers, who would then pass the information to their staff members. Monthly testing of interoperability features should be considered and integrated with the quarterly training. A short classroom session, followed by hands-on training, would be useful to demonstrate the features and usage of the interoperable radio system. One of the quarterly training sessions should be coordinated with the "Snow Meeting" training that focuses on winter operations.

2.8.1 Training Subject Matter

The training subject matter needed to address whom to call, how to request a patch from the dispatcher, which frequencies to use, when to request service from the other agency, and how to include sufficient definitions of common terminology and call signs to make the communications brief, clear and effective. It was anticipated that a structured training plan with one to two hours of training could achieve these goals. Special joint training in Phoenix with DPS OpCom and the TOC dispatchers was to be conducted on the use of the CAD system, the ringdown lines, and the set-up of the crosspatches.

Computer Aided Dispatch (CAD) is a critical part of the DPS OpCom dispatch system, which inventories and directs all calls for service (75% to 80% of all DPS radio communications are between officer and dispatcher). CAD also allows for the dispatcher to insert remarks in an incident file. This allows for details of a requested crosspatch to be notated. The ADOT TOC has access to view the DPS CAD data files, but cannot enter data into them. CAD is less critical to the TOC since their role is not typically to "dispatch," but to respond to requests for service from ADOT field personnel. Only about 10% to 20% of ADOT radio communications are from a TOC radio console operator to a field worker. As a result, any ADOT-requested crosspatch incidents had to be entered manually on report form sheets.

2.8.2 Training Challenges

Some challenges were expected to be encountered during the development of the training program and the presentation of the training program. These challenges were identified so that they could be considered and mitigated to the extent possible during the development of the training program:

- Differences in the "10 codes" used by ADOT and DPS will need to be considered in the training.
- DPS uses additional codes, which may need to be considered in the training.
- ADOT dispatches primarily in plain language.

- DPS primarily dispatches using codes, but can switch to plain language when needed.
- Differences in call sign assignments need to be explained. (See Appendix B.)
- Hours of availability for various different ADOT dispatchers will need to be considered along with whom to contact when ADOT District Offices do not have a dispatcher on duty.

2.9 RECOMMENDATIONS

The following key recommendations were made in the Pilot Project Design Phase, based upon a review of the foregoing user needs and the research project's resources:

1. Proceed with the Pilot Projects 4 and 5 as described in the SPR 561 study:

    a. Procure as many ADOT-configured VHF radios for car-to-car communications as funding allows, for deployment in selected DPS patrol squads.
    b. Reserve sufficient funds to create two console crosspatch circuits between the Flagstaff and Tucson OpCom centers, and the ADOT TOC.
    c. Add the ADOT MVD frequencies to the VHF radios in the DPS vehicles in the I-10 corridor.

2. Implement a training program for use the interoperable radio systems.

3. Conduct a 7 to 9 month evaluation program to determine the comparative value of the interoperable systems, including part of a snow season.

Chapter 6 of this report describes in detail the actual implementation efforts and the research findings for Pilot Project 4 and Pilot Project 5. A training program for use of interoperable radio systems was successfully implemented as a part of the project.

No testing of the interoperability during snowy conditions was conducted, as there was no significant regional snowfall during the project's 7-month, May to November, evaluation period.

3. DEPLOYMENT PLAN

3.1 OBJECTIVES

The objectives of the technical analysis were to develop a deployment plan as follows:

- Identify and prioritize DPS locations, units, and squads to receive ADOT-compatible VHF radios for Pilot Project 4.
- Provide Equipment and Installation Specifications for the required radio and antenna equipment for Pilot Project 4.
- Develop Equipment Installation Procedures.
- Provide a System Design and Interconnection Diagram for Pilot Project 5.
- Provide Equipment Specifications for Pilot Project 5.
- Identify a procurement mechanism for the deployment.
- Provide an Engineer's Opinion of Cost for the proposed deployment.
- Identify a Maintenance Plan for the proposed equipment.

3.2 STUDY METHODOLOGY

Information on user needs was acquired through radio interoperability workshops and group interview sessions held in Flagstaff and Tucson, and by Phoenix-Flagstaff-Tucson videoconferences during August and September 2005. ADOT participants in these regional workshops included ADOT Maintenance and Construction staff. DPS personnel included the Northern Regional Commander, Lieutenants, Sergeants, OpCom staff and DPS radio experts. Additional information was obtained through telephone interviews and literature review.

In the northern study area, DPS Squads 1, 4, and 5 patrol the US and state highways in the Flagstaff area. Squad 2 is focused on the region between Williams and the Grand Canyon. All of these areas are in the ADOT Flagstaff Maintenance District.

The southern regional study area includes DPS District 9, which patrols along I-10 from Benson to the New Mexico border, and other highways around Sierra Vista and Bisbee. These routes are in the ADOT Safford Maintenance District.

3.3 PILOT PROJECT 4 DEPLOYMENT RECOMMENDATIONS

3.3.1 Introduction

The recommendations presented below represented an expansion of the existing de facto interoperability strategy, by which some DPS Highway Patrol sergeants in northern Arizona have had older surplus ADOT radios in their patrol cars for many years. In addition, DPS has funded informal deployments of ADOT radios in DPS vehicles in

some of the more remote parts of the state such as the I-15 corridor, and the Page region. The key aspect of this pilot project was to deploy ADOT-compatible VHF radios into all patrol officer vehicles in each squad.

3.3.2 Base Case Recommendation

The base case involved the deployment of 42 mobile VHF radios into DPS vehicles, using ADOT Homeland Security funding that had been specifically allocated for radio interoperability. The expanded case recommendation was based on later deployment of approximately 23 additional research-funded radios, for a total of approximately 65 new ADOT-type VHF radios. The initial recommendation was to maintain an inventory of two spare radios in each of the Flagstaff and Tucson DPS radio shops.

Table 1: ADOT VHF Radio Deployment Recommendations

Location	DPS District	Squad	No. of Radios
Flagstaff	2	1	9
Flagstaff	2	4	9
Flagstaff	2	5	8
Benson	9	2	6
Willcox	9	3	6
Spare	*NA*	*NA*	*4*
Initial Pilot Deployment Recommendation			42

3.3.3 Expanded Case Recommendation

During the first half of the data collection phase of the research, the console crosspatch option would be the primary interoperability tool for the squads listed below, to serve as the control group for comparison with the car-to-car interoperability group. As an incentive for participating in the control group, research-funded radios were offered to control group participants halfway through the data collection phase to allow direct before and after comparisons.

Table 2: ADOT VHF Radio Deployment Expansion Recommendations

Location	DPS District	Squad	No. of Radios
Williams	2	2	9
Sierra Vista	9	1	6
Bisbee	9	4	6
Spare	*NA*	*NA*	*2*
Expanded Case Recommendation (21 + 2)			23

3.3.4 Radio Hardware Recommendation

Two radios were identified that were suitable for this application: the M/A-Com 7100, and the Kenwood TK790 (See Figure 1). The Kenwood TK790 radio was recommended for this radio interoperability study, because it provides the required features at the lowest cost. Table 3 provides specification and pricing information regarding the preferred Kenwood TK790 radio based on the old and new procurement contracts.

Figure 1 – Kenwood TK790 Radio Hardware

3.3.5 Radio Installation Recommendations

The following recommendations were made for radio installation:

- For all VHF radio deployments, the recommended installation method would be a retrofit installation into existing DPS patrol vehicles by the DPS radio shop. The 38 installations (plus spares) for the test group were to be complete by May 2006, to allow the next phase of the research to proceed on schedule.
- The DPS radio shop would install the 21 expanded-case group radios after several months of car-to-car interoperability evaluation.

3.3.6 Maintenance Recommendation

The following recommendation was made for ongoing maintenance of test units:

- The deployed project equipment should be maintained by the DPS radio shops.

3.3.7 Engineer's Opinion of Probable Cost

The original estimated total cost of the recommended VHF radio deployment program was just over $82,000. These were to be purchased in two phases, overlapping two

separate State radio contract time periods. Radios purchased for the first phase[6] and the second phase[7] are represented in Table 3.

Table 3: Engineer's Opinion of Probable Cost for Hardware Recommendations

Description	Quantity	Unit Price	Extension
Kenwood Radio (Kelley)	42	$1,213.83	$50,980.86
Antenna & Mount	42	$29.27	$1,229.34
Kenwood Radio (B & B)	23	$1,277.21	$29,375.83
Antenna & Mount	23	$29.27	$673.21
			$82,259.24

The first 42 radio units were purchased with ADOT Homeland Security funding, as noted previously. ADOT research funds were then used to procure the 23 additional radios needed for the expanded deployment case. This initial estimate was very accurate and was within $200 of the actual cost of the two phases of VHF radio deployment.

3.4 PILOT PROJECT 5 DEPLOYMENT RECOMMENDATIONS

3.4.1 Introduction

Pilot Project 5 involves linking the ADOT-Phoenix TOC Motorola Gold-Elite dispatch console system to the DPS-Phoenix Orbacom TDM150 dispatch consoles.

Two generic dark-channel links allow any ADOT VHF channel or 800 MHz talk-group to be crosspatched to any channel appearing on the DPS dispatch consoles. These include the DPS statewide UHF radio network, or, some of the statewide VHF/UHF/800 Arizona Interoperable Radio System (AIRS) channels. This approach is highly flexible in utility, but link setup requires careful coordination, which may limit application of this strategy to pre-planned events or incidents with significant duration.

The expected benefit of implementing these links was to enable direct communications between any ADOT field radio and any DPS field radio statewide.

The largest challenge associated with implementing this type of interoperability is coordinating the actions of two separate dispatchers, because this form of interoperability requires direct dispatch operator intervention at two separate dispatch center locations.

3.4.2 Deployment Location Recommendations

The following sequential recommendations were made for deployment location:

1. Hardware installation was required in the ADOT Traffic Operations Center at 2302 West Durango Street, and the DPS Phoenix OpCom Center at 2102 West Encanto Boulevard.

2. Ringdown telephone installations were to be implemented at the DPS OpCom Centers in Tucson and Flagstaff. A three-line telephone was to be installed in the Phoenix TOC to provide ADOT with direct ringdown line communications with the two DPS OpCom Centers (see Figure 2).

3. Ringdown line communications to the DPS Flagstaff and Tucson OpCom Center was to be provided on the existing DPS microwave network without purchase of additional analog microwave hardware.

4. The proposed console link was to utilize SONET multiplexer equipment installed as part of a separate project, and DS-3 multiplexer equipment that is being ordered by DPS as part of the ADOT / DPS computer-aided dispatching project.

5. Installation of the proposed console links over existing fiber was to enable statewide ADOT – DPS crosspatch interoperability between:
   - DPS Flagstaff OpCom and the ADOT TOC.
   - DPS Tucson OpCom and the ADOT TOC.

6. The console crosspatches would use an existing fiber optic link between the TOC and the Phoenix DPS OpCom facilities.

7. A probable opinion of cost for adding the third channel to the console link is approximately $3,500. This expenditure is not necessary for the SPR 569 research, which focuses on the northern and southern portions of the state.

8. Console crosspatch interoperability would be tested in the Williams, Sierra Vista and Bisbee areas. During the data collection phase it will be important not to have car-to-car interoperability in these areas to allow comparison between the console crosspatch and car-to-car approaches.

9. Due to the flexibility of the console crosspatch approach, additional testing with other interested DPS squads and ADOT Maintenance Districts was encouraged.

Figure 2 – ADOT TOC Workstation and DPS Dispatch Console

3.4.3 Hardware Recommendations

A block diagram of the approach is shown in Figure 3. This block diagram shows interconnection of the two existing consoles using standard telephone equipment and provides for a telephone ringdown hotline between the two consoles to coordinate the establishment of crosspatches.

The design relies on the availability of existing dark fiber between the ADOT TOC and the DPS Encanto Campus. Because this is a short-term research project, no special provisions have been made for redundancy or path diversity.

3.4.4 Equipment Specifications

Console interconnection was achieved with a commercially available T-1 Channel Bank known as the Harris Intraplex ACS 166 Access Server.

3.4.5 Installation Procedures

The equipment was designed to be bolted into existing racks at both facilities. This work was done by the DPS radio technicians. DPS microwave technicians also installed voice frequency channels for the remote ringdown lines for Tucson and Flagstaff.

Several problems were encountered in both the ringdown circuits and console channel installations, which were eventually overcome by DPS engineers and technicians.

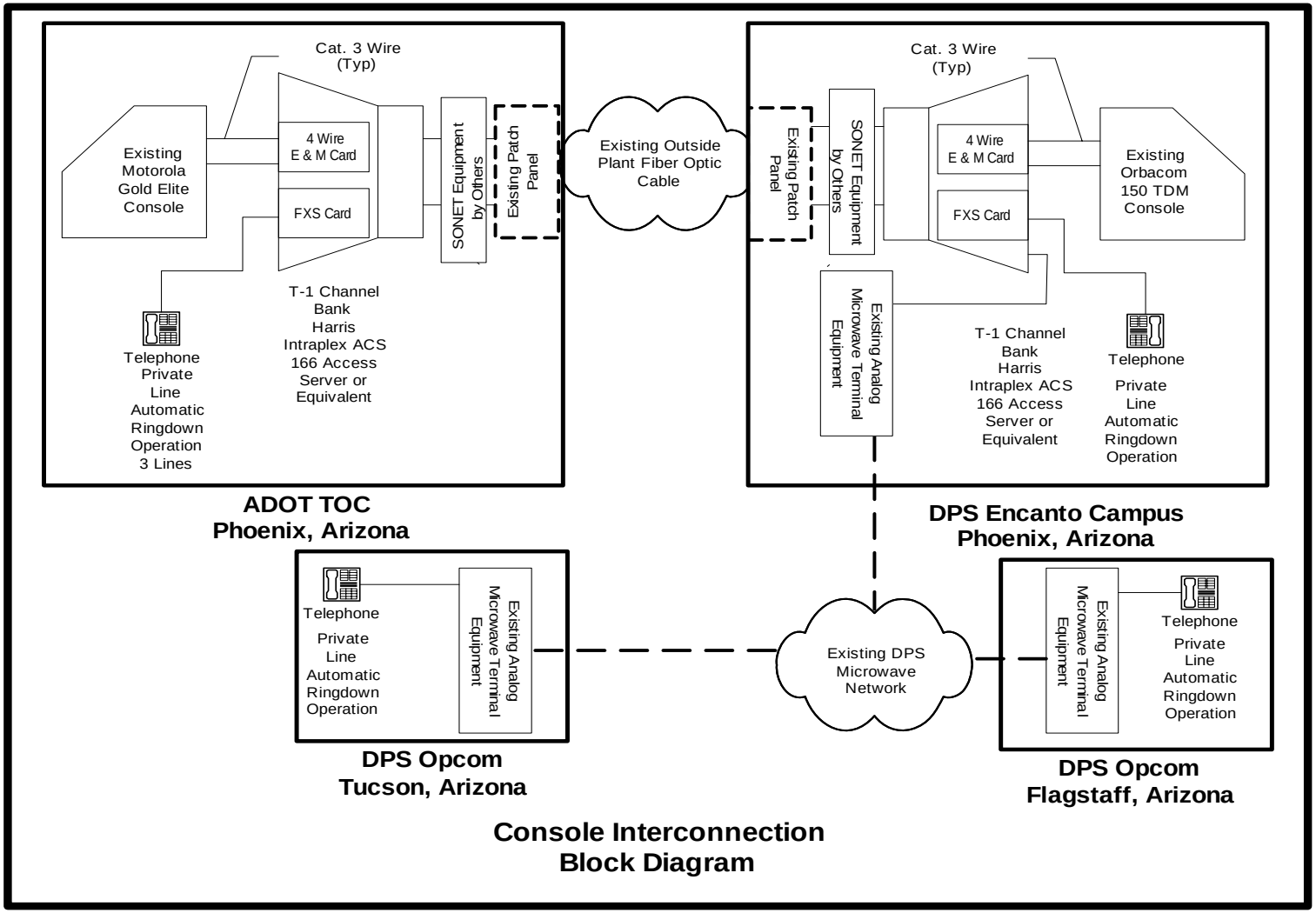


Figure 3 – Console Interconnection Block Diagram

3.4.6 State Contract Intraplex Equipment Costs

Current State of Arizona Term Contract pricing and design specification information for the purchase of the necessary interconnection equipment[7] is listed below:

Table 4: State Contract Intraplex Equipment Costs

Description	Qty	Unit	Unit Price	Extension
Line Item #5.08 Intraplex ACS166-48 channel bank w/-48VDC PS	1	Each	$6,228.00	$ 6,228.00
Line Item #5.09 Intraplex ACS166-24 channel bank w/-24VDC PS	1	Each	$6,228.00	$ 6,228.00
Line Item #5.11 Intraplex Common Equipment Modules	2	Each	$ 66.00	$ 132.00
Line Item #5.2 Intraplex VF25 +MA305 4W-E&M Modules	3	Each	$ 548.00	$ 1,644.00
Line Item #5.4 Intraplex VF16 + MA304 2W-FXS Modules	3	Each	$ 692.00	$ 2,076.00
Line Item #5.55 Intraplex PS5048 Power Supply (Spare)	1	Each	$ 665.00	$ 665.00
Line Item #5.56 Intraplex PS5024 Power Supply (Spare)	1	Each	$ 665.00	$ 665.00
Harris-Intraplex M13 Multiplexers (DPS Stock)	1	Lump	$ -	$ -
Granger DTL 7300 Analog Multiplexer Cards (DPS Stock)	1	Lump	$ -	$ -
3 Line Telephone	1	Each	$ 200.00	$ 200.00
Standard Telephone (3ea)	3	Each	$ 75.00	$ 225.00
			Sub-Total	$18,063.00
			8.1% Tax	$ 1,463.10
			TOTAL	**$19,526.10**

3.4.7 Maintenance Recommendations

The following recommendations were made for maintenance:

- A small quantity of spare parts and components was to be included in the project cost estimates. In the event the components are utilized to restore service outages, the stockpile should be replenished.
- The Harris equipment has been recommended specifically because DPS maintenance staff members are familiar with this equipment.

3.5 FINAL IMPLEMENATION COSTS

An inventory of the final implementation costs in the following Table 5 identifies the expenditures for the equipment installed for both Pilot 4 and Pilot 5 of this project.[6, 7]

Table 5: Radio Procurement Budget Elements

Description	Funds	Quantity	Unit Price w/ Tax	Extension
Mobile Radio Eqpt (Pilot 4)				
Kenwood Radio (Kelley) Phase 1	HS	42	$1,213.83	$50,980.86
Kenwood Radio (B & B) Phase 2	R	21	$1,277.21	$26,821.41
Kenwood Radio (B & B) Spares	R	2	$1,283.15	$2,566.30
Antenna & Mount with Tax	R	62	$33.55	$2,080.10
All Mobile VHF				$82,448.67
Console Radio Eqpt (Pilot 5)				
Research Funds: Pilot 5 consoles	R		Intraplex, w/ tax	$18,396.00
Total Project Radio System Costs				$100,844.67

Table 6: Deployment Installation

	Initial	Expanded	Total VHF Mobiles
Flagstaff Region	26	9	35
Safford Region	12	12	24
Total in Patrol Units (deploy plan)	38	21	59
Spares	4	2	6
Sum:	**42**	**23**	**65**

4. TRAINING PLAN

4.1 OBJECTIVES

The three key objectives of the training plan were:

- To define policies and procedures for use of the car-to-car and crosspatch interoperability tools.
- To define protocols for communicating using the interoperability tools.
- To recommend procedures for ongoing testing and training to enhance, exercise, and maintain the skills of ADOT and DPS personnel responsible for using each interoperability tool.

Training was necessary to standardize policies, procedures and protocols for use of the radio interoperability technology. The actual training presentation was made to the field and dispatch staff during Phase B, after the hardware was installed, so that the training was fresh in the minds of the users at the time that the hardware became available.

Training of DPS and ADOT-TOC dispatch operators, and DPS officers and ADOT field workers, was a required priority for the SPR569 project to be successful. Interoperability is more a matter of policy, procedure, and training, than it is of technical equipment. Training of DPS officers and ADOT highway workers was required for both Pilot Projects 4 and 5. DPS and ADOT dispatcher crosspatch training was required only for Pilot 5. The following groups were identified as candidates for training:

- Group 1 - DPS Officers in the evaluation squads.
- Group 2 - ADOT Field Workers (Construction & Maintenance) in the evaluation Orgs/Areas.
- Group 3 - ADOT TOC Operators and Supervisors.
- Group 4 - DPS Flagstaff/Tucson Dispatch Supervisors/Trainers.

4.1.1 Use of the Training Plan

The DPS requires that all employee training must be conducted by certified trainers. These are DPS individuals who have gone through a specific program on training and have been handpicked by their supervisors for their training skills, abilities and knowledge of standard DPS procedures and policies. Certified trainers are available in virtually every operational unit of DPS.

This research project's training plan document served as a guide to the DPS trainers and ADOT staff, who conducted the actual on-site training of local field personnel. These training outlines did not aim to provide all details of the information to be disseminated

during the training, but to provide a syllabus of topics along with some key details to be covered by the assigned trainer or supervisor.

Highway worker training varied slightly, depending upon their area and type of operations, and on which Pilot Project was active in their area (Pilot 4 or Pilot 5).

4.2 STAFF TO BE TRAINED

The training program for the Pilot Project 4, VHF car-to-car radio participants, was oriented towards DPS officers and ADOT field staff. The training described a set of radio protocols to be used by each agency when contacting the other via radio.

The crosspatch training program for the Pilot Project 5 participants was oriented towards DPS officers and ADOT field staff, and it required training of DPS OpCom dispatchers and ADOT TOC operators. Joint training of both the TOC and DPS dispatchers together in Phoenix was to be conducted, considering that Pilot 5 is more difficult to coordinate between dispatchers operating two dissimilar radio consoles at two separate locations.

4.2.1 Recommended Field Partner Training for Pilot Projects 4 and 5

The ADOT research consultant team was tasked to initially train a group of management personnel and agency field trainers. It was proposed that the training sessions for the field staff involved in both the car-to-car and crosspatch interoperability tests would be held in Flagstaff and Tucson, or Sierra Vista. Table 7 identifies the location of these "train- the-trainer" sessions, and the anticipated participants.

Table 7: Regional Train-the-Trainer Participants

Flagstaff	Tucson/Sierra Vista
DPS Flagstaff Area Sergeants (4) DPS Flagstaff OpCom Manager (1) ADOT Maintenance Engineers (1) ADOT Construction Engineer (1) ADOT Maintenance Superintendent (1) ADOT Flagstaff Maintenance Supervisors (Williams, Little Antelope, Gray Mountain, East Flagstaff) (4) ATRC Project Manager (1)	DPS Benson and Willcox Sergeants (2) DPS Certified Dispatch Trainers (2) DPS OpCom Manager (1) ADOT Maintenance Engineer (1) ADOT Construction Engineer (1) ADOT Maintenance Supervisors for St. David and Willcox (2) ATRC Project Manager (1)

It was also decided that a single training session for statewide dispatch staff involved in Pilot Project 5, Crosspatch Interoperability, would be held in Phoenix at the ADOT TOC, with a field visit to the DPS OpCom Center. Table 8 identifies the participants that were recommended to attend the dispatch console crosspatch training session.

Table 8: Phoenix Console Crosspatch Training Participants

Statewide Dispatch Console Training
DPS Dispatch Supervisors (Flagstaff) (4)
DPS Dispatch Supervisors (Tucson) (4)
DPS OpCom Trainers (2)
DPS OpCom Manager (1)
DPS Telecommunications Engineer (1)
ADOT TOC Shift Supervisors (4)
ADOT TTG Management Personnel (3)

4.2.2 Field Staff Training

The trainers who received training in these sessions would then be responsible for the training of maintenance workers and patrol officers in their respective districts or areas. In addition, senior staff that were unable to participate in the "train-the-trainer" sessions were invited to participate in the field training via live-recorded videotaped sessions, as well as new personnel who came in during the project evaluation phase.

4.2.3 Refresher Training

The agency trainers were strongly encouraged to offer the dispatcher training in Flagstaff and Tucson on a quarterly basis. It was recommended that all of the above training be repeated quarterly so that new employees could be familiarized with the process, and existing staff who may forget how the system works can get refreshed on the protocols.

New ADOT field workers and DPS officers in the pilot project areas should be trained by their Sergeants or Supervisors within 30 days of being assigned to the area.

4.2.4 Quarterly Evaluation Meetings

Quarterly field review meetings in Tucson and Flagstaff were held as part of the project's Evaluation Plan to discuss how the interoperability functions were working, identify data gaps, and discuss other issues related to the Pilot Projects. These meetings would serve as a useful tool for refreshing of supervisory level training, and interest and participation in the project.

4.2.5 System Testing

Ongoing testing of the system would be done at two levels:

1. Car-to-Car System Testing: DPS field officers with Kenwood VHF radios would attempt to make at least one weekly contact with a local ADOT field worker working in the same geographic region as the officer.
2. Crosspatch Testing: At a monthly agreed-to time, both the I-10 corridor and the I-40 corridor crosspatch interoperability should be tested.

4.3 TRAINING SYLLABUS, TRAINING PROTOCOLS AND PROCEDURES

The following subsections present the class material outlines as developed for the proposed training sessions for each of the user groups, including:

- Pilot Project 4 DPS Officer Training.
- Pilot Project 5 DPS Officer Training.
- Pilot Project 4 Highway Worker Training.
- Pilot Project 5 Highway Worker Training.
- DPS Dispatcher and TOC Operator Training.

Each training session for the field staff included a classroom component lasting approximately two hours, and a hands-on demonstration.

The dispatcher training was a half-day session, consisting of approximately two hours of classroom instruction, plus one hour of hands-on demonstration at the TOC and at the DPS Phoenix OpCom Center.

DPS officers, according to their Sergeants, could be trained at regular squad training meetings. Two classes of training were required.

4.3.1 Pilot Project 4 - Officer Training

For those with Kenwood VHF radios, the concepts of protocols, channels, and over-the-air use were essential to training. Since ADOT and DPS use different callsign designators, and slightly different 10 codes, the following protocols would be utilized when DPS is requesting assistance from ADOT road workers (Pilot 4 only):

1. Plain English should be used at all times, not 10-Codes or 900 codes.

2. The phonetic alphabet may be used when necessary as the phonetic alphabets used are identical.

3. The DPS officer should initiate a call to an ADOT employee by first stating the ADOT callsign of the person he or she wishes to communicate with, followed by his or her own callsign, preceded by "DPS."

4. Calls should be initiated on the local ADOT District simplex (car-to-car) channel first. If no answer is received because it is believed the ADOT unit is too far away to hear a car-to-car call, the DPS officer should switch to the local ADOT repeater channel and repeat the call (per Appendix A: ADOT Radio Map & Channel Plan).

5. If no answer is received after a second call on the repeater channel, the officer should wait a few minutes before trying again, as the highway worker may be out of his or her truck, and cannot hear the radio (ADOT doesn't use nearly as many portable radios as DPS).

6. Avoid use of proper names over-the-air if possible.

7. Sign off last transmission, or group of transmissions, with callsign, followed by the word "CLEAR."

8. Initial calls for snowplow coordination should be directed first to the ADOT Maintenance Supervisor on duty in the area. After agreeing on a plan of action, the DPS officer may contact the snowplow operator(s) directly.

4.3.2 Pilot Project 5 Officer Training

For those officers without Kenwood VHF radios who are attempting the use of a dispatch console crosspatch for communications (Pilot 5), the following rules of operation apply:

1. Plain English should be used at all times, not 10-Codes or 900 codes.

2. The phonetic alphabet may be used when necessary, as the phonetic alphabets used are identical.

3. The DPS officer should initiate a call to an ADOT highway employee by first switching to the UHF "State" channel on his or her radio, and then calling the dispatcher with his or her normal callsign.

4. When the dispatcher answers, the officer should request an "ADOT PATCH" to a "SITE NAME" and "CALLSIGN" of the local ADOT repeater station needed to contact the ADOT employee.

5. The DPS dispatcher will contact the TOC via the ringdown circuit, and request the TOC operator to set up the crosspatch on their console.

6. When the TOC operator confirms to the DPS dispatcher that the patch is set-up, and confirms this fact to the officer, the officer should initiate a call to the ADOT highway worker as stated below.

7. The DPS officer should initiate a call to an ADOT employee by first stating the ADOT callsign of the person he or she wishes to communicate with, followed by his or her own callsign, preceded by "DPS" (see Appendix A: ADOT Radio Map & Channel Plan).

8 If no answer is received after a second call on the repeater channel, the officer should wait a few minutes before trying again as the highway worker may be out of their truck, and cannot hear the radio. (ADOT doesn't use nearly as many portable radios as DPS.)

9. Avoid use of proper names over-the-air if possible.

10. Sign off last transmission, or group of transmissions, with callsign, followed by word "CLEAR."

11. Initial calls for snowplow coordination should be directed first to the ADOT Maintenance Supervisor on duty in the area. After agreeing on a plan of action, the DPS officer may contact the snowplow operator(s) directly.

12 After the last transmission, or when the incident or operation has ended, the DPS officer should then notify the dispatcher that the crosspatch now needs to be "DISABLED." The DPS officer should proceed back to his or her normal District frequency channel, and notify their dispatch that this has been done.

4.3.3 Pilot Project 4 Highway Worker Training

Highway workers need to be notified whether the DPS officers operating in their area have VHF radios in their patrol cars, or not. For those officers with VHF radios (Pilot 4), ADOT should initiate calls in a similar manner as the DPS to ADOT calls for Pilot 4.

4.3.4 Pilot Project 5 Highway Worker Training

In those areas where it is known that the DPS officer does NOT have a VHF test radio (Pilot 5), the procedure to be used by an ADOT highway worker attempting to contact a DPS officer is similar to that of a DPS officer contacting an ADOT worker in Pilot 5, except the ADOT field worker contacts the TOC operator first.

4.3.5 DPS Dispatcher & ADOT-TOC Operator Training (Pilot Project 5)

Training was especially critical for the dispatchers at the two DPS OpCom Centers in Tucson and Flagstaff, and at the ADOT Traffic Operations Center. The DPS State Communications Manager had suggested that all supervisors from Tucson and Flagstaff could be brought to Phoenix for a half-day training meeting, if planned well in advance. DPS could also bring in at least two trainers for the beginning session.

ADOT indicated some flexibility in bringing in people for training outside of their shifts. It was strongly recommended that these people be brought together with their DPS counterparts for this interoperability training. This training would be enacted just prior to official "turn-on" of the pilot projects, so as to minimize any potential loss of knowledge through non-use.

It was assumed that the DPS supervisors and trainers and the TOC operators were quite familiar with use of their respective dispatch console functions. Though the dispatchers have no active role in the Pilot 4 evaluation, since those local communications are carried out directly between DPS and ADOT field personnel, their dispatch function is essential for Pilot 5 to effect crosspatching between stations on the ADOT VHF radio system, and the DPS UHF radio system.

