TRANSPORTATION COMMUNICATIONS INTEROPERABILITY: PHASE 1 - NEEDS ASSESSMENT

Final Report 561

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16. Abstract

ADOT's ability to successfully fulfil its responsibilities for highway maintenance and construction, event traffic management, incident response, and regional security depends on reliable radio communications among its field units and with partner agencies. This needs assessment research represents an initial step in a comprehensive ADOT program aimed at improving statewide radio communications interoperability internally and with ADOT's various partner agencies.

Currently no single radio frequency in the state allows for all responder groups to talk to each other. A critical need exists for secure cross-channel communications both within ADOT and with its transportation agency and emergency response partners of all levels. It is anticipated that systematic and coordinated equipment and infrastructure upgrades combined with shared and enforced communications protocols will overcome the lack of common radio frequencies, channels, or system between response team agencies, and across jurisdictional boundaries. The results of this project help define effective transportation interoperability throughout Arizona, and support ADOT's planning and future tests and deployments, for operations and for local and regional incident response and command.

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SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

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

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

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ACRONYMS AND ABBREVIATIONS

(Also see Glossary in Appendix A)

ACIC	Arizona Crime Information Center
ACU-1000	A portable device developed by Raytheon, used for cross-patching of otherwise non-interoperable wireless communications systems.
ADEMA	Arizona Department of Emergency and Military Affairs
ADOT	Arizona Department of Transportation
ALERT	Advanced Law Enforcement Response Technology Arizona Local Emergency Response Team
AMPS	Advanced Mobile Phone System
ANSI	American National Standards Institute
APCO	Association of Public-Safety Communications Officials International, Inc.
ARRC	Arizona Regional Review Committee - Standing Committee of APCO
ATRC	Arizona Transportation Research Center
AVL	Automatic Vehicle Location
AZWINS	Arizona Wireless Integrated Network System
bps	Bits per second
CCIR	International Radio Consultative Committee (Now ITU-R)
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
DPS	Department of Public Safety (Arizona 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
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
HAAT	Height Above Average Terrain
HAGL	Height Above Ground Level
IARS	State Interagency Radio System
ID	Identification number
I-D	Infrastructure Dependent
I-I	Infrastructure Independent
IRAC	Interdepartment Radio Advisory Committee
ITD	Intermodal Transportation Division of ADOT, formerly ‘Highways Division’
Kbps	Kilobits per second
kHz	Kilohertz

ACRONYMS AND ABBREVIATIONS

(Also see Glossary in Appendix A)

LMR	Land Mobile Radio
MCDOT	Maricopa County Department of Transportation
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
NDOT	Nevada Department of Transportation
NIJ	National Institute of Justice
NMDOT	New Mexico Department of Transportation
NPR	National Performance Review
NPRG	National Partnership for Reinventing Government
NPSPAC	National Public Safety Planning Advisory Committee; see Appendix E for NPSPAC regional interoperability communications requirements
NTIA	National Telecommunications & Information Administration
PC	Personal Computer
PCS	Personal Communication Service
PLAR	Private Line Automatic Ringdown
PSCC	Public Safety Communications Committee
PSWAC	Public Safety Wireless Advisory Committee (under the NTIA's Office of Spectrum Management)
PSWN	Public Safety Wireless Network (program within SAFECOM of the US Dept of Homeland Security)
PTT	Push-to-talk
RF	Radio frequency
RSSI	Receiver Signal Strength Indication
SCADA	Supervisory Control and Data Acquisition
SEVRN	Statewide Emergency Voice Radio Network
SIS	Statewide Interoperability Solution
SMR	Specialized Mobile Radio
SPS	Spectrum Planning Subcommittee
TAC	Technical Advisory Committee
TCP/IP	Transmission Control Protocol / Internet Protocol
TDMA	Time-Division Multiple Access
TIA	Telecommunications Industry Association
TIA/EIA	Telecommunications Industry Association/Electronic Industries Alliance
TOC	Traffic Operations Center
UHF	Ultra High Frequency band
UHF-T	Ultra High Frequency band for Television
USA-1	See Glossary
USGS	United States Department of the Interior, Geological Survey
VHF	Very High Frequency band
VoIP	Voice over Internet Protocol

EXECUTIVE SUMMARY

BACKGROUND

The Arizona Department of Transportation (ADOT) depends on reliable radio communications between its field units and with partner agencies in fulfilling its responsibilities for highway maintenance and construction, event traffic management, incident response, and regional security issues. Currently no single radio frequency in the state offers interoperable communications among all responder groups. It is anticipated that systematic and coordinated equipment and infrastructure upgrades combined with shared and enforced communications protocols will overcome the lack of common radio frequencies, channels, or system between response team agencies, and across jurisdictional boundaries.

RESEARCH OBJECTIVES AND METHODOLOGY

This research evaluated challenges to radio interoperability for ADOT and its partners and recommended incremental solutions to radio interoperability throughout Arizona supporting both routine operations and incident response and command. The project's stated objectives were:

- Document the current state of communications interoperability within and between Arizona's transportation agencies.
- Identify potential deficiencies.
- Recommend potential solutions.
- Develop a test plan for the proposed solution.
- Report and present research findings.

The research methodology reflected the multitude of radio stakeholders who play a role in radio interoperability in Arizona. Information and opinions on interoperability needs, issues, and desired solutions were solicited and acquired from ADOT and its partners at focus groups held in Phoenix, Kingman, Flagstaff, Holbrook, Safford, and Tucson, through online and mailed stakeholder surveys, and through a multi-agency table-top exercise. Stakeholder input was reviewed, categorized and analyzed, allowing a subsequent assessment of the existing interoperability conditions, formulation of needs, and recommendations of viable radio systems configurations supporting both ADOT's internal needs and its partnership responsibilities.