4.3.6 DPS-Initiated Crosspatch

Based on the factors discussed above, the following protocol was established for DPS-initiated crosspatches. If a DPS officer had switched over to the UHF "STATE" channel and contacted the OpCom dispatcher requesting an ADOT crosspatch, then the following events should occur:

1. The officer should state which ADOT site/channel he or she wishes to have patched. The DPS OpCom dispatcher will press the "DARK CHANNEL" crosspatch button, and link it to the channel the officer has called on, and then contact the TOC either via the ringdown circuit or a direct dial-up number to relay the requested patch information.

2. The TOC operator presses the patch "DARK CHANNEL" button, and links it to the requested ADOT VHF radio channel (there is no need to link to any of the 800 MHz "talk groups" in this project).

3. The TOC operator will then notify the DPS dispatcher, via the same telephone circuit, that the requested radio crosspatch has been affected.

4. The DPS dispatcher will then notify the requesting officer that the patch is active.

5. The DPS officer will then initiate a call to an ADOT highway worker by first stating the highway worker callsign, followed by "DPS" and his or her callsign.

6. If no answer is received after a second call on the repeater channel, the officer should wait a few minutes before trying again, as the highway worker may be out of his or her truck and cannot hear the radio (ADOT doesn't use nearly as many portable radios as DPS).

7. Avoid use of proper names over-the-air if possible.

8. Sign off last transmission, or group of transmissions, with callsign, followed by word "CLEAR."

9. Initial calls for snowplow coordination should be directed first to the ADOT Maintenance Supervisor on duty in the area. After agreeing on a plan of action, the DPS officer may contact the snowplow operator(s) directly.

10. After completion of the communications or calls, or when incident is over, the DPS officer will again contact the dispatcher and request that the crosspatch be disabled. The same procedure as before is then initiated. The DPS dispatcher contacts the TOC via the ringdown line, disconnects at his or her own console first, and notifies the TOC that they may also disconnect at their end.

11. The DPS officer returns to the normal District channel and notifies the dispatcher that he or she has done so.

4.3.7 ADOT-Initiated Crosspatch

The same process, but in reverse, was agreed on for an ADOT-requested crosspatch, except that the highway worker is to call the TOC console operator first. Likewise, the ADOT field worker is to request that the TOC operator break down the patch when the communication is completed.

5. EVALUATION PLAN

5.1 PROJECT STAKEHOLDERS

The first step in the development of the interoperability project evaluation plan was to identify the interested stakeholders and partners. Table 9 identifies the key stakeholders who would participate in this evaluation process.

Table 9: Identified Project Stakeholders

Arizona Department of Public Safety	Arizona Department of Transportation
Officers participating in Pilot Project 4	Maintenance Workers who contact DPS via Radio
Officers participating in Pilot Project 5	Maintenance Workers who are contacted by DPS via Radio
Flagstaff OpCom Dispatchers	Flagstaff Area Maintenance Superintendents
Tucson OpCom Dispatchers	Flagstaff Area Maintenance Engineer
OpCom Supervisors	Willcox and Bowie Area Maintenance Superintendents
Flagstaff, Bowie, and Willcox Area Sergeants	Safford Area Maintenance Engineer
Telecommunications Engineers	TOC Operators
Northern and Southern Area Commanders	TOC Shift Supervisors
	Transportation Technology Group Managers
	The ATRC Project Manager
	The Evaluation Consultant

5.2 INTEROPERABILITY GOALS

Seven key radio interoperability goal areas, as identified in Table 10 below, were based upon input from the project stakeholders:

Table 10: Radio Interoperability Goals

Goals
1. Improve Response Times
2. Reduce Latency of Message Relay
3. Reduce Confusion
4. Provide an Easy to Use Interoperability Tool
5. Enhance DPS Support of ADOT Snow Removal Operations
6. Improve Coordination of DPS & ADOT Operations at Incident Scenes
7. Enhance DPS Support of ADOT Construction & Maintenance Operations

5.3 HYPOTHESES

The research plan established a series of hypotheses for which data would be collected, in an attempt to validate or disprove each of these hypotheses:

1. This radio interoperability tool reduces initial response time.

2. Radio interoperability tool users perceive that response is reduced.

3. This radio interoperability tool reduces message latency.

4. This radio interoperability tool will allow users from one agency to readily make contacts with users from the other agency.

5. This radio interoperability tool will reduce confusion in the field and for the dispatchers.

6. This radio interoperability tool is easy to use.

7. This radio interoperability tool enhances joint response to incidents.

8. This radio interoperability tool enhances snow plow operations.

9. This radio interoperability tool enhances roadway construction and maintenance activities.

10. Interoperability tool A is better than use of the current modes of interagency communications.

11. Interoperability tool B is better than use of the current modes of interagency communications.

12. Interoperability tool A is better than interoperability tool B.

13. Interoperability tool B is better than interoperability tool A.

5.4 MEASURES OF EFFECTIVENESS

Table 11 maps potential measures of effectiveness to each of the seven key project goals. When possible, quantitative measures of effectiveness have been identified.

Table 11: Project Goals and Measures of Effectiveness

Goal 1 Improve Response Times	Goal 2 Reduce Latency of Message Relay	Goal 3 Reduce Confusion	Goal 4 Provide an Easy to Use Interoperability Tool	Goal 5 Enhance DPS Support of ADOT Snow Removal	Goal 6 Enhance Joint DPS & ADOT Operations in Response to Incidents	Goal 7 Enhance DPS Support of ADOT Construction / Maintenance Operations
Average Initial ADOT Response Time	Average Time to Relay A Message	User Perception of Confusion	User Ratings of Ease of Use	Snowplow Operator Perceptions	% Of Incidents With 1 - 2 Hour Duration With An ADOT Response	Number of Field Meetings
Average Initial DPS Response Time	Average Time to Make Initial Contact	% Of Time That Initial Information Provided Proper Resources	Frequency of Use	Officer and DPS Sergeant Perception: Snowplow Operations	Perception Of Time Saved During an Incident With Interoperable Communication	Anecdotal Reports From DPS Officers and ADOT Staff In Work Zones
User Perceptions of Response Time	User Perception of Message Latency	Dispatcher & Operator Perception of Confusion			Average Time To Clear Roadway After a Heavy Vehicle Incident	
% Of Attempted Contacts That Result In Actual Contacts						

5.5 DATA COLLECTION PERIOD

A full one-year data collection period would have been desirable, but it was not feasible. Ideally, the project's evaluation period would have included at least one full snow season. However, based upon the late start of the project due to equipment procurement and installation, the evaluation program ran for seven months, from May through November. The data collection period began with a training meeting for each group.

Field staff training meetings were used to explain:

- The purpose of the research.
- How to use the interoperable radio tools.

- How to complete the survey forms (See Appendices D and E).
- When and where to turn in the survey forms.
- Schedules for subsequent evaluation focus groups.

The interoperable radio hardware was not to be activated until the training meeting had taken place. However, some officers did receive their radios prior to completing their training. In several cases, initial communications were not very effective as a result, but several other cases were noted in which they were effective prior to the training.

5.5.1 Paired Comparisons

The proposed structure of the research involved paired comparisons between various different interoperability treatments:

- Car-to-car interoperability compared with no interoperability.
- Crosspatch interoperability compared with no interoperability.
- Car-to-car interoperability compared to crosspatch interoperability.

5.5.2 Sampling Plan

Table 12 identifies the type of radio interoperability each participating squad received at different times throughout the lifecycle of the research.

Table 12: Participating Squads Radio Interoperability

Squad(s)	Number of Members	Stage 1 Before Experiment	Stage 2 Month 1 through 4 Interoperability Strategy	Stage 3 Month 5 through 7 Interoperability Strategy
Northern Region				
Williams	9	None	Crosspatch Only	Car-to-Car*
Flagstaff	26	None	Car-to-Car*	Car-to-Car*
Southern Region				
Benson	6	None	Car-to-Car*	Car-to-Car*
Willcox	6	None	Car-to-Car*	Car-to-Car*
Bisbee	6	None	Crosspatch Only	Car-to-Car*
Sierra Vista	6	None	Crosspatch Only	Car-to-Car*

* Crosspatch interoperability was also available to Car-to-Car interoperability users at all times.

5.6 DATA COLLECTION METHODS

Three data collection methods were used for this research:

1. **Structured Interviews:** Structured group interviews were expected to be a useful tool for comparing Stage 1 and Stage 2, and for gathering anecdotal information on user experiences with the interoperable radio systems. It was anticipated that field user interviews would be scheduled quarterly in each of the study areas. Participants would include DPS Sergeants and patrol squad members, ADOT maintenance managers and supervisors, and DPS Dispatchers and OpCom supervisors. This data collection method was expected to yield qualitative results.

2. **Dispatcher Logs**: Both TOC Operators and DPS dispatchers were asked to fill out a log sheet anytime crosspatch interoperability is invoked. A sample form for the log sheet is provided. This form should was also to be filled out during regular tests of the crosspatch interoperability.

3. **Interoperability Field Reports**: ADOT and DPS Stage 2 and 3 field staff were asked to fill out a short field report form each time they made use of the interoperable radio features. The form was to be filled out shortly after the interoperable radio feature was used, so that valuable research data was not lost from short-term memory. Interoperability field reports were to be turned in to supervisors on a weekly basis. Each supervisor would briefly review the forms for completeness. Supervisors would be provided with pre-addressed and stamped envelopes to return the forms to the research team. Forms would be mailed to the research team monthly or brought to an upcoming interview session should a session be scheduled within the next month. The interoperability field report was the primary tool used to examine the operation of the car-to-car interoperability features.

5.7 DISPATCHER LOG AND INTEROPERABILITY FIELD REPORT

Dispatch logs could be maintained either by using the form shown in Appendix D or the equivalent in the CAD system. The interoperability field report is shown in Appendix E.

5.8 DATA QUALITY ASSURANCE

On-site review was recommended, ideally by the DPS Administrative Sergeant and by a member of ADOT's administrative staff as designated by the Maintenance Engineer. The research team also discussed completed and incomplete survey results at each group interview session in an effort to learn more details about incidents. In addition, efforts were made to compare reports from multiple staff members involved in an incident.

5.9 DATA ANALYSIS & REDUCTION

The research team was tasked to analyze the data and prepare summaries of the data; the results were to be compiled into this detailed research report. The following evaluation factors, relative to the goals shown in Table 10, would be considered for each mode of interoperability in preparing the research report:

- Response time.
- Message latency.
- Number of field meetings required.
- Level of confusion.
- Frequency of interoperability technology use.
- User perception of interoperability tools.

Comparing and contrasting car-to-car interoperability and crosspatch interoperability was also expected to provide data and guidance to ADOT, DPS and the PSCC in determining which approach would be best to implement further; perhaps on a statewide basis.

Chapter 6 describes many of the more significant field interoperability events during the seven-month field evaluation period, based upon both DPS and ADOT user feedback. It also summarizes the quantifiable data, and it discusses subjective results and perceptions in regard to the goals of the study.

6. FIELD EVALUATION

6.1 INTRODUCTION

This section describes the Field Evaluation Program as conducted from May 1 through late November, 2006. The Evaluation phase of the project actually began from the time that DPS officers received their VHF mobile radios: some in March, and some in April. Though they had not yet been through the formal training, use of the radios was an important tool for the March and April dust storms in southern Arizona.

Training classes for the field use of interoperable radios were held on March 21for Tucson and on March 30 for Flagstaff. The dispatch interoperability training class was held on April 20. The console crosspatch mode (Pilot 5) was not available in either the northern or southern regions until May 1, 2006, which therefore was the official start date of the evaluation phase of the project. Unfortunately the evaluation was not conducted through a complete snow season, when major field activity is normally anticipated in the northern region. There were no major snowstorms to hit the I-40 or I-17 corridors by the completion of the evaluation period.

The evaluation data came from three sources. First, and most important, were the "Interoperability Field Report" sheets returned by DPS officers and ADOT field workers. A total of 37 incidents were thoroughly documented via this method. The second source, the console operator/dispatch log sheets (2 incidents documented), and the third source, the quarterly meetings held in Tucson and Flagstaff, provided valuable feedback on the progress of the project. These latter sources provided for discussion of incidents previously reported in the Interoperability Field Report sheets, and other minor incidents that did not seem to warrant a more complete field report.

The data has been reviewed both microscopically (case study analysis - see Section 6.2) and macroscopically (overall analysis - see tables and charts in Section 6.3). From this review, there are certain conclusions that readily became obvious, and others that are more tenuous. In addition, there was one major unanticipated clear benefit of the interoperable VHF radios that was a surprise to all parties, except DPS – it allowed for improved radio communication among local, county, and state law enforcement agencies.

6.2 REPORTED INCIDENTS

A number of incidents were reviewed microscopically to glean as much data as possible from them because of their complexity or importance. These major incidents usually involved a number of vehicles, larger vehicles, or a serious situation threatening life and/or property. These incidents were a kind of "bellwether" that led to certain logical conclusions, particularly after discussion in the quarterly regional meetings. Many other documented incidents were meaningful, but not to the extent of the major incidents where life and property were immediately at risk. The minor incidents were reviewed less comprehensively, and their context taken more as a whole, macroscopically.

6.2.1 Major Incidents

Several major incidents were found to be representative of the various scenarios anticipated, particularly major ones involving imminent life and safety issues. There was one additional incident that proved the value of interoperability for public service events with multiple agency involvement, which was the best example of use of console crosspatching. (Note: this event, the MS150 bike race, was outside the study area, but officers assigned there used the crosspatch tool to assist long-term interoperability.)

Eight incidents were then reviewed in depth with the parties involved in the incident at the review meetings. These are discussed below for their individual merits and aspects:

1. Propane Tanker Rollover & Recovery on SR 80
2. Monsoon Flooding Road Closure on I-10
3. MS150 Colorado River Bike Race in Western Arizona
4. UPS Truck vs. County Road Grader Accident on I-10
5. Gasoline Tanker Rollover on SR 90
6. Forest Fire on I-40 near Winona
7. Flooding on SR 186 near Willcox
8. Collision Due to Dust Storm on I-10

1. Propane Tank Rollover & Recovery on SR 80

Figure 4 – Propane Tanker Rollover Incident

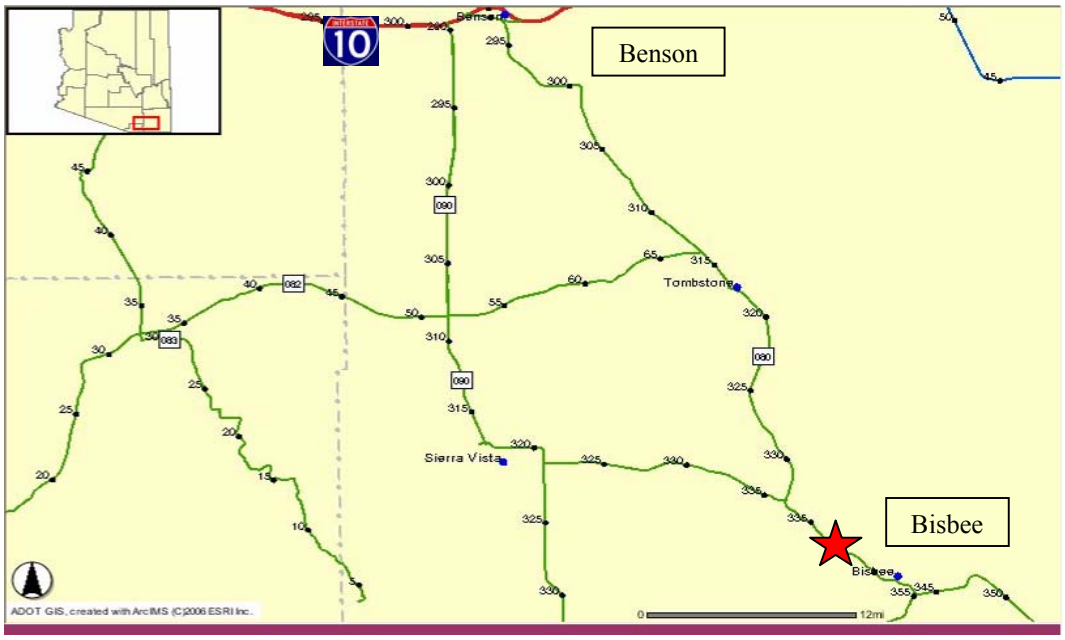


Figure 5 – Incident Location for Propane Tanker Rollover

Incident Interoperability Statistics:

- Date: March 8, 2006
- Location: SR 80, MP 337 (Bisbee)
- Duration: 14 Days (Burn-Off, Clean-Up and Recovery)
- Interoperability Type: Car-to-Car
- Initial Attempt to Contact: Successful
- Time to Make Contact: 2 Minutes
- Level of Confusion: 2 (Low)
- Ease of Use: 2 (Easy)
- Extent of Distraction: 1 (None)
- Incident Details: DPS Callsign 945 was dispatched to respond to a rollover incident. A tanker truck carrying 9,300 gallons of propane struck and penetrated a guardrail, overturning into a steep mountain canyon. He immediately contacted his ADOT counterparts in the area and completed communications for advance preparation of the incident. ADOT and DPS arrived on-scene within 30 minutes. DPS 945 stated that ALL agencies interacted very well, including response efforts by Cochise County Sheriffs Office and the Bisbee Police Department. Additional DPS resources called to the incident scene included Air Rescue and Hazardous Materials units. Burn-off operations began once the incident site was secure. The roadway reopened 3 days later on March 10, but recovery efforts continued until March 22, hampered by cold weather and high winds. Local police evacuated area residents citing a danger of explosion. DPS HazMat personnel estimated that a fireball explosion 20-acres in area would have resulted had the tanker exploded.