EXISTING ADOT RADIO SYSTEMS

All of ADOT's radio systems rely on the Arizona Department of Public Safety (DPS) statewide microwave network for control of the base/mobile-relay stations at dispatch control points in the district offices, and at the Phoenix Traffic Operations Center (TOC). Although DPS and ADOT share this microwave system, their respective radio systems are not interconnected. The DPS statewide radio network uses UHF frequencies and is not directly interoperable with ADOT radio systems that operate on VHF and 800 MHz frequencies.

Statewide Maintenance/Construction Radio System

The ADOT Maintenance and Construction VHF radio system is based on decentralized dispatching through each district's dispatch console, which typically controls only the local district's channels. Notable exceptions are the Prescott and Flagstaff district consoles, which control additional channels, and the shared Phoenix Construction and Maintenance Districts' 800 MHz trunked system. The districts' dispatch consoles all are manned during normal business hours (8 AM to 5 PM) and have limited crosspatch capability. Interoperability is typically limited to other ADOT VHF channels appearing on the console. The system is designed for mobile radio coverage along the highways and does not support portable radios.

There are four dispatch console operator positions at ADOT's Phoenix TOC. These consoles control every VHF ADOT Maintenance/Construction channel in the State, and provide daytime backup in the event that a district console is out of service. At least one of the consoles is monitored on a continuous basis.

Recently upgraded, the State's base stations, repeaters, and mobile radios operate in the wideband mode but are capable of the more desirable narrowband operation. The mobile radios allow 192-channel operation over a bandspread of 150-174 MHz and can potentially support interoperability statewide. These radios could be programmed to use the 155.475 MHz national public safety interoperability channel and the new narrowband interoperability frequencies, once the adjacent channels are cleared. Many older radios, not capable of narrowband operation, remain in use in the districts.

Overall, ADOT's VHF analog radio system used by the rural districts is deemed adequate for most routine operations; however, it lacks many of the features of a modern digital public safety radio system, and a level of intra-operability between districts as well as multi-agency interoperability that is desired.

Motor Vehicle Division Radio System

The Motor Vehicle Division (MVD) Enforcement Section's radio system uses 23 high-site VHF repeater stations. The system is dispatched statewide between 8 AM and 5 PM from the MVD office in Phoenix, which is linked through commercial landline to the DPS microwave room, also in Phoenix. After-hours radio backup is not provided for the MVD system by the Phoenix TOC.

The majority of the 150 MVD mobile radios are capable of 192-channel wideband and narrowband interoperability. Their new base and repeater stations support narrowband channel operation. Most of the MVD mobile radios and some of the portable radios have the national VHF interoperability channel (155.475 MHz) and the old DPS statewide VHF channel (154.935/155.190 MHz) programmed into them. MVD desires to have other agencies' channels programmed into their radios, which can be accomplished

through letters of authorization. In addition, MVD desires to operate a 24-hour dispatch but budgetary limitations prohibit this in the foreseeable future.

Like the ADOT VHF rural Construction/Maintenance radio network, the MVD radio network is an adequate analog system but lacks many of the features of a modern, digital public safety radio system that could provide the desired level of interoperability.

Phoenix Construction District & Maintenance District: 800 MHz Trunked System

Built in the 1990s to support the rapidly increasing amount of construction operations in the Phoenix District, this 8-channel, 4-site simulcast Smartnet radio system is based on a 10 GHz digital microwave network, which is independent of the State analog microwave network. The system is configured for 15 talk groups for both Phoenix Maintenance and Construction, and four talk groups for the MVD (no longer used). There are currently 400 Motorola vehicular radios and 350 portable radios in the system. Dispatch is handled by the ADOT TOC, which controls these 15 talk groups. No back-up dispatch point for this system exists but remote control stations can be used on a single talk group basis.

The system operates on wideband channels and has performed well over the years; however, with the exception of the dispatch consoles, its equipment is now obsolete and should be replaced. The majority of the equipment cannot support narrowband operations, which makes it difficult to use the national 800 MHz interoperability channels, as they are limited to narrow KHz bandwidth. Many of the older radios used by the Phoenix Districts cannot support the higher frequency National Public Safety Planning Advisory Committee (NPSPAC) interoperability channels.

At the present time, no 800 MHz system interoperability exists, except by cross-patching to other ADOT VHF statewide channels on the TOC consoles. This is rarely done; however, due perhaps to lack of demand or technical training. If the TOC consoles had channels linked through the ADOT microwave to the DPS microwave hub in Phoenix, limited interoperability with DPS UHF channels in the State could be obtained.

EXISTING CONDITIONS OF PARTNER AGENCY RADIO NETWORKS

Urban Partner Radio Systems

The key public safety organizations in Maricopa County are gravitating toward the 800 MHz band. The new Phoenix-Mesa 800 MHz trunked system will bring with it the Valley-wide Phoenix Fire Consortium, and Chandler, Gilbert, Tempe, Glendale, Scottsdale, Goodyear, Paradise Valley, Maricopa County, and ADOT Maintenance/ Construction are already on 800 MHz. The national Common-Calling channel, USA-1, is monitored by the Maricopa Sheriff's Office dispatchers, and can be cross-patched on demand to the VHF/UHF Interagency Radio System (IARS). The newer ADOT trunked radios can be programmed to operate on 800 MHz interoperability channels, enabling direct radio links with most agencies in the Valley.

Rural Partner Radio Systems

Over 75% of the rural public safety radio systems in Arizona operate on conventional VHF channels, which are generally compatible with ADOT's VHF system. Programming of some of ADOT's VHF channels into a partner agency's mobile/portable radios and vice-versa would resolve most rural interoperability problems on a case-by-case basis.

From a larger perspective, the IARS system operates on many rural mountain-top sites in the State and could be accessed by both ADOT Maintenance and MVD radios. Even without a local mountain-top VHF/UHF crossband repeater, ADOT's mobile and portable radios could be programmed on the simplex VHF-IARS channel for short-range car-to-car universal interoperability with those agencies that also have it programmed.

RADIO INTEROPERABILITY NEEDS

The bulk of ADOT's interagency radio communications occurs with the DPS, whose officers provide a safe work environment for the highway maintenance and construction crews. Radio calls are patched through DPS, ADOT district, and Phoenix TOC consoles; however, direct person-to-person communications can often better accommodate field circumstances. Cellular phones and in-person meetings currently substitute direct radio calls. Additionally, DPS vehicles are frequently equipped with ADOT radios while in some cases DPS UHF radios have been placed in ADOT supervisor vehicles. Internally, ADOT construction and maintenance staff needs the capability to communicate via radio not only within their district, but also with their counterparts in adjacent districts and within other divisions.

Numerous circumstances where intra-operability and inter-operability of radio communications would benefit ADOT and its partner agencies were reported by the project participants, including such common occurrences as detours on the state highway system involving routing traffic through jurisdictionally-owned facilities and ADOT's requests for assistance from another agency or vice-versa. ADOT and its partners routinely expend additional time and costly resources to overcome today's lack of interoperable radio communications. This not only introduces costly inefficiencies into routine operations but affects emergency situations where constant or frequent need for coordination requires that ADOT staff be in physical contact with the emergency partner, in order for direct communications to occur. In summary, clearly stated needs exist for direct radio communications among:

- All ADOT "Highways Division" vehicles (common reference term for the ADOT Intermodal Transportation Division).
- ADOT Highways Division, and Motor Vehicle Division Enforcement vehicles.
- All ADOT vehicles, and all DPS vehicles.
- Any ADOT unit taking part in incident response, and partner agency responders.
- ADOT partners, and ADOT Maintenance, Construction, HAZMAT (Hazardous Materials Safety), and MVD.

TECHNOLOGY SUPPORTING RADIO INTEROPERABILITY

In the context of this research, interoperability was defined as the ability to communicate from the radio unit of one person to that of another, who is typically not in the same day-to-day radio talk-group or channel. The two major types of radio interoperability solutions are Infrastructure Independent (I-I) and Infrastructure Dependent (I-D). Each solution has both a technical (hardware) component and an operational training component, and both are critical to successful interoperability.

Infrastructure Independent Radio

An example of I-I interoperability is when ADOT units communicate car-to-car on the district talk-around channels. In the I-I mode, two or more radios must operate in the same band, and on the same frequencies, using the same kind of modulation. Since about 70% of the public safety radio users in Arizona are still on VHF High-Band (150-174 MHz), as is ADOT and the MVD, this type interoperability is easily accomplished by reprogramming additional channels into radios that have available blank channels. While few users in the metro Phoenix use VHF, interoperability with NMDOT, and county road departments outside of Maricopa and Pima Counties can be accomplished programming additional channels into existing radios.

Infrastructure Dependent Radio

I-D interoperability occurs when two radio units located as far as a hundred miles apart communicate through a mountain-top repeater. I-D systems are more flexible, and can generally operate over a much wider geographic area than I-I systems but are typically much more complex and expensive. I-D systems range from simple accessing of a single shared repeater, to fixed or portable cross-band repeaters (utilizing two or more radio bands), to simple console cross-patching of any channels available at the console, to more sophisticated programmable radio cross-patching devices. The computerized patch devices may be at a fixed location or made portable to handle longer-term disaster/emergency situations.

The most sophisticated and costly I-D systems use multi-site trunking and allow for wide area roaming, instant talk group set-ups, unit identification, and emergency button features. Generally, these systems are shared platforms in metropolitan areas in order to provide wide areas of coverage, and good building penetration. If the cost of the platforms themselves is not shared, the systems are typically linked between controllers to make their use transparent to the end users.

Phoenix and Mesa have constructed such a system, which will eventually interconnect to that of Maricopa County. Pima County has a trunked system as well, but it is not compatible with Maricopa County's. The City of Tucson is contemplating constructing its own trunked system. ADOT's Phoenix Construction and Maintenance Districts operate an older I-D system, which cannot be easily linked with any of the other 800 MHz trunked digital systems in the metro Phoenix area. The only 800 MHz interoperability currently available could occur through the National Common-Calling Channel ("USA-1"), or through the White Tanks and Thompson Peak repeaters, and then only with some of the mobile and portable radios in the ADOT system.

Infrastructure dependent solutions also include off-the-shelf, portable cross-patching systems such as the Raytheon (formerly JPS) ACU-1000 that can provide interoperable radio communications during incidents. This technology allows ad-hoc and as-needed cross-connectivity to multiple, normally incompatible, radio systems. While these units are popular with many agencies, their operation has been problematic when connected to digital or trunked radio systems. Their operation requires complex skills and constant presence of the cross-patching operator, resulting in high operations and maintenance cost. Generally intended for portable, incident command use, these types of cross-patching systems do not appear to offer the range required for implementing permanent regional interoperability. As a result, the ACU-1000 and similar devices are not considered a good radio interoperability solution for ADOT and its partner agencies. If needed by ADOT, these units are expected to be available from ADEMA and / or county government partners.

RECOMMENDED RADIO INTEROPERABILITY SOLUTIONS AND STRATEGIC PLANNING

The needs assessment resulted in four master goals that were formulated and refined through this research:

I. Interoperability Among All ADOT Highways Division (ITD) Radios.
II. Interoperability Among Every MVD Enforcement Vehicle Radio and Every Highways Division Radio.
III. Interoperability Among Every ADOT Radio and Every DPS Radio.
IV. Interoperability Among Any ADOT Units Responding to Incidents and Other Agency Responders.

The specific improvements aimed at providing improved radio interoperability within ADOT and among ADOT and its partners are outlined as action items within each of the four key goals, and vary from partial or local solutions to statewide interoperability strategies. To test the recommended concepts while advancing the interoperability through low-cost initial investment, five pilot projects were defined. Finally, in addition to the discrete action items aimed at advancing each goal, a long-term strategy is recommended as a separate item, due in part to its relatively high cost.