2. Monsoon Flooding Road Closure on I-10

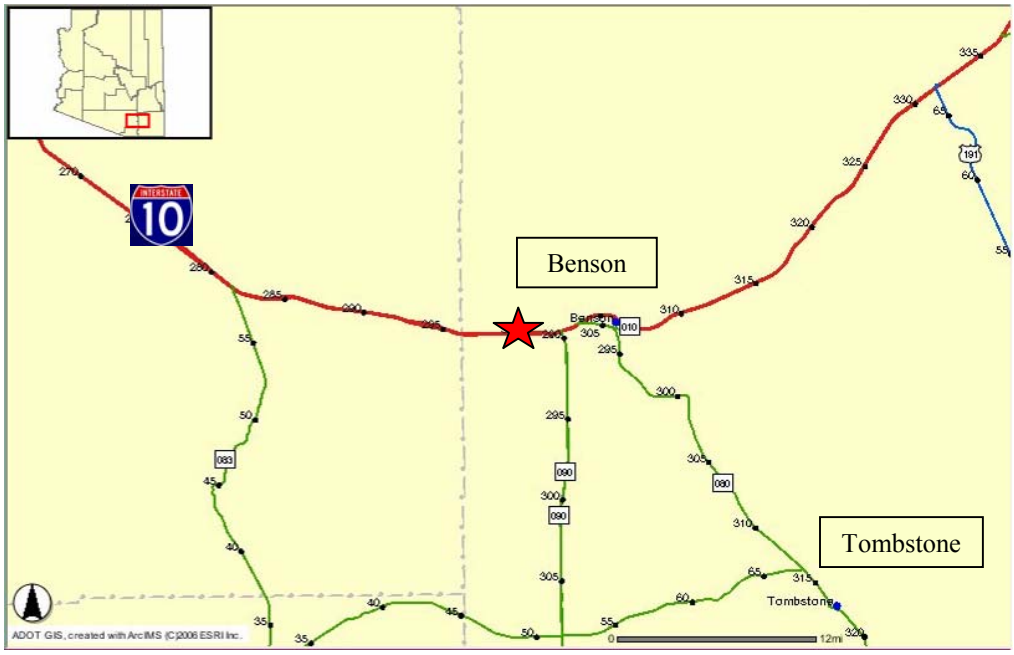


Figure 6 – Incident Location for I-10 Monsoon Flooding Road Closure

Incident Statistics:

- Date: July 7, 2006
- Location: I-10, MP 300 (Benson)
- Duration: 2 Hours
- Interoperability Type: Car-to-Car
- Initial Attempt to Contact: Successful
- Time to Make Contact: 15 seconds
- Level of Confusion: 1 (None)
- Ease of Use: 1 (Very Easy)
- Extent of Distraction: 1 (None)
- Incident Details: A monsoon storm flooded I-10 near Benson. DPS Callsign 920 was called by Unit S53 of ADOT to coordinate the incident. It turned out that Callsign 920 was only about 30 seconds behind Unit S53, returning from a meeting in Tucson. Unit S53 had a radio call from his office describing the problem, and Callsign 920 heard the incident being discussed on the VHF radio channel. Callsign 920 saw the wash "top-out" and contacted Unit S53 immediately (5 seconds), and information about the situation was exchanged. The road closure was established.

3. MS150 Colorado River Bike Race in Western Arizona

Figure 7 – Multiple Sclerosis MS150 Best Dam Bike Tour

Incident Statistics:

- Date: October 29 & 30, 2006
- Location: West Phoenix to the Colorado River near Parker Dam
- Duration: 2 Days
- Interoperability Type: Console Crosspatch and Car-to-Car
- Incident Details: This annual race takes place on various 2-lane state roads where thousands of riders usually take part in the ride. The route included SR 74, US 60, US 93, SR 72, and SR 95. The race is closely monitored by DPS and ADOT to prevent accidents with motorized vehicles and care for riders who become sick or have bicycle accidents. In the past, direct field radio communications between ADOT and DPS have been limited.

  ADOT event coordinators asked the TOC to patch channels between the Black Metal Mountain and Oatman Mountain repeaters for wide-area communications in western Arizona. This was done with ADOT channels A8 on the Black Metal Mountain repeater, and B9 on the Oatman Mountain repeater near Quartzite. It allowed ADOT to communicate directly with individual units over a wide area. California Highway Patrol was also temporarily issued VHF radios by ADOT to help coordinate operations throughout the event area. Although the event was outside the geographic scope of this project, it was nonetheless an opportunity for the successful implementation of the new crosspatch capabilities.

4. UPS Truck vs. County Road Grader Accident on I-10

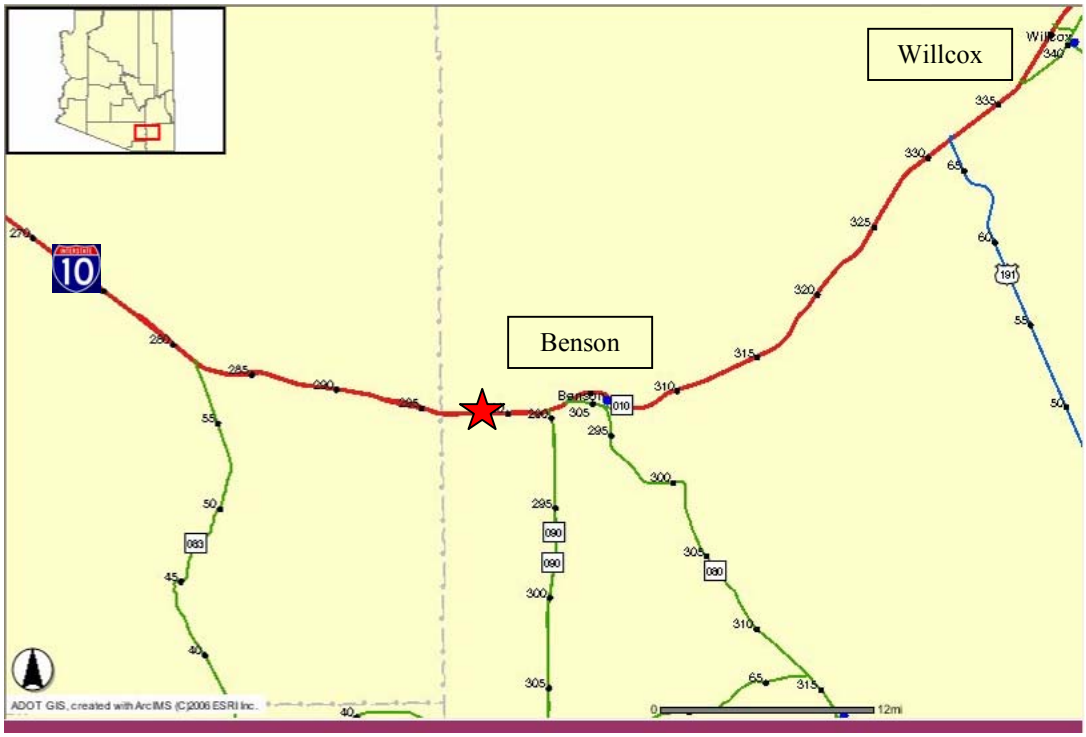


Figure 8 – Truck vs. Road Grader Incident Location

Figure 9 – Truck vs. Road Grader Collision Incident

Incident Statistics:

- Date: August 24, 2006
- Location: I-10, EB MP 298 (Benson)
- Duration: 8.5 Hours
- Interoperability Type: Car-to-Car
- Initial Attempt to Contact: Successful
- Time to Make Contact: 30 seconds
- Level of Confusion: 1 (None)
- Ease of Use: 3 (Moderate)
- Extent of Distraction: 1 (None)
- Incident Details: A UPS truck struck the rear of a county road grader that edged into the travel lane from the highway shoulder. The severe crash resulted in the destruction of both vehicles and closure of the freeway. DPS Callsign 921 responded from Benson. Callsign 921 immediately contacted his counterpart in ADOT on his VHF radio to coordinate on-scene efforts. Callsign 921 reported things went relatively smoothly, until he was on-scene when signals became weak and he was advised to switch to another channel. As a result he downgraded the "Ease of Use" question to a "3." However, the incident was otherwise handled smoothly.

5. Gasoline Tanker Rollover on SR 90

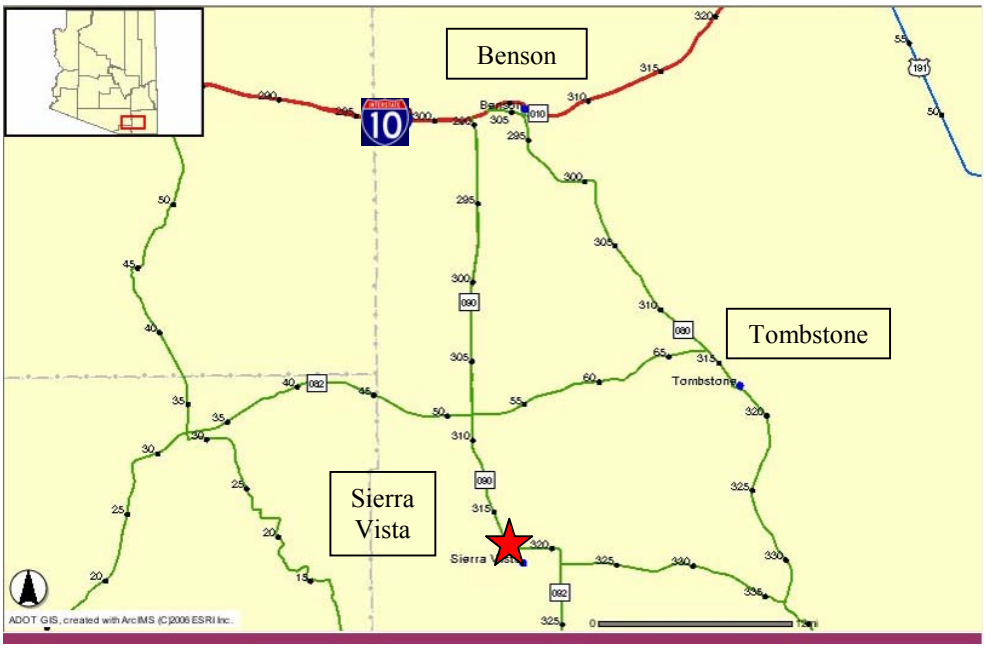


Figure 10 – Incident Location for Gasoline Tanker Rollover

Figure 11 – Gasoline Tanker Rollover Incident

Incident Statistics:

- Date: June 11, 2006
- Location: SR 90, MP 317 (Sierra Vista)
- Duration: 15 Hours
- Interoperability Type: Car-to-Car
- Initial Attempt to Contact: Successful
- Time to Make Contact: 30 Seconds
- Level of Confusion and Extent of Distraction: 1 (None)
- Incident Details: A gasoline tanker truck rolled over near Sierra Vista. DPS Callsign 910 was dispatched to the scene. He initiated contact with his ADOT counterpart and coordinated activities relating to the incident. Callsign 910 reported no difficulties with the contact.

6. Forest Fire near Winona on I-40

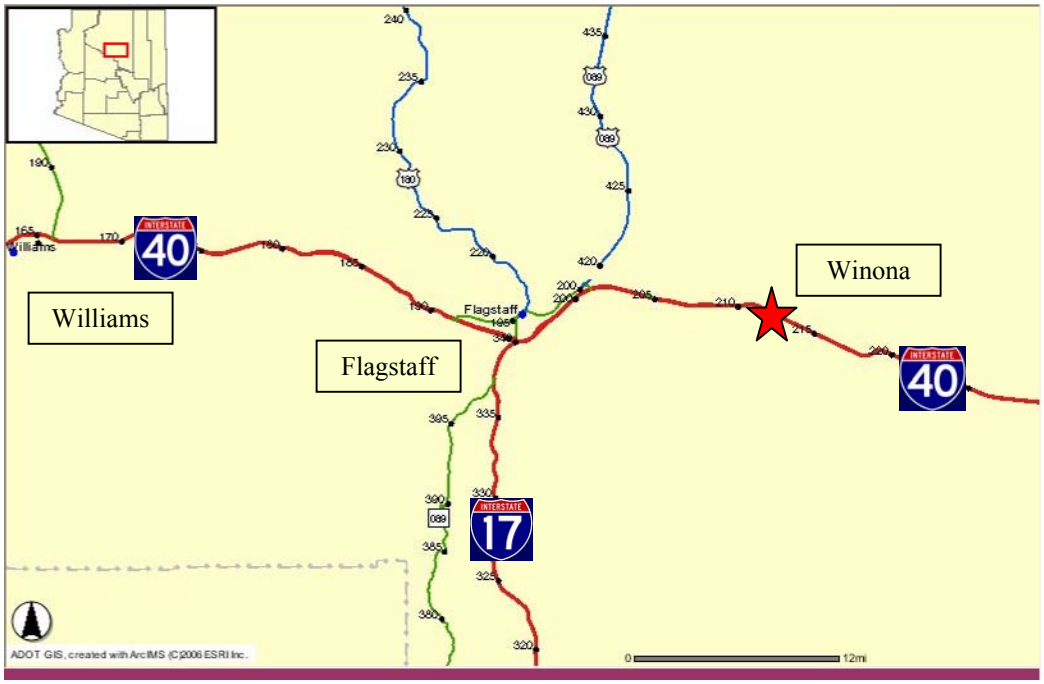


Figure 12 – Incident Location for Forest Fire on I-40

Incident Statistics:

- Date: May 27, 2006
- Location: I-40, MP 211 (Winona)
- Interoperability Type: Car-to-Car
- Level of Confusion: 1 (None)
- Incident Details: ADOT Unit F50 noted a small forest fire on I-40. He contacted his DPS counterpart via VHF radio and they coordinated while on-scene to establish traffic control and call for the necessary resources. Unit F50 noted no problems or confusion in use of the VHF ADOT car-to-car frequency.