Goal I: Interoperability Among All ADOT Highways Division (ITD) Radios	
Action Items	Cost
1. Develop cross-patch training program	$10,000
2. Statewide cross-patch training of district users	$10,000
3. Modify the TOC console	$20,000
4. Additional channels for district consoles (incl. new Flagstaff console)	$329,000
TOTAL:	$369,000

Goal I focuses on improved interoperability between ADOT's Phoenix Maintenance District units, operating on 800 MHz, and the Maintenance units of surrounding districts, which use VHF radio; and on improved communications between VHF Maintenance units, which are too widely separated to communicate through a single mountaintop site repeater.

These objectives can be addressed technically through dispatch console cross-patching. Interoperability between the Phoenix District and the rural districts can be achieved by cross-patching on the Phoenix TOC console. Communications between VHF Maintenance units statewide can be accomplished through the Phoenix TOC dispatch consoles, or on a more limited, regional basis, through the rural district office remote dispatch consoles. Most console setups would require additional hardware to accommodate cross-patching across district boundaries.

Goal II: Interoperability Among Every MVD Enforcement Vehicle Radio and Every Highways Division Radio	
Action Items	Cost
1. Reprogram MVD's VHF mobile radios statewide	$3,500
2. Develop cross-patching training program for TOC operators	$10,000
3. TOC operator training on MVD / Highways Division cross-patching	$10,000
4. Re-write ADOT radio operations manual	$10,000
5. Upgrade TOC consoles to dispatch MVD	$50,000
TOTAL	$83,500

Immediate Goal II interoperability can be achieved by programming the Highways Division channels into MVD vehicular radios statewide, thus allowing direct unit-to-unit short-range communications, longer distance communications through ADOT repeaters, and MVD radio access to the TOC operators after 5 PM and on weekends for emergency situations. As in Goal I, developing procedures and proper training will be essential to successful interoperability. Continued operator and user training, testing and exercising of the procedures and equipment will be necessary to ensure proper operation.

Allowing MVD access to all other services of dispatch radio that are available to ADOT Highways units 24/7 through the Phoenix TOC can be accomplished by combining MVD dispatch at the TOC on one or more dispatch consoles. This will involve resolving operational problems such as MVD's security requirements and access to the dispatch

area. It is recommended that ADOT continue to study this issue, and combine MVD dispatch operations at the TOC as soon as practical. The TOC Motorola console central electronics would need to be expanded by 23 channels to accommodate the combined operations.

Goal III: Interoperability Among Every ADOT Radio and Every DPS Radio	
Action Items	Cost
1. Establish ring-down circuits from TOC to all DPS dispatch centers	$3,000
2. Fiber multiplexing equipment for TOC-DPS link	$25,000
3. Reprogram 2000 ADOT VHF radios with IARS and VHF "State"	$50,000
TOTAL	$78,000

Accomplishing Goal III will involve: (a) providing a ring-down telephone circuit from DPS Phoenix, Flagstaff, and Tucson dispatch centers to the TOC to speed transfer of critical information - these circuits would be carried over the DPS microwave system from Tucson and Flagstaff, and linked with the dark fiber between the TOC and Phoenix DPS communications, and (b) establishing cross-patch circuits over the fiber between the TOC and the DPS Phoenix microwave room, which would allow for cross-patching of DPS circuits dispatched out of the Phoenix, Flagstaff, and Tucson dispatch centers to any ADOT statewide Highways channel through the TOC consoles.

Establishing effective policies, procedures, and training will be critical in achieving Goal III because of the involvement of multiple dispatch centers and agencies in the cross-patching. Monthly test and training exercises will be important to maintaining the knowledge, skills, and equipment necessary to ensure that a cross-patch can be successfully made when emergency circumstances demand.

In addition, ADOT could also access the old VHF "State" channel on a shared (non-exclusive, occasional) basis to have direct access to a DPS dispatcher (most MVD radios already have this channel programmed into their vehicular radios). This would allow, in some limited areas of the State, quicker access to a console cross-patch to a DPS officer, since the ADOT TOC would not need to be directly involved.

Goal IV: Interoperability Among Any ADOT Units Responding to Incidents and Other Agency Responders	
Action Items	Cost
1. Nine ring-down lines to ADOT offices and ADEMA	$9,000
2. Fiber multiplex equipment to link TOC and 800 MHz systems in Maricopa	$25,000
3. Reprogram 2000 ADOT VHF radios with IARS and VHF "State"	$50,000
TOTAL	$84,000

The path to reaching Goal IV is complex as it involves a multitude of agencies statewide, with different protocols, procedures, and operating many different types of radio systems

on various VHF, UHF, and 800 MHz bands. The recommended solutions combine coordinated planning and technology.

Common communications planning practices used by public safety agencies on a daily and emergency basis should be adopted. These will involve lists of frequencies, radio channels, CTCSS tones, and mnemonics or acronyms that have been agreed upon between the participating agencies for an agency or activity that will be universally implemented at a specific date and time, within a defined region or area. The set-up of interoperable radio communications under emergency situations should be practiced frequently. It is the emergency command staff's responsibility to determine if existing communications equipment brought by a supporting agency will be used, or if they will be required to use other communications equipment provided by the designated Incident Command agency. In order to complete statewide deployment of all finalized ADOT communication plans, ADOT should identify either a primary statewide communications manager or consultant for management of all facets of implementation.

The following immediate actions are recommended:

- ADOT should sign intergovernmental agreements (IGAs) with partner agencies to exchange existing VHF mobile radio channels
- ADOT should reprogram its VHF vehicular radios to operate on the national Interagency Radio System channel (IARS), to enable access to many other VHF agencies statewide and to several of the county sheriff dispatch centers.
- Authorize each ADOT district office to add supplemental channels to the current statewide ADOT VHF communications protocol.
- No ADOT radios should be authorized to vary from the approved communications plan or channel assignments, which should be "enforced" by ADOT technical support and DPS telecommunications staffs.
- All future construction contracts that require the use of ADOT or DPS personnel or equipment should provide for the use of VHF radios programmed to a specific district ADOT communications plan, with the contractor identifying which radio channels will be used at the sites. Any gaps in the radio communication coverage should be filled by using temporary repeater systems.
- ADOT should meet on a regular basis with district partner agencies to review interoperability issues to allow modifications to protocols and procedures.
- ADOT and DPS should work out consistent mnemonics, acronyms, and other channel identifiers. All references to radio sites and previous channels names or numbers should be eliminated. *Only* the new names/acronyms/mnemonics should be used and strictly practiced.
- The Phoenix Construction and Maintenance Districts should kick off regular discussions with key ADOT partners to review potential solutions based on available cross-patching technologies. Short-term interoperability solutions would be managed through the TOC, and installed and administered using ADOT and DPS telecommunications support.