7. Flooding on SR 186 near Willcox

Figure 13 – Road Wash-Out on SR 186

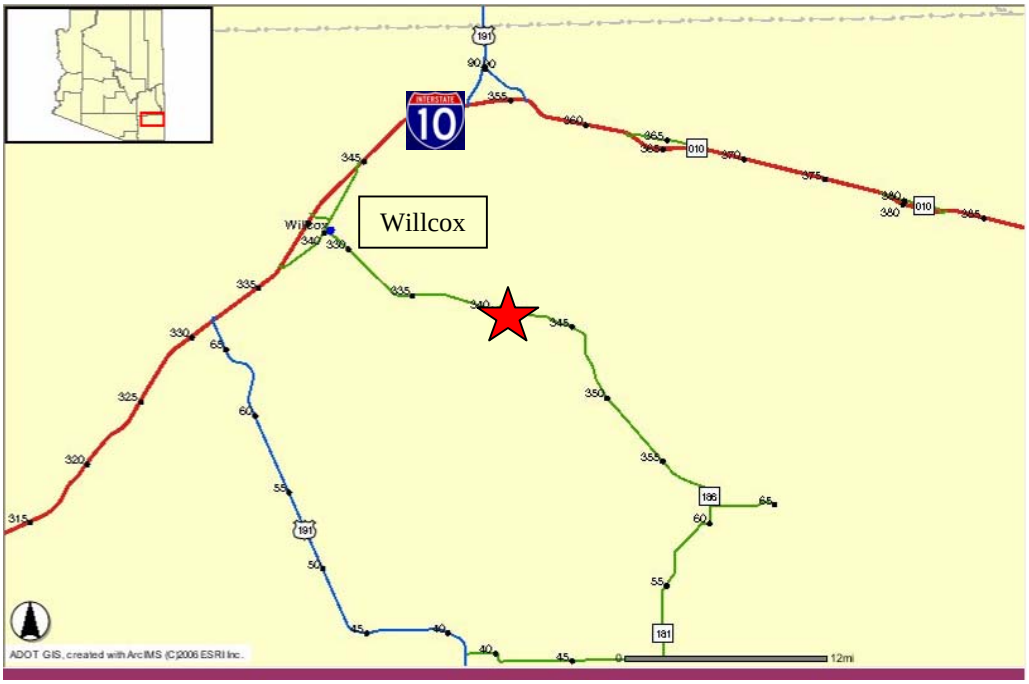


Figure 14 – Incident Location for Flooding on SR 186

Incident Statistics:

- Date: July 31, 2006
- Location: SR 186 (Willcox)
- Duration: 8 Hours
- Interoperability Type: Car-to-Car
- Initial Attempt to Contact: Successful
- Level of Confusion: 1 (None)
- Ease of Use: 1 (Very Easy)
- Extent of Distraction: 1 (None)
- Incident Details: A monsoon storm caused a washout of SR 186. ADOT Unit S52 called his DPS counterpart and requested on-scene assistance. He was also able to have the DPS officer relay to the DPS Ranger helicopter to pick up an ADOT crew member who had gotten stuck between two flooded locations and couldn't get out. The incident was easily handled with no problems.

8. Collision Due to Dust Storm on I-10

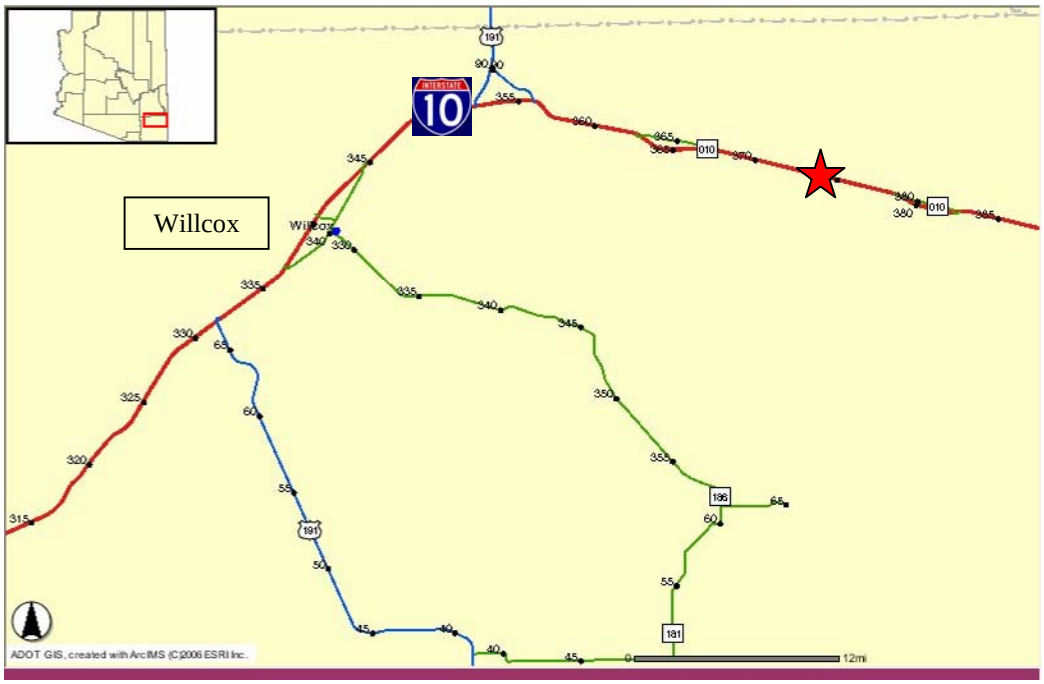


Figure 15 – Incident Location for Collision Due to Dust Storm on I-10

Figure 16 – Collision on I-10 Due to Dust Storm Incident

Incident Statistics:

- Date: June 21, 2006
- Location: I-10, MP 368 (East of Willcox)
- Duration: 7.5 Hours
- Interoperability Type: Car-to-Car
- Initial Attempt to Contact: Successful
- Time to Make Contact: 10 to 15 Seconds

- Ease of Use: 1 (Very Easy)
- Extent of Distraction: 1 (None)
- Incident Details: A major accident on I-10 involving a 5-vehicle pile-up was a result of low visibility conditions due to a dust storm. The collision blocked I-10 resulting in a roadway closure, with DPS requesting ADOT presence for traffic control and incident response. ADOT Call Sign S52 was in route to the incident scene. He was able to communicate with DPS Call Sign 920 to receive information to summon ADOT crew responding with the correct equipment. The radio interoperability saved ADOT extra delay that would have been required for the ADOT responding crew to bring the correct applicable equipment.

6.2.2 Incidents Identified Using Evaluation Reports

Other incidents of interest, which involved interoperable radio use documented with evaluation forms, include the following:

- 04-05-06: I-10, MP352, detour due to dust storm in NM w/ traffic control.
- 04-25-06: I-10, MP327.8, moving lane closure for accident removal.
- 06-20-06: I-10, MP327.89, commercial vehicle collision.
- 07-07-06: I-10, MP300, flooding incident.
- 07-31-06: Tucson DPS Dispatch, patch for DPS to ADOT Willcox for flooding.
- 07-31-06: SR186, East of Dos Cabezas, flooding at several locations.
- 07-31-06: SR181, flooding.
- 09-13-06: I-10, MP297, standing water on road.
- 09-14-06: SR191, MP56, five undocumented aliens on road.
- 09-30-06: I-10, NM state line, accident at MP3 in NM blocking I-10.
- 10-07-06: SR80, MP340, fictitious plate, possible drugs load.
- 10-10-06: SR80, MP349, fatality, “failure to yield.”
- 10-14-06: I-40, MP152, single vehicle rollover.
- 10-15-06: SR80, MP341, vehicle stop & search.
- 10-16-06: I-10, MP296, fatal collision.
- 10-22-06: I-10, injury collision.
- 10-30-06: I-10, MP322.6, notification of construction crew of wide load.
- 11-01-06: I-10, MP310.5, vehicle rollover and lane blocked.
- 11-02-06: SR90, two-vehicle fatality involving a truck and pedestrian.
- 11-29-06: I-40, MP195, single vehicle incident involving Air Ranger.
- 12-15-06: US191, MP167, DPS interagency communications for bomb alert.
- 12-28-06: I-10, in Texas Canyon, weather condition update between agencies.
- 01-01-07: I-10, DPS interagency communications with local enforcement.
- 01-12-07: I-10, MP310, vehicle rollover blocking westbound lanes.

6.2.3 Other Incidents

DPS identified other incidents where radio interoperability was used with other agencies outside of ADOT. Each incident involved a coordinated response that would have been more difficult and time-consuming without the VHF radios installed in the DPS vehicles. The events identified were several note-worthy incidents and only represent a fraction of the total events where radio interoperability was used. These incidents included:

- Apprehension of Homicide Suspects: US Border Patrol agents located two homicide suspects in the Willcox area. Benson area DPS officers utilized radio interoperability to coordinate the intercept, including state, county, and municipal officers. Through the coordinated effort, the number of responding officers overwhelmed the suspects, who were apprehended without incident.
- Surveillance of Gathering: DPS officers coordinated efforts with Graham County Sheriffs Office and personnel of an observatory using the VHF radios to efficiently communicate vital intelligence obtained by field units contacting members of an association. This information was relayed to field commanders and supervisors.
- Medical Response to Remote Area: DPS coordinated with city police and medical staff to set-up a road closure such that the Air Ambulance was available for a medical evacuation in a remote area.
- Pursuit of Stolen Vehicle: DPS directly contacted county sheriff's deputies to coordinate the effort to stop a stolen vehicle.
- Burglary in Progress: DPS assisted city police with a burglary occurring at a local store by arranging a response and establishing a perimeter.
- Domestic Violence/Assault: DPS assisted city police with an assault by locating the suspect described over the radio.
- Medical Helicopter Landing: DPS officers assisted city police by setting up a landing zone for a medical helicopter responding to a request for evacuation of a subject sustaining a serious injury.

6.3 INTEROPERABILITY EVALUATION SUMMARY & ANALYSIS

This section summarizes the evaluation forms returned from participating agencies' members. The forms were collected during the evaluation period, and some incidents were evaluated prior to this period and are included in the analysis. Almost all of the evaluation forms returned were from the southern region as the evaluation period fell during an unusually quiet time for the northern region. The returned forms all represented car-to-car radio interoperability.

6.3.1 Incident Location

The incident locations were the primary corridors in the southern region, including I-10, SR 186, SR 191, SR 80, and SR 90. The majority of documented incidents, over 55%, occurred on I-10, with over 25% of the incidents occurring on SR 186 and SR 80.

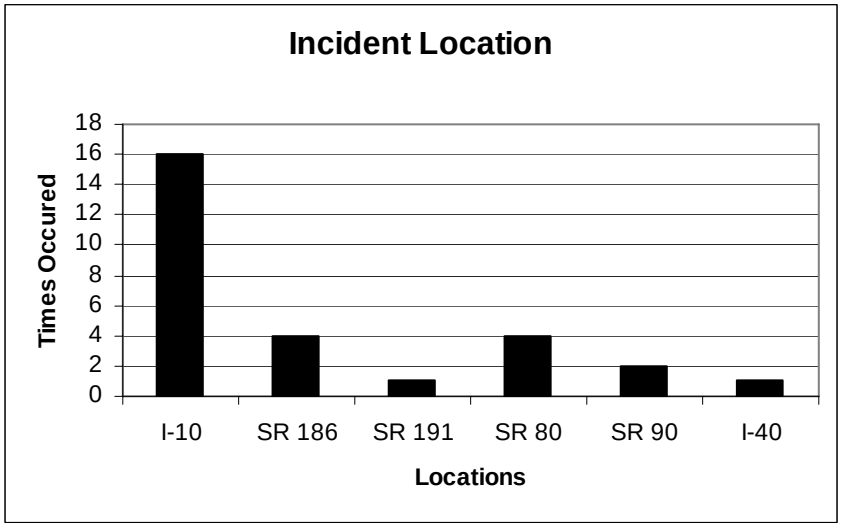


Figure 17 – Results: Incident Locations

6.3.2 Type of Incident

Each incident was identified with a related cause. These causes included: flooding, vehicle crash, law enforcement stops, dust storms, roadway closures, and other. As shown in Figure 18, 43% of all incidents involved vehicle-on-vehicle crashes, while 30% resulted from roadway flooding and dust storms, and 12% resulted from roadway closures. 9% of the incidents involved typical law enforcement activities such as vehicle stops and searches.

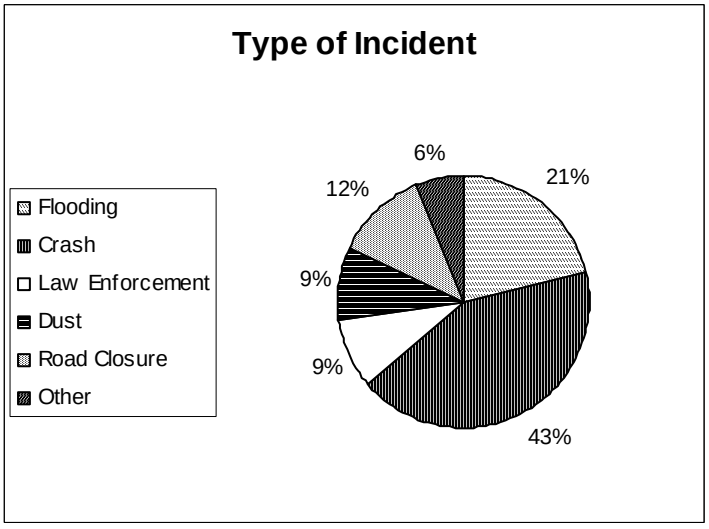


Figure 18 – Results: Incident Types

6.3.3 Incident Duration

The reporting agency identified the incident duration, recording the incident start time and the end time for clearance. The minimum incident duration was 10 minutes. The median duration, where 50% of the incidents were longer and 50% were shorter, was 2 hours and 36 minutes. The mean of the incident durations was 4 hours and 10 minutes. The maximum documented incident duration was 16 hours and 30 minutes.

One particular incident was determined to be an outlier for the data set, as the incident spanned over 2 weeks. This was an incident involving a propane tanker truck rollover and recovery, where the propane was burned off slowly while the roadway was reopened to traffic. This incident was not included in the calculations.

6.3.4 Heavy Vehicle Involvement

Over 60% of the documented incidents involved a heavy vehicle, which was defined as a vehicle weighing 10,000 pounds or more in gross vehicle weight (GVW).

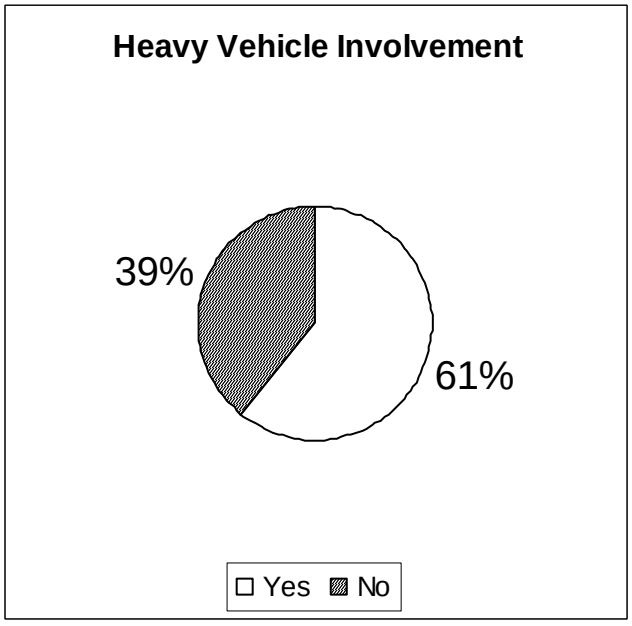


Figure 19 – Results: Involvement of Heavy Vehicles

6.3.5 Corresponding Agency Contact

In over 90% of the documented incidents, the responding agency knew who to contact at the corresponding agency.