From the hardware perspective, direct telephone ring-down circuits between ADOT's Phoenix TOC and the dispatch centers of ADOT's core partners should be installed. These lines will allow ADOT immediate contact and identification of telephone calls from and to those agencies that need a higher priority of response than standard incoming telephone calls. The direct lines will also eliminate any communications delays associated with the overloading of the telephone company's central that may be experienced during regional emergencies. The lines should be established, at the minimum, between the TOC and the dispatch centers of ADOT district offices, the MVD, the DPS, and the statewide ADEMA Communications Center. The success of this task will rely on ADEMA's willingness to revise any current communications plans to actively include selected ADOT channels for use in major emergencies.

LONG-TERM INTEROPERABILITY STRATEGIES

ADOT should support the long-term solution to statewide interoperability proposed by the Public Safety Communications Committee (PSCC), which is for a new, integrated statewide digital system. The PSCC's draft recommendation is for a statewide 700 MHz digital trunked radio system conforming to APCO Project 25 standards. The system, with options of 90% and 95% geographic-area coverage, would include (among many other features), interoperability improvements between existing modern 800 MHz trunking systems as well as legacy conventional VHF and UHF systems.

The total costs to the State are estimated to be in excess of $300 million, and the design-construction time frame is six years minimum. The deployment of the new system would begin with the rebuilding the State microwave network. The all-700 MHz system would likely be expensive, requiring new sites to fill in gaps in coverage and replacement of all ADOT mobile and portable radios. The costs shown here represent the overall order of magnitude of deploying the new 700 MHz system statewide.

Goal: Long-Term Statewide Radio Interoperability	
Action Items	Cost (millions)
1. Replace Statewide DPS Microwave Network	$60M
2. Construct a new statewide 700 MHz interoperable radio system	$300M
3. Procure 3000 new 700 MHz mobile/portable radios	$9M
TOTAL	$369M

PILOT PROJECTS

Five pilot projects are suggested, consistent with the recommended action items for the four interoperability goals. Each of the projects constitutes a test of a recommended solution and moves ADOT along the path toward short- and medium-term improvements in statewide interoperability. These pilot projects address interoperability of the ADOT Highways Division, MVD Enforcement, and one of ADOT's core partners – DPS.

No.	Pilot Project	Estimated Cost
1	Expand VHF Infrastructure-Independent, car-to-car, local interagency interoperability along I-40 by reprogramming key ADOT Maintenance vehicle radios.	Under $5,000
2	Reprogram MVD mobile radios with ADOT VHF statewide channels. Provide for emergency after-hours access to the TOC dispatch center for MVD.	Under $5,000
3	Install "hard" cross-links on the TOC dispatch console between specific 800 MHz Maintenance talk-groups, and adjacent district VHF Maintenance channels.	Under $50,000
4	Install low-cost VHF mobile radios in DPS Highway Patrol vehicles in all squads that operate along I-40.	Under $100,000
5	Provide for dispatch console gateways to link DPS channels, to ADOT's VHF and 800 MHz Maintenance systems.	Under $100,000

SUMMARY

This Phase 1 communications systems research analyzed specific challenges of radio interoperability for ADOT and its core and incidental partners and recommended short- and long-term actions and strategies to incrementally address the expressed interoperability needs. The results of this project outline effective transportation interoperability solutions that can be applied locally and statewide, and support ADOT's planning and future tests and deployments, for operations and for local and regional incident response and command.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

Communication is the key to all Arizona Department of Transportation (ADOT) operations and emergency response roles in both rural and urban areas of Arizona. ADOT's responsibilities include daily maintenance and construction, event traffic management, incident response, and regional security issues. These activities require reliable means of radio communications within ADOT and among ADOT and other agencies. Currently no single radio frequency allows for all responder groups to talk to each other. A critical need exists for secure cross-channel communications, using the present radio systems, both within ADOT and with its transportation-agency and emergency-response partners of all levels. Radio interoperability technology can overcome the lack of a common frequency, channel, or system among response team agencies, and across jurisdictional boundaries.

To quote an industry reference, "Put plainly, interoperability makes sense. It's a cost-saver, a resource saver and a life-saver. Moreover, interoperability encourages inter-agency cooperation" (Hess, 1993). Homeland security concerns have created a new incentive, and new resources, to address key communications issues at all levels through strategic plans and interagency partnerships. However, the critical focus on homeland security must not downplay transportation-specific concerns. This Phase 1 transportation communications systems research project addresses specific current challenges of radio interoperability for ADOT and for its transportation-agency partners.

1.2 RESEARCH OBJECTIVES

By mandate, ADOT is always a primary responder and often the lead agency for incidents, events, and operations on state highways. ADOT's role requires reliable real-time communications both internally and with its partner agencies.

Currently in Arizona, as in most other states, no single radio frequency or hardware system will allow transportation agencies to talk to each other. Radio systems of many agencies, including ADOT, are largely antiquated. Person-to-person or vehicle-to-vehicle communications are frequently effected through a patchwork of local solutions, which include radio swapping, use of cellular phones, and almost any other means of communications to get the job done.

This program was launched to enhance ADOT's performance in homeland security, enforcement, incident management, and daily operations, by improving interagency communications. The Phase 1 Needs Evaluation, presented in this report, assessed the current ADOT capabilities, constraints, problems, practices, and equipment, as well as those of ADOT's partner agencies.