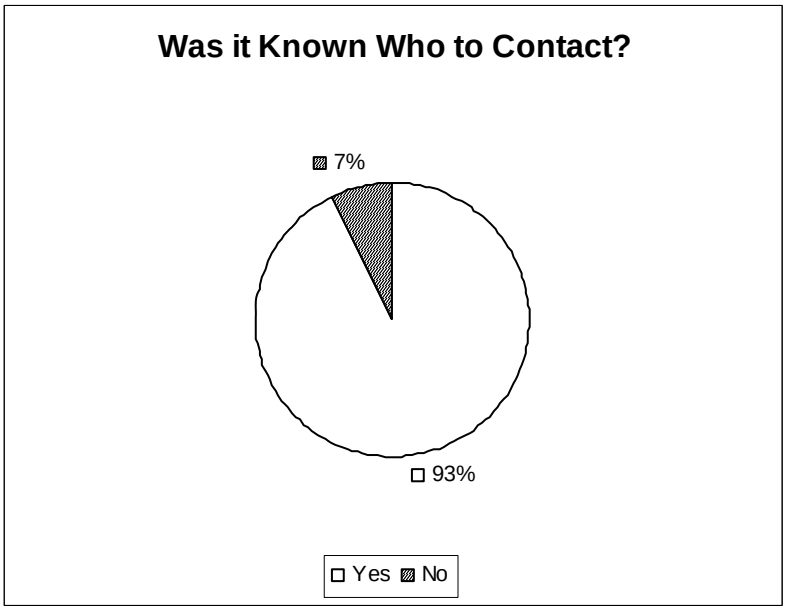


Figure 20 – Results: Agency Contact

6.3.6 Initial Successful Radio Contact

For almost 90% of the documented incidents, initial contact with the corresponding agency was successful. Regarding the unsuccessful initial attempt, the mean number of attempts for successful contact following the initial attempt was four.

Figure 21 – Results: Initial Successful Radio Contact

6.3.7 Corresponding Agency Contact Time

The reporting agency identified the total time for contacting the corresponding agency. The minimum contact time was 1 second. The median contact time, where 50% of the durations were longer and 50% were shorter, was 15 seconds. The mean of the contact times was 26 seconds. The maximum documented contact time was 2 minutes. One particular incident was determined to be an outlier for the data set as the contact time was 10 minutes. This contact time was not included in the calculations. Several of the responders indicated the contact time with check marks and not specific lengths of time. A typical communication effort between DPS and the dispatcher is established within a similar 10-second timeframe.

6.3.8 Communication Duration

The reporting agency identified the total time for communicating with the corresponding agency. The minimum communication time was 2 seconds. The median communication time, where 50% of the durations were longer and 50% were shorter, was 37 seconds. The mean of the communication times was 1 minute and 10 seconds. The maximum documented communication time was 5 minutes. One particular incident was determined to be an outlier for the data set, as the communication time was 10 minutes. This communication time was not included in the calculations. Several of the responders indicated the communication time with check marks and not specific lengths of time.

6.3.9 Corresponding Agency Arrival Time

The reporting agency identified the total time for the corresponding agency to arrive upon request. The arrival times ranged from already on the scene to 30 minutes. For the majority of the reported incidents, the requested agency arrived in less than 10 minutes. All of the responding partners indicated that the effort of the corresponding agency involved the proper resources to handle the situation.

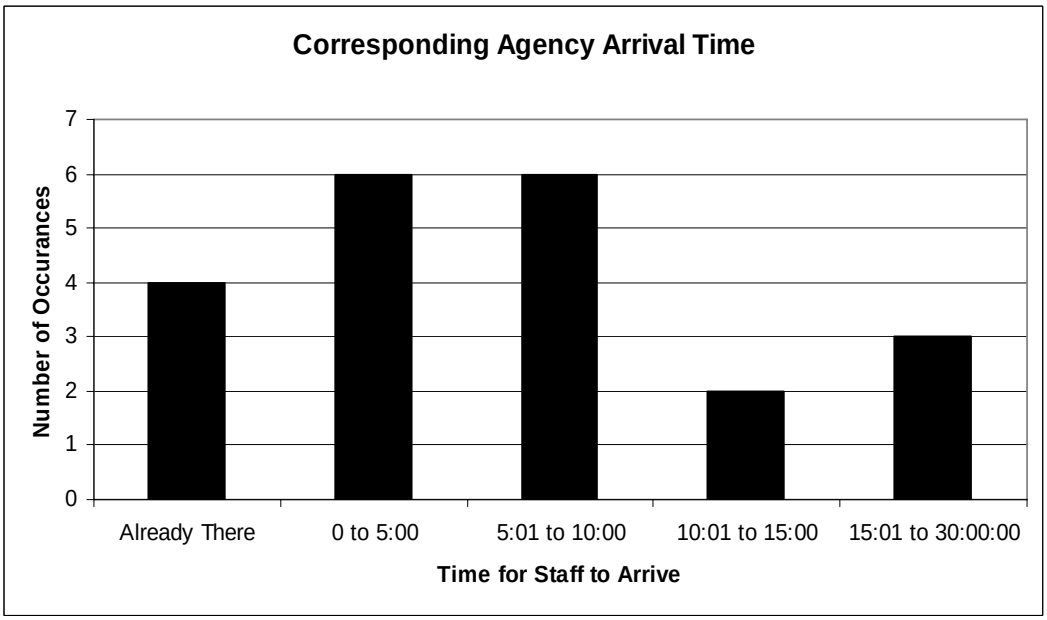


Figure 22 – Results: Corresponding Agency Arrival Time

6.3.10 Message Relay Method

Of the methods identified for relaying communications between DPS and ADOT, including interoperable radio, dispatcher, cell phone, or field meeting, 61% of all the methods involved interoperable radio. For the remaining methods, 23% of the communications involved dispatch, 10% resulted from field meetings, and 6% were from cell phone contact or other methods of contact.

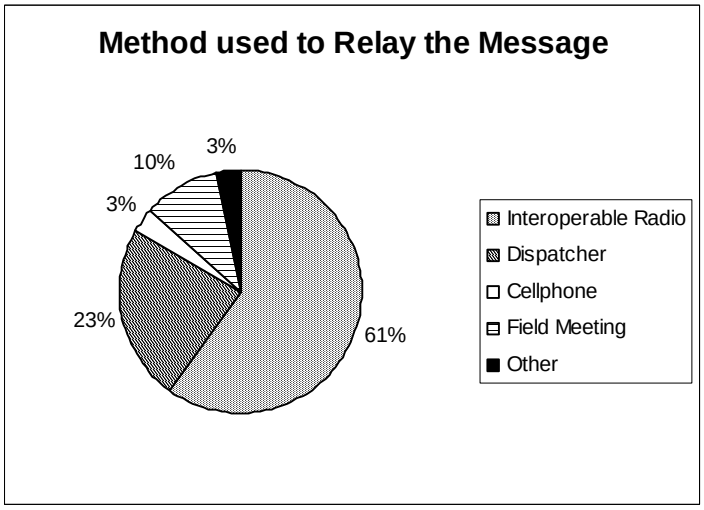


Figure 23 – Results: Agency Message Relay Method

6.3.11 Interoperable Radio Level of Understanding

As the primary method of communication between ADOT and DPS, radio interoperability level of understanding is an important element to gauge for the success of this method.

Of the documented reports that involved radio interoperability, the vast majority of the responders indicated that there was little to no confusion for this application. Responders indicated high levels of confusion for radio interoperability in only 2 instances.

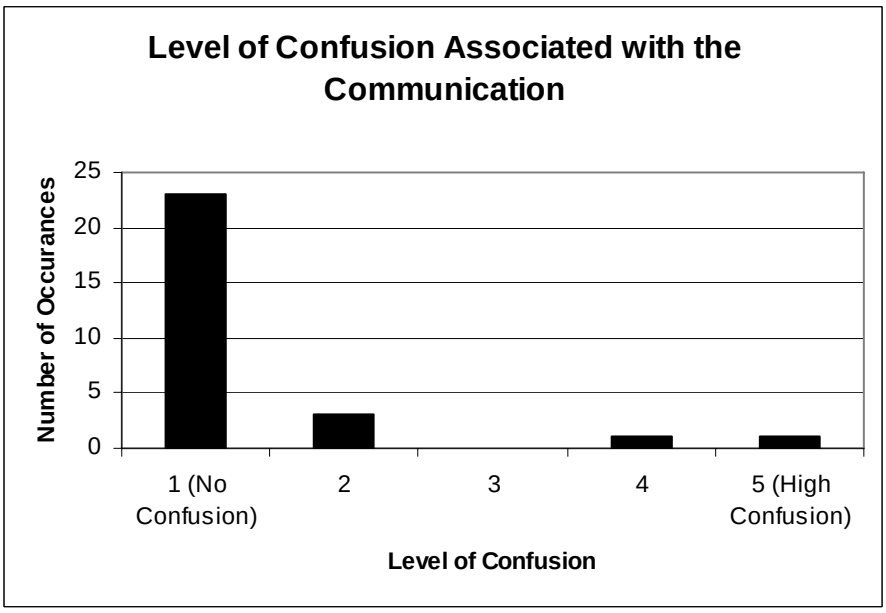


Figure 24 – Results: Interoperable Radio Level of Confusion

6.3.12 Interoperable Radio Level of Confusion

Similar to the level of understanding, radio interoperability ease of use is an important ele-ment to gauge for the success of this method. The results mirrored the results the reported levels of understanding.

Of the documented reports that involved radio interoperability, the vast majority of the responders indicated that radio interoperability was easy to use or very easy to use. Only a single responder indicated his experience was very difficult.

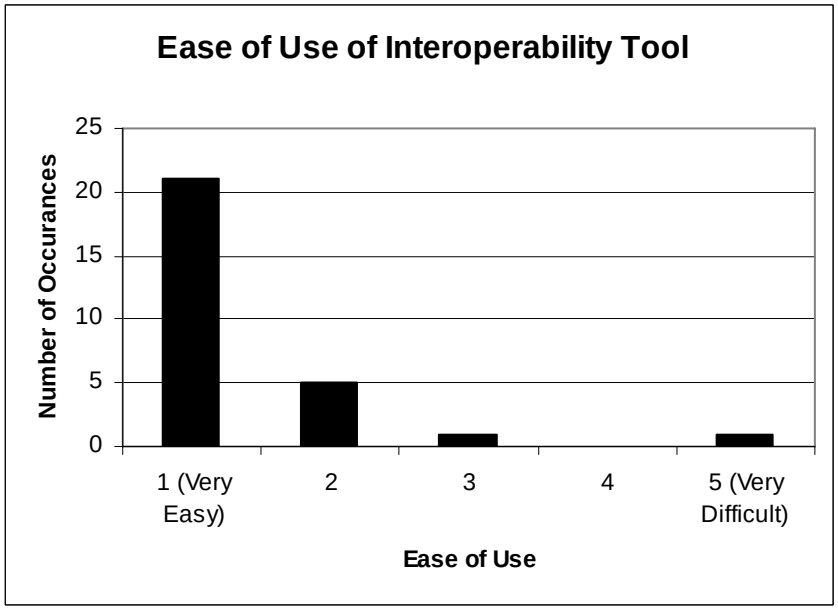


Figure 25 – Results: Interoperable Radio Ease of Use

6.3.13 Interoperable Radio Level of Distraction

It was important to gauge the level of distraction associated with use of radio interoperability to make sure that this method did not interfere with other duties or functions. Of the documented reports that involved radio interoperability, the vast majority of the responders indicated that radio interoperability was not a distraction to the performance of other duties. No evaluations indicated an extensive distraction. This indicates that the interoperability is a time-saver, where direct communications are available as opposed to an extensive routing of communications via third parties.

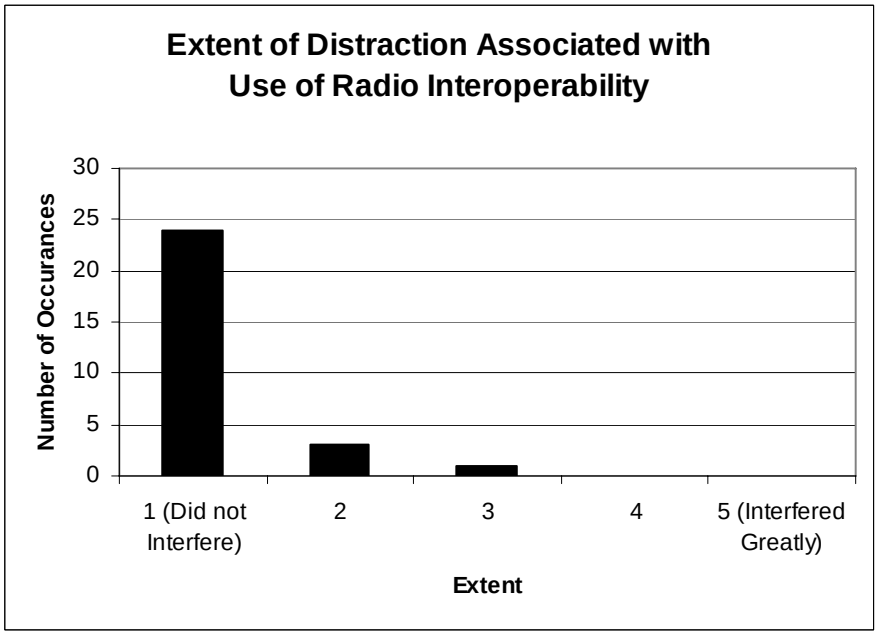


Figure 26 – Results: Interoperable Radio Level of Distraction

6.3.14 Communication Problems with Radio Interoperability

Of the documented reports that involved radio interoperability, 86% of the responders indicated that they had no problems with communication.

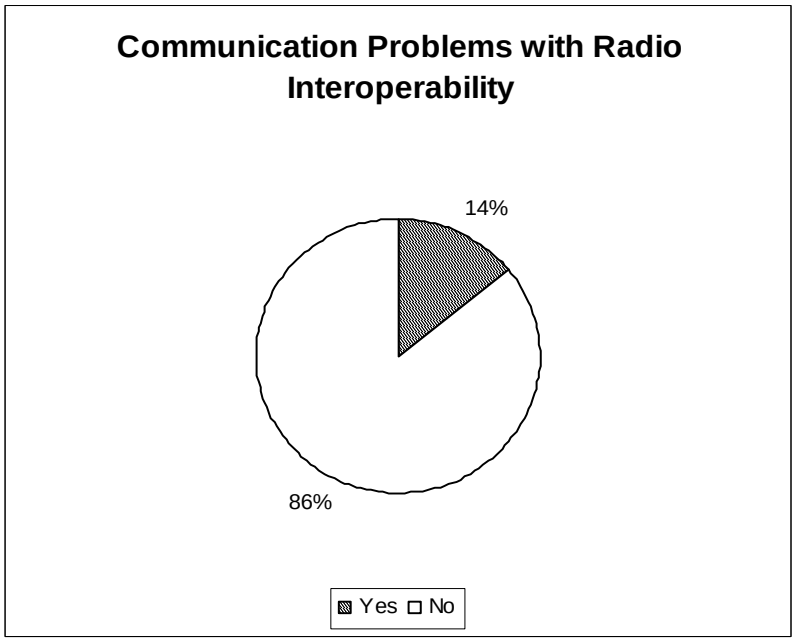


Figure 27 – Results: Communication Problems with Radio Interoperability

6.3.15 Responder Comments

The following table lists the interoperability user comments as recorded on the evaluation forms. The comments very much reflected the positive indications from the survey.

Table 13: Evaluation Survey Comments

Comments
Radio traffic went smoothly. All agencies interacted very well. The emergency response vehicle from the Cochise county sheriff's office was a valuable asset using telephone, computers, etc.
Used ADOT radio expected response for detour set up. Works excellent. Also enabled discontinuing of detour once I-10 was reopened in New Mexico.
Dust storm/multiple vehicle fatality coordinated response with Willcox org. & VMS board.
As usual, Excellent cooperation from ADOT; (ADOT foreman) and his squad were extremely useful to our operation.
There was a major accident. While on my way to the scene (approx. 35 minute drive) I was able to talk to DPS 920 who gave me all the info I needed to get our crew headed out with the right equipment. The radio saved us the extra delay that would have happened if I would have had to get to the scene!
Was calling for assistance for closure but detail was little. About 1 hour drive to the area. Never could talk with DPS. TOC gave me some details but no clear idea of what was needed until arriving at scene.
Flooding across I-10 at milepost 300, submerged vehicle at exit 299
I noted a wash crossing I-10 was at its banks - called my office to have crew monitor. 920 DPS officer was behind me and heard what I was talking about - he saw wash top out onto I -10- and relayed it immediately to me. I retained maintenance crew to stay to reopen interstate.
Radio was used to pass on road conditions on both 186 and I-10 which were having flood issue for a bit of time. Was also able to have DPS relay with Ranger Helicopter to pick up one of our crewmembers who had gotten stuck between 2 flood locations and couldn't get out.
Some break up of signal.
I-10 was completely shut down for 2 hours. As I approached the scene my car-to-car signal got weak. I was told to go to different frequency. I was able to coordinate a quick ADOT response using car-to-car.
By contacting ADOT directly, I was able to save time. It also freed up dispatch to work several collisions in the area.
I told officer we were past Birch Road and he thought we were on Birch Road. I should have been a little more clear where I was at, for example saying "mile marker 191."
We were called to setup an I-10 Detour for NM accident. DPS 930 got word from NM State Police that closure was not as long as first thought so detour was not needed. DPS 930 was able to let me know on radio so we were able to stop detour before we got setup. We then did some traffic control at the state line until DPS 930 was given word that all was open. He let us know; saved us time in leaving the scene.
This form itself is keeping some officers from using the radios in their vehicles.
Communication was unsuccessful initially because DPS officers were outside of their vehicle. When we have questions, we talk in person.
Traffic control for fatal rollover. #1 lane closed.
Advised ADOT TOC of occurrences.
We were escorting a 23 foot-wide truck. ADOT crew working on Johnson Road overpass. We contacted them by cell phone.
ADOT provided a lane closure which allowed me to investigate and clean up scene.
ADOT was on scene with traffic control. Allowed me to conduct my investigation.

6.4 OBSERVATIONS

A number of observations were made based upon data from the critical incidents, and the data summaries of the previous section.

6.4.1 General Observations

- The first observation is that the car-to-car mode of interoperability is every bit as functional, useful, and even more flexible than first assumed. The users found a number of unique modes of use for communications with ADOT, which provided shortcuts to establishing quick communication when needed. For instance, merely by monitoring the ADOT primary channel in the area, DPS officers were able to get early information of a problem and respond, even before a call was made to them by an ADOT field worker.

- The second observation was a major surprise. DPS was allowed to program other law enforcement agency channels into their VHF radios to monitor and transmit. Approximately 70% of public safety agencies outside Maricopa and Pima counties still use VHF radio networks. The project provided DPS a much wider level of interoperability than was initially presumed. As a result, DPS frequently used their VHF radios for interoperable communications with agencies other than ADOT. In fact, interoperability use in this capacity was estimated by DPS at 75% of the time for all radio use in the District 9 Benson-Willcox area, and 50% of the time in the District 2 Flagstaff area.

- During the March 8 propane tanker rollover incident, DPS initially communicated with the Cochise County Sheriff's Office and the Bisbee Police Department to establish the evacuation perimeter in case of an explosion. The safety benefits for establishing interagency communications is imperative to coordinate the response effort, including local county, municipal public works, sheriffs office, police, fire, HazMat, emergency medical personnel, volunteer organizations, and other local first responders. Many of these agencies could be programmed into these VHF radios as well.

- The third observation was as expected, that the radio-to-radio interoperability mode (Pilot 4) was extremely useful in meeting the needs of short duration incidents (less than several hours). The simplicity, ease of use, and continuous "on-line" capability made these radios an instant success with DPS officers and ADOT technicians.

- The fourth observation, concerning Pilot Project 5, is that it proceeded as expected. It was not used for short-duration incidents, though it was attempted with little success. Despite training, and occasional testing by the DPS dispatchers and the ADOT-TOC operators, the set-up of a console crosspatch did not always succeed. They proved difficult to initiate and set up. Part of the problem may have been in the understanding of the dispatch operator of what the DPS officer or ADOT field worker was requesting. In any event, there was only one long-duration event which operated over a wide area, the MS150 race, that was the ideal condition envisioned for a console crosspatch.

- Since the test project did not experience a major multi-day, region-wide event (no area-wide forest fires or snowstorms in the test area) there was minimal need to even request a console-based crosspatch. Still, the mechanism exists to do these patches, after the pilot program has been completed, and may be used more in the future for long duration, wide-area events.

6.4.2 Observations of Goals

The study's outcome and resultant observations enable a review of the actual goals that were met, versus those hoped for and assumed in the "Design" phase of the project. The key project goals (Table 11, Section 5.4) are repeated in Table 14 for the reader's convenience.

Table 14: Project Goals and Measures of Effectiveness

Goal 1 Improve Response Times	**Goal 2 Reduce Latency of Message Relay**	**Goal 3 Reduce Confusion**	**Goal 4 Provide an Easy to Use Interoperability Tool**	**Goal 5 Enhance DPS Support of ADOT Snow Removal**	**Goal 6 Enhance Joint DPS & ADOT Operations in Response to Incidents**	**Goal 7 Enhance DPS Support of ADOT Construction / Maintenance Operations**
Average Initial ADOT Response Time	Average Time to Relay a Message	User Perception of Confusion	User Ratings of Ease of Use	Snowplow Operator Perceptions	% Of Incidents With 1 - 2 Hour Duration With an ADOT Response	Number Of Field Meetings
Average Initial DPS Response Time	Average Time to Make Initial Contact	% Of Time That Initial Information Provided Proper Resources	Frequency of Use	Officer and DPS Sergeant Perceptions: Snowplow Operations	Perception Of Time Saved During An Incident With Interoperable Communication	Anecdotal Reports From DPS Officers And ADOT Staff In Work Zones
User Perceptions of Response Time	User Perception of Message Latency	Dispatcher & Operator Perception of Confusion			Average Time To Clear Roadway After a Heavy Vehicle Incident	
% Of Attempted Contacts That Result In Actual Contacts						

6.4.3 Evaluation of Goals s Met

A quick evaluation of the project outcome, relative to its key goals, yields the following comparative analysis:

Goal #1

- **Improved Response Time** – General Perception – "*Met.*"
- **Average Initial ADOT Response Time** – *Probably Met*; no specific ADOT data.
- **Average Initial DPS Response Time** – *Probably Met*; no specific DPS data.
- **User Perception of Response Time** – General Perception: Improved – "*Met.*"
- **% of Attempted Contacts Resulting in Contacts** – 89%.

Goal #2

- **Reduce Message Delay Latency** – *Probably Met.*
- **Average Time to Relay a Message** – 1 Minute, 10 Seconds.
- **Average Time for Initial Contact** – 26 Seconds.
- **User Perception of Message Latency** – *Much Improved.*

Goal #3

- **Reduce Confusion** – *Met*; 95% reported No Confusion.
- **% of Time Communication Provided Proper Info** – 86%.
- **Dispatcher & Operator Perception of Confusion** – *Not Fully Met*; only had limited responses from DPS Dispatchers & ADOT TOC Operators

Goal #4

- **Provide Ease-to-Use Interoperability Tool** – Pilot 4: *Met*; Pilot 5: *Not Met.*
- **User Ratings; Ease of Use** – Pilot 4: 95%; Pilot 5: Insufficient Data.
- **Frequency of Use** – Pilot 4: Moderate to Heavy; Pilot 5: Very Light.

Goal #5

- **Snow Operations Support** – No Data; No snow during project period.

Goal #6

- **Enhance DPS-ADOT Joint Incidence Response** – General Perception is "*Met.*"
- **% Incidents of 1-2 Hr Duration with Joint Response** – Not Measured.
- **Perception of Time Saved on Joint Incidents** – General Perception: 5-10 Minutes.
- **Average Time to Clear Roadway w/ Heavy Vehicle Incident** – Insufficient Data.

Goal #7

- **Enhanced DPS Support of ADOT Construction/Maintenance** – General Perception – "*Met.*"
- **Number of Field Meetings** – *Goal Met*; 3 in Tucson; 3 in Flagstaff.
- **Anecdotal DPS/ADOT Reports from Work Zones** – Many expressed in field meetings; General Consensus is that coordination improved and negated the need for some face-to-face meetings.

7. RECOMMENDATIONS

Based upon the data received from DPS and ADOT during this project several potential recommendations are suggested.

7.1 PILOT PROJECT 4 IMPLEMENTATION – Car-to-Car Statewide

The field users almost universally acclaimed the use of car-to-car VHF radio as an invaluable interoperability tool. Its is recommended that Pilot Project 4 be expanded to include mid-cost secondary VHF radios in all DPS Highway Patrol cars statewide, outside of Maricopa County – approximately 440 units. Because there are no further ADOT research funds to implement this project, the necessary additional funding will need to be developed through DPS resources. It is suggested that grant funding from all possible sources be researched.

The use of the interoperable radio in DPS vehicles has proven its value not only in direct communications with ADOT personnel, but also with many other key partners. DPS has indicated that 50% to 75% of their VHF radio use was to communicate with other first responders, including local law enforcement, fire, medical, and HazMat personnel. This is indeed a multiplier on the value of investment of VHF radios. This benefit can extend beyond construction of a new statewide interoperable radio network as many local agencies may not have funding to join the system, but will choose to remain on their current VHF systems. There is a realized long-term benefit to having a back-up radio in each patrol car to maintain communications with these local agencies.

Since these VHF radios cost approximately $1,500 each, equipping another 440 DPS cars (those outside Maricopa County), including spares, would cost approximately $660,000. This will benefit not only ADOT-DPS interoperable communications, but also give DPS interoperable communications to other rural law enforcement agencies. This investment is very reasonable as an intermediate step of interoperability improvement until the statewide public safety interoperable radio system is designed, funded, and built by the DPS-PSCC. It would provide further long-term flexibility also.

Small enhancements could be made in future implementations, such as adding in-grille loudspeakers to the vehicles of those officers who specifically request installation. UHF-VHF mobile “extender” radios could also be added to some vehicles. This would allow a DPS officer to use his or her current DPS UHF portable radio to communicate directly with ADOT. However, this option would add at least $1500 in cost to each vehicle.

Expansion of Pilot Project 4 would greatly augment the Arizona Interoperable Radio System (AIRS), which is currently under construction at 44 DPS communications sites. AIRS is designed primarily for emergency communications, but has a limited number of radio “talk paths” available, and is not designed for routine traffic, such as typical ADOT to DPS communications. It also requires some operator intervention.

Pilot Project 4 could be expanded into Maricopa County by procuring 800 MHz ADOT trunked radios. However, the need is not as great in Maricopa for two reasons. First, there are many more alternative means of interoperable communications, including commercial systems, available in Maricopa County than there are in rural areas. Secondly, most other law enforcement agencies in Maricopa County are no longer on VHF, but utilize 800 MHz radio systems. However, their systems utilize much more complex digital 800 MHz networks that would require expensive upgrades to the incompatible 800 MHz radios, contrasting with the current ADOT Smartnet II system.

Discussion occurred during the field review meetings in both Flagstaff and Tucson regarding portable VHF radio units to be carried by DPS officers. Although some interest was expressed, it is not recommended that portable VHF radios be purchased for use by all DPS officers because of their limited range and the added weight on the officer's utility belt. However one or more VHF portable radios could be made available for each squad in the squad office for specialized applications including, but not limited to, long-term events.

7.2 PILOT PROJECT 5 IMPLEMENTATION – Phoenix Capacity Expansion

Although Pilot Project 5 dispatch console crosspatch interoperability was far less of a field-proven success, the limited duration of the project, along with lack of a snow-season test, probably means that Pilot 5 was not allotted an adequate evaluation period. As anticipated, the problems noted with its use were insufficient exposure and operator understanding, as well as the extra steps and complexity of crosspatch initiation.

Given the limitations noted in this test, and some technical problems in latency of end-to-end communications, it would hardly justify a major, costly expansion of such a system. However, the current system allowing DPS Flagstaff and Tucson dispatchers to link to the TOC is fully functional and will remain in place. It would cost only an estimated $3,500 (DPS engineering estimate) to expand the system to the DPS Phoenix OpCom center, including a telephone ring-down circuit. Given this minimal cost, it would be advisable to expand this system to the Phoenix DPS center to provide complete statewide ADOT-DPS crosspatch interoperability.

Along with these recommendations, a continued and expanded training and periodic testing program is recommended to enable this crosspatch system to be set up rapidly when required, while limiting the level of confusion and keeping operating procedures fresh in the minds of the users. Both DPS dispatchers and ADOT TOC console operators should take part in this training, and it is suggested that all training exercises include both agencies simultaneously. The class videotapes made during this pilot project could be used as a starting point for any future training and testing.

Console crosspatching could prove invaluable for future major wide-area events, such as snowstorms or forest fires. It should be considered as one of the "tools" in the public safety interoperability toolbox.

7.3 CONTINUED USER TRAINING

The success of expanded radio interoperability will depend on the quality and frequency of future user training. The pilot projects have shown that even with scheduled user training, actual use can break down due to lack of system knowledge and protocol training. This is particularly true for dispatch channel crosspatch activity. Therefore, it is recommended that all new DPS officers and ADOT field technicians be given adequate training during their orientations, based upon the videos produced for this project. Also, all new TOC operators and DPS dispatchers should be given training on how to conduct a crosspatch during their training and orientation.

Refresher training for current staff for both DPS and ADOT should be mandatory on an annual basis. The existing materials and videotapes which were made to train both field personnel and ADOT operators and DPS dispatchers were quite successful and can be used as a starting point for future training, but new materials should be developed based on the statewide implementation plans. These materials should be reviewed and updated annually to reflect any modifications to technical systems or operational procedures.

7.4 SUMMARY

On a statewide basis, long-term solutions are in the planning stages but are probably still nearly a decade away. They will also require funding on a scale of at least 2 orders of magnitude higher than those solutions currently being implemented in the State.