One key goal of Phase 1 was to begin developing a broad understanding of the radio systems, frequencies, hardware, software, and operating plans currently in use by local

and regional transportation agencies. This information will support ADOT's strategic planning and the Department's coordination with the state-level communications upgrade programs for homeland security. Another key goal was to review and recommend interoperable communications system configurations and processes for Arizona's rural transportation system.

This research was tasked with developing recommendations of viable radio systems configurations, e.g. central, regional, or district-level system, or some combination thereof, supporting both ADOT's internal needs and its partnership responsibilities. The effort included the development of pilot projects to test and validate study recommendations under the communications conditions of rural Arizona. The specific objectives of this project were to:

- Document the current state of communications interoperability within and among Arizona's transportation agencies.
- Identify potential deficiencies.
- Recommend potential solutions.
- Develop a test plan for the proposed solution.
- Report and present findings.

1.3 STUDY PARTICIPANTS

ADOT's Homeland Security Communications team and the Kingman and Flagstaff Districts were joint sponsors for this project, with technical and advisory support from the Arizona Department of Public Safety (DPS) and Federal Highway Administration (FHWA). Local and regional partner agencies in and around Arizona were contacted and participated, directly and indirectly, in this research. Those 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 USE OF RESEARCH RESULTS

This project will help define effective transportation interoperability throughout Arizona, and it will directly support ADOT's planning and future tests and deployments, both for day-to-day operations and for local and regional incident response and command.

1.5 REPORT ORGANIZATION

Chapter 2 - EXISTING ARIZONA RADIO NETWORKS, discusses the history and evolution of the prevalent public land mobile dispatch radio systems in use in Arizona and explains the key communications notions utilized throughout this report.

Chapter 3 - PARTNER AGENCY INPUT, provides a summary of the feedback received during the focus groups conducted with ADOT's interoperability partners throughout Arizona and describes the results of an interagency table-top exercise conducted to simulate radio communications needs during a highway incident.

Chapter 4 - NEEDS ASSESSMENT, provides an assessment of interagency radio interoperability needs in Arizona, which were identified by working with the various project stakeholders.

Chapter 5 - INTEROPERABILITY SCENARIOS, discusses some of the circumstances brought up by the project stakeholders where radio interoperability is likely to enhance ADOT's and partner agencies' operations.

Chapter 6 - INTEROPERABILITY TOOLS AND CONCEPTS, describes key technology concepts applicable to this research.

Chapter 7 - RECOMMENDED INTEROPERABILITY SOLUTIONS AND STRATEGIC PLANNING, introduces a number of short-, mid-, and long-range recommendations aimed at providing radio interoperability between ADOT and its partners, in the context of the agency systems and plans discussed earlier in the report.

Chapter 8 – CONCLUSIONS, summarizes the study goals and recommendations.

1.6 ACKNOWLEDGEMENTS

ADOT's Lonnie Hendrix and Tim Wolfe (Homeland Security Communications Team), along with the Flagstaff and Kingman District core staffs, are the program and project champions. Steve Owen was the ATRC project manager during this *Transportation Communications Interoperability: Phase 1 – Needs Assessment* research project. A Technical Advisory Committee (TAC), listed below, gave guidance and support to the consultant team.

Technical Advisory Committee

TAC Member	Agency / Section
Lonnie Hendrix	ADOT Homeland Security Communications Team
Tim Wolfe	ADOT Transportation Technology Group
John Harper	ADOT Flagstaff District
Kent Link	ADOT Flagstaff District
Jeff Swan	ADOT Holbrook District
Rance Spurlock	ADOT Kingman District
John Hauskins	ADOT Phoenix Maintenance District
Steve Puzas	ADOT Safford District
Jim Dorre	ADOT Central Maintenance
Courtney Perrier-Bear	ADOT HAZMAT (Hazardous Materials Safety) Team

TAC Member	Agency / Section
Lisa Mattke	ADOT Information Technology Group
Denise Johnson	ADOT Information Technology Group
Lori Elzy	ADOT Motor Vehicle Division - Enforcement
Scott Grissom	ADOT Motor Vehicle Division - Enforcement
Sonya Herrera	ADOT Safety & Health
Manny Agah	ADOT Transportation Technology Group, Traffic Operations Center
Curt Knight	Arizona Department of Public Safety - Telecommunications
Alan Hansen	Federal Highway Administration

Consultant Team

Team Member	Company
Michael Wendtland	ITS Engineers & Constructors, Inc.
Mike Klein	ITS Engineers & Constructors, Inc.
Andrew Kolcz	ITS Engineers & Constructors, Inc.
Rick Tannehill	Rick Tannehill, PE & Associates
Mark Schroeder	Rick Tannehill, PE & Associates
Carl Gruhn	Rick Tannehill, PE & Associates

2. EXISTING ARIZONA RADIO NETWORKS

2.1 INTRODUCTION

Documenting the existing radio systems, communications processes and interoperability issues was one of the objectives of this needs assessment effort. Chapter 2 provides a review of these topics based in part on the feedback provided by project stakeholders. DPS communications management staff and members of the project Technical Advisory Committee provided additional input and corrections.

2.2 MAJOR RADIO SYSTEMS IN ARIZONA

Public agency radio systems in use in Arizona are a melange of technologies, frequencies, protocols, and hardware that were acquired or developed over several decades. While some agencies, like ADOT or DPS, use mostly standardized systems statewide, others rely on a variety of solutions with limited compatibility. Table 1 presents a high-level summary of the agency radio systems in use today. The remainder of Chapter 2 describes the history of the more prominent radio systems in the state and their current operations.