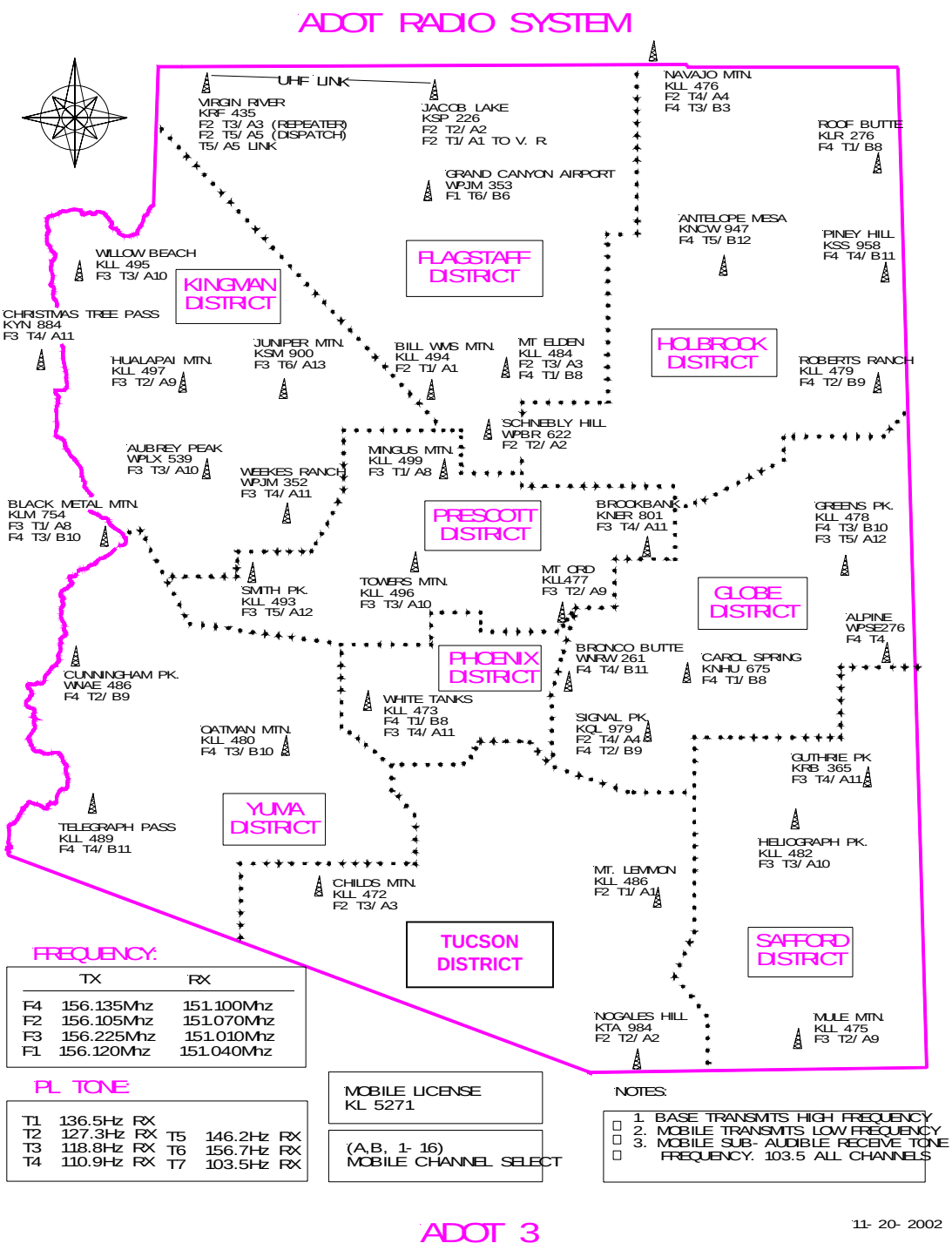
Whether such funding will actually become available is still unknown. Therefore, it is prudent to take any and all intermediate measures for improved interoperability that are available at the present time.

Particularly, the cost levels estimated for the proven Pilot 4 and Pilot 5 enhancements are very reasonable to complete statewide interoperability between DPS and ADOT, with the additional benefit to DPS of being able to communicate directly with other local first-responding agencies.

APPENDIX A

ADOT RADIO MAP & CHANNEL PLAN

APPENDIX A - ADOT RADIO MAP & CHANNEL PLAN



ADOT VHF MAINTENANCE RADIO NETWORK CHANNEL PLAN

DISTRICT	CHANNEL	MOUNTAIN TOP SITE	CALL	TX FREQUENCY	RX FREQUENCY	PULSE TONE
Tucson	A1	Mt. Lemmon	KLL486	156.105 Mz	151.070 Mz	136.5 Hz
Flagstaff	A1	Bill Williams	KLL494			
Flagstaff	A1	Jacob Lake -Virgin River	KSP226			
Tucson	A2	Nogales Hill	KTA984	156.105 Mz	151.070 Mz	127.3
Flagstaff	A2	Jacob Lake	KSP226			
Flagstaff	A2	Schnebly Hill	WPBR420			
Tucson	A3	Childs Mtn.	KLL472	156.105 Mz	151.070 Mz	118.8
Flagstaff	A3	Mt. Elden	KLL484			
Flagstaff	A3	Virgin River	KRF435			
Tucson	A4	Signal Pk.	KQL979	156.105 Mz	151.070 Mz	110.9
Flagstaff	A4	Navajo Mtn.	KLL476			
Flagstaff	A5	Virgin River-Linked	KRF435	156.105 Mz	151.070 Mz	146.2
Flagstaff	A6	Grand Canyon	WPJM353	156.105 Mz	151.070 Mz	156.7
Car-to-car	A7	None	KL5271	156.105 Mz	156.105 Mz	103.5
Prescott	A8	Mingus Mtn.	KLL499	156.225 Mz	151.010 Mz	136.5
Kingman	A8	Black Metal Mtn.	KLM754			
Kingman	A9	Hualapai Mtn.	KLL497	156.225 Mz	151.010 Mz	127.3
Prescott	A9	Mt. Ord	KLL477			
Safford	A9	Mule Mtn.	KLL475			
Safford	A10	Heliograph Peak	KLL482	156.225 Mz	151.010 Mz	118.8
Kingman	A10	Willow Beach	KLL495			
Kingman	A10	Aubrey Peak	WPLX539			
Prescott	A10	Towers Mtn.	KLL496			
Safford	A11	Guthrie Pk.	KRB365	156.225 Mz	151.010 Mz	110.0
Kingman	A11	Christmas Tree Pass	KYN884			
Kingman	A11	Weeks Ranch	WPJM352			
Prescott	A11	Brookbank	KNER801			
Prescott	A11	White Tanks	KLL473			
Prsct/King	A12	Smith Peak	KLL493	156.225 Mz	151.010 Mz	146.2
Kingman	A13	Juniper Mtn.	KSM900	156.225 Mz	151.010 Mz	156.7
Car-to-car	A14	None	KL5271	156.225 Mz	156.225 Mz	103.5
Car-to-car	A15	None	KL5271			
Car-to-car	A16	None	KL5271			
Yuma	B8	White Tanks	KLL473	156.135 Mz	151.100 Mz	136.5
Holbrook	B8	Roof Butte	KLR276			
Flagstaff	B8	Mt. Elden	KLL484			
Globe	B8	Carol Springs	KNHU675			
Yuma	B9	Cunninghm Pk.	WNAE486	156.135 Mz	151.100 Mz	127.3
Holbrook	B9	Robert's Ranch	KLL479			
Globe	B9	Signal Peak	KQL979			
Yuma	B10	Oatman Mtn.	KLL480	156.135 Mz	151.100 Mz	118.8
Holbrook	B10	Greens Peak	KLL478			
Yuma	B10	Black Metal Mtn.	KLM754			
Holbrook	B10	Navajo Mtn.	KLL476			
Yuma	B11	Telegraph Pass	KLL489	156.135 Mz	151.100 Mz	110.9
Holbrook	B11	Piney Hill	KSS958			
Globe	B11	Bronco Butte	WNRW261			
Holbrook	B12	Antelope Mesa	KNCW947	156.135 Mz	151.100 Mz	146.2
Not Used	B13	Not Used	KL5271	156.135 Mz	151.100 Mz	156.7
Car-to-car	B14	Not Used	KL5271	156.135 Mz	151.100 Mz	103.5
Car-to-car	B15	Not Used	KL5271			

*Note: Receiver CTCSS PL Tones for all channels is 103.5 Hz

Abbreviations:

Mtn. = Mountain	Pk. = Peak
TX = Transmit	RX = Receive
Mz = Megahertz	Hz = Hertz

APPENDIX B

DPS CALLSIGN SYSTEM

APPENDIX B - DPS CALLSIGN SYSTEM

ARIZONA DPS HIGHWAY PATROL OFFICER CALLSIGN ASSIGNMENTS

Highway Patrol officer radio callsign assignments are structured on a common logical basis for all RURAL Highway Patrol Districts. (Note: This assignment methodology does NOT apply to any highway patrol radio callsigns in the Phoenix Metro Districts; Metro West, Central, or East)

The first digit of the callsign specifies the DPS Patrol District number. This could be from 1 to 12, but excludes 5, 7, and 10. (District numbers no longer used)

The second digit of the callsign specifies the squad number within that District. For instance, if the second digit is a 2, that would specify the 2nd squad.

The third digit of the callsign specifies the particular squad member within that District and squad.

A zero digit following any number indicates the leader of that unit. For instance, the Lieutenant of District 2 would have a callsign “A200". The Sergeant of the first squad of District 2 would have a callsign 210. And the third squad member of the 1st squad of District 2 would have a radio callsign “A213".

Another typical example: Radio callsign “A935" would indicate that the officer is the 5th member of the third squad, of District 9.

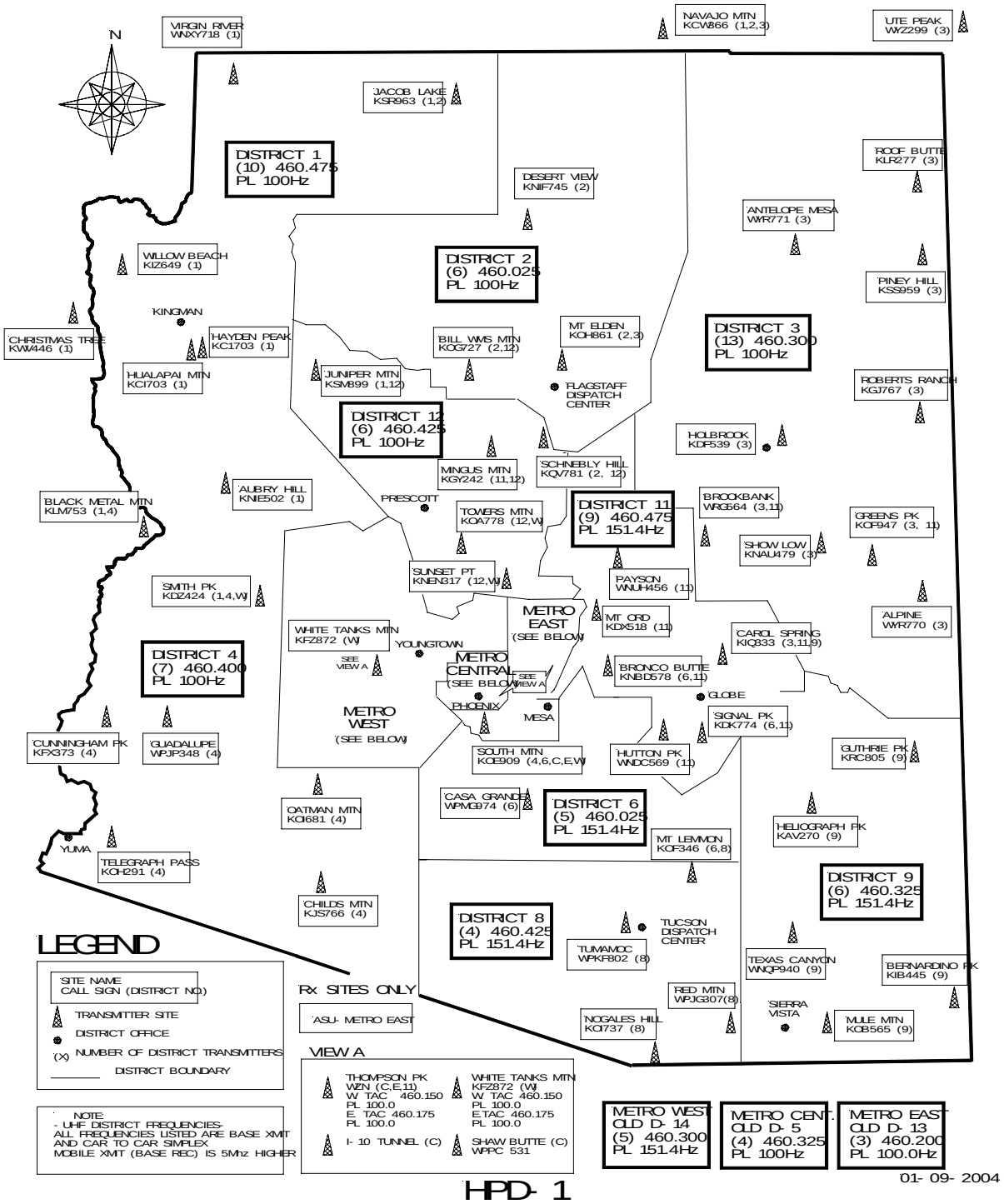
Note: Radio callsigns do NOT track an officer’s badge number in any respect.

APPENDIX C

DPS RADIO MAP

APPENDIX C - DPS RADIO MAP

HIGHWAY PATROL DISTRICT RADIO SYSTEM



APPENDIX D

INTEROPERABILITY DISPATCH REPORT

APPENDIX D – INTEROPERABILITY DISPATCH REPORT

Center: (check one) □ ADOT TOC □ DPS Flagstaff □ DPS Phoenix □ DPS Tucson	**Date:** _____	**Operator Name:** _____
Start Time: _____ **End Time**: _____	**Successful Communication?** (check one) □ Yes □ No	**Incident Location** **Highway**: _____ **Milepost**: _____
Response Time: _____	**Setup Time**: _____	**VHF Repeater Site Name:** _____
Problems? (check one) □ Yes □ No **If Yes, Describe:** _____ _____ _____ _____ _____ _____	**Incident Type: (check one)** □ Traffic Collision □ Heavy Vehicle Coll. □ Hazardous Materials □ Debris Removal □ Construction Work zone □ Law Enforcement □ Dust □ Ice □ Snow □ Test □ Other _____	**Radio Channels Patched**: (check **TWO**) □ ADOT VHF Car-to-Car □ ADOT VHF Repeater **AND** □ DPS UHF STATE □ DPS UHF District
Comments _____ _____ _____		

APPENDIX E

INTEROPERABILITY FIELD REPORT

APPENDIX E – INTEROPERABILITY FIELD REPORT

Date: _____ Your Name/Call Sign: _____

Incident Location: _____

Incident Description: _____

Starting Time: _____ Ending Time: _____

Type of Interoperability Used? (circle one)

Car-to-car Crosspatch

1. Were any heavy vehicles (10,000 GVW or greater) involved in this situation? (circle one)

Yes No

2. Did you know who to contact at the other agency for this situation? (circle one)

Yes No

3. Was your initial attempt to communicate with a member of the other agency's staff via radio successful? (circle one)

Yes No

4. If no, how many more time did you try?

_____

5. How long did it take to make contact with a member of the other agency's staff?

_____ Minutes _____ Seconds

6. How long did it take to relay the message?

_____ Minutes _____ Seconds

7. How long did it take for a member of the other agency's staff to arrive at your location or provide the requested service?

_____ Minutes _____ Seconds

8. **Did the other agency's initial response include the proper resources to handle the situation? (circle one)**

Yes No

9. **What method was ultimately used to relay the message? (circle one)**

Interoperable Radio Dispatcher Cellphone Field Meeting Other_____

10. **On a scale of 1 to 5, how would you rate the level of confusion associated with this communication?**

No Confusion Extensive Confusion

1 2 3 4 5

11. **On a scale of 1 to 5, how would you rate the ease of use of the interoperability tool?**

Very Easy to Use Very Difficult to Use

1 2 3 4 5

12. **On a scale of 1 to 5, to what extent if any did use of the interoperable radios distract you from performing other duties?**

Not At All Extensive Distraction
1 2 3 4 5

13. **Did you encounter any problems with the communication? (circle one)**

Yes No

14. **Comments**

_____
_____
_____
_____
_____
_____
_____

THANK YOU FOR COMPLETING THIS SURVEY

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[7] State Radio Term Contracts AD000012-007 & AD050017-A5; Available on the web from the State Procurement Office at: https://spirit.az.gov/Applications/SPIRIT/SR.nsf.