Table 1 – Major Agency Radio Systems in Arizona

	RADIO SYSTEM		
	VHF	**UHF**	**800 MHz**
Agency Name/Description	**150-174 MHz**	**450-470 MHz**	**806-869 MHz**
DPS - Highway Patrol		X	
ADOT Maintenance / Construction	X		
ADOT Phoenix Maintenance/ Construction			X
ADOT ALERT (Phoenix metro area freeways)			X
ADOT Motor Vehicle Division	X		
County Sheriff Departments	X	X	X
County Road Departments	X	X	X
County Emergency Management Coordinator	Uses all of the systems of the host county		
Municipal Police Departments	X	X	X
Municipal Fire Departments	X	X	X
Municipal Emergency Medical Services (EMS)	X	X	X

2.2.1 ADOT Radio System - Historical Overview

The Arizona Department of Transportation has operated several two-way radio systems since the 1940's. These early systems used Low-Band (30-50 MHz) simplex frequencies. The ADOT statewide Maintenance radio network operated on a Low-Band system until the late 1960's. Between 1967 and 1970 that system was converted to VHF High-Band (150-174 MHz -VHF) repeater system. The Motor Vehicle Division continued to operate a simplex Low-Band statewide system until 1997-2000 when it was also upgraded to VHF frequencies. Between 1990-1994, an 800 MHz trunked radio network was developed for both the Phoenix Construction and Maintenance Districts, in order to support the massive freeway construction program that began a few years earlier.

ADOT's radio systems use the DPS statewide microwave network for control of the base/mobile-relay stations at their dispatch control points in the district offices, and at the Phoenix Traffic Operations Center. Although DPS and ADOT share the microwave network, their respective radio systems are not interconnected. DPS uses UHF frequencies and is not directly interoperable with any of the ADOT radio systems that operate on VHF and 800 MHz frequencies.

2.2.2 ADOT Maintenance and Construction Radio System

The statewide VHF Maintenance/Construction radio system was developed between 1967-1970. The initial system comprised four repeater channel pairs (156 MHz repeater output, 151 MHz repeater input). Originally, the Phoenix District utilized one of the pairs, with the remaining pairs used by the other three ADOT districts. Later, ADOT reorganized into seven construction and maintenance districts. The three rural channel pairs were reallocated to the opposite sides of the state, allowing continued operation, without interference between districts using the same channels. Around 1990, ADOT reorganized into 10 statewide maintenance/construction districts. The radio frequencies were again reorganized, but with only three pairs available (the centrally located Phoenix District touched all the others, so its channel was not reusable), there was overlap between district coverages from various base station sites. This was minimized as much as possible with antenna pattern shaping, and use of additional CTCSS tones, known as PL tone squelch. Finally, in 1998, the Phoenix District VHF channel was taken out of service and reallocated as the Motor Vehicle Division's southern regional channel.

The ADOT Maintenance/Construction radio system uses decentralized dispatching. Each district office, except Phoenix Construction and Maintenance, has a small radio dispatch console. Each console typically controls only the channels within the local district. The Prescott District controls many additional channels of the Yuma and Kingman districts due to the need to provide dispatch to other groups beside maintenance over the entire western portion of the State. Flagstaff dispatch also controls several additional channels for groups other than construction and maintenance. These dispatch consoles are manned during normal business hours (8 AM to 5 PM) and have very limited cross-patch capability for interoperability. Interoperability is typically limited to other ADOT VHF channels appearing on the console.

In general, it is difficult for a maintenance unit in one district to talk to a unit in another, if both cannot access the same repeater station at the same site. Except for occasional complaints of dead spots in coverage, this system generally serves the rural ADOT services well. The DPS Engineering Section generally reviews the dead spots to determine if any of the existing DPS high radio sites can provide the needed additional coverage. If an additional station can resolve the coverage problems, a new station is planned and budgeted. If no site is available to fill the dead spots, no action is taken. ADOT understands that their system is designed for mobile radio coverage along the highways; not for portable radio coverage, since these operate at a much lower power level.

There are four dispatch console operator positions at ADOT's Phoenix TOC (part of the Freeway Management Center). These dispatch consoles control every VHF ADOT Maintenance/Construction channel in the state. At least one of these consoles is theoretically monitored on a continuous basis. They also provide daytime backup in the event that a district console is out of service.

The first generation of ADOT VHF radios were not capable of interoperability. Those radios were crystal-controlled, capable of only four channels, and had a 2 MHz bandwidth limitation for both transmitting and receiving. The early radios were replaced between 1979 and 1982 with more modern units with up to 32 channels and 20 MHz of bandwidth. Unfortunately, all 32 channels were necessary to accommodate the statewide matrix of ADOT radio frequency (RF) channels and tone frequencies. Several later models of these newer radios provided additional channels. A few of the units used in northern Arizona, primarily in the Flagstaff District, were programmed with operating channels of other local jurisdictions, including Coconino County, the City of Flagstaff, the City of Williams, and other agencies. However, since the DPS had converted its radio network from VHF to UHF in the late 1970s, interoperability with DPS winter storm patrolling or accident operations was still not possible.

ADOT's statewide VHF Construction/Maintenance radio network underwent another round of equipment upgrades, beginning in the mid-1990s. The State purchased new base stations, repeaters, and mobile radios that currently operate in the wideband mode, but are capable of narrowband operation on a channel-by-channel basis, in compliance with FCC (Federal communications Commission) rules. The new mobile radios (MA/Com-Orion) are capable of 192 channel operation over a bandspread of 150-174 MHz, allowing for a great deal of flexibility in supporting interoperability statewide. At this time, all but 300 (out of 2000) of the older Motorola mobile radios have been replaced. The program should be completed in the next fiscal year (2004-05); however, many older portable radios, which are not capable of narrowband operation, remain in use in the districts. Most of these older radios are only capable of 16-channel operation. All of the newer radios could be programmed to use the national 155.475 MHz public safety interoperability channel and the new narrowband interoperability frequencies, once the adjacent channels are cleared.

Currently, ADOT has over 2000 VHF Orion mobile radios, and nearly 1000 VHF portable radios of all types. This includes MA/Com MRK -II units capable of statewide

operation, and a number of very inexpensive 16 channel portable radios limited to one or two district VHF operation. There are 54 MA/Com Orion fixed consolette utility radios in construction and maintenance offices around the state.

In summary, the ADOT rural Construction/Maintenance VHF radio network is a fairly good analog system, with new, modern radio equipment. However, it lacks many of the features of a modern digital public safety radio system, and a level of intra-operability between districts, and multi-agency interoperability that is desired.

2.2.3 ADOT Motor Vehicle Division Radio System

The Motor Vehicle Division (MVD) radio system was converted to VHF repeater operation between 1997 and 2000. The old Phoenix Maintenance District repeater channel was recycled as the Southern Regional MVD channel. Another pair of frequencies formerly used by the DPS, and currently utilized in Southern Arizona by the Department of Corrections, was designated as the Northern Regional MVD channel. A number of separate PL tones were designed into the system to prevent overlap of coverage from different high sites. There are currently 23 high-site repeater stations in the system.

The system is dispatched statewide from the MVD's 25th Avenue office in Phoenix, located under the Interstate 10 freeway. The dispatch center is linked by commercial landline to the DPS microwave room in Phoenix. Due to personnel limitations, it operates only from 8 AM to 5 PM, and it is *not* backed up after hours by the ADOT TOC. This set-up was intentional at the time of the last TOC dispatch console upgrade, due to issues regarding secured access to NCIC/ACIC law enforcement data by all dispatch operators within the facility. The 23 statewide MVD channels could be added to the TOC console, with some additional hardware and software modifications, but this does not appear to be viable at this time due to costs, and operational certification requirements.

All but 30 out of roughly 150 MVD mobile radios are new MA/Com Orion units, capable of 192 channel wideband and narrowband interoperable channel operations. Likewise, their base stations and repeater stations are new and capable of narrowband channel operation. MVD also has a number of VHF *portable* radios capable of narrowband operation as well as some older units purchased before the actual VHF conversion began, which are only capable of wideband operations.

Most of the MVD mobile radios and some of the portable radios have the national VHF interoperability channel (155.475 MHz) and the old DPS statewide VHF channel (154.935/155.190 MHz) programmed into them. MVD would like to have other agency's channels programmed into their radios, which can be accomplished after MVD obtains letters of authorization from these other agencies.

MVD would also like to have 24-hour dispatch operation but budgetary limitations prohibit this in the foreseeable future. A plan to share dispatch facilities and personnel with the State Agriculture Department was abandoned. The Department of Agriculture requested a cross channel agreement from ADOT-MVD but was turned down in June

2004, based on current statewide Public Safety Communications Committee (PSCC) and DPS planning activities and due to MVD system capacity constraints.

There are about 140 MA/Com VHF mobile radios in the MVD system statewide, and only about 20 VHF portable radios in the system. There are about 15 MA/Com Orion consolette radios at MVD ports of entry statewide.

Like the ADOT VHF rural Construction/Maintenance radio network, the MVD radio network is a fairly good analog system, with new, modern radio equipment. However, it lacks many of the features of a modern digital public safety radio system, and a level of intra-operability and interoperability that is desired.

2.2.4 ADOT Phoenix District 800 MHz Trunked Radio System

In 1990, major construction of the Phoenix freeway network was underway. ADOT requested three additional VHF repeater channels and three supplementary simplex frequencies to support the vastly increased scale of construction operations. At that time, there were no additional VHF channels (either simplex channels or duplex pairs) available in the Phoenix metropolitan area. To solve this problem, ADOT Construction agreed to finance the backbone of an 800 MHz trunked radio system. Motorola was chosen as the contractor to provide an 8-channel, 4-site simulcast Smartnet system. Construction of the system was completed in 1997. A 10 GHz digital microwave network, shown on a map in Appendix F2, links the four sites:

- White Tanks Mountain
- South Mountain
- Thompson Peak
- Shaw Butte

This network is independent of the State analog microwave network. The system is configured for 15 talk groups for Phoenix Maintenance and Construction, and four talk groups for the MVD (Note: MVD abandoned the use of this system in 2000 after their own VHF system was constructed). Currently, there are a total of about 400 Motorola vehicular radios (Primarily Maxtrac and MCS2000) and 350 portable radios (mostly MTX-810 and MTX820) in the system.

Dispatch of the system is handled by the ADOT TOC, through the TOC's four dispatch console positions. These consoles were upgraded at the end of 2002 to what was then the latest Motorola configuration. The TOC controls all talk groups, with the exception of those set aside for MVD. There is no back-up dispatch point for this system, other than utilizing remote control stations on a single talk group basis.

The system, which operates on wideband channels, has performed well over the years. However, with the exception of the dispatch consoles, its equipment is now obsolete and should be replaced over the next five years. Almost none of the equipment is capable of operating on narrowband channels, although this is not a necessity for the frequencies that ADOT currently has licensed. This makes operating on the national 800 MHz

interoperability channels difficult, since those channels are limited to narrow KHz bandwidth, and the trunked system operates on a wide bandwidth. In addition, many of the radios purchased in the early years of the 800 MHz project are not capable of operation on the higher frequency National Public Safety Planning Advisory Committee (NPSPAC, see Glossary) interoperability channels. The radios that are capable of narrowband operation could be programmed onto the NPSPAC Common-Calling and interoperability channels, including the National Common-Calling channel, known as USA-1 (see Glossary). This would allow a level of limited interoperability with the new City of Phoenix and City of Mesa radio systems on the national interoperability channels. Maricopa County, as well as the Cities of Glendale, Tempe, Goodyear, and Chandler also operate older type 800 MHz radio systems, which are thought to be compatible with the national interoperability channels.

At the present time, no 800 MHz system interoperability exists, except by cross-patching to other ADOT VHF statewide channels on the TOC consoles. This is rarely done, perhaps out of lack of need, or possibly lack of training. If the TOC consoles had channels linked through the ADOT microwave to the DPS microwave hub in Phoenix, limited interoperability with DPS UHF channels in the State could be obtained.

Some Phoenix Maintenance District personnel have become concerned that they can no longer talk directly to rural maintenance units from adjacent districts of the Phoenix metro area, without having two radios in their truck. One possible solution is to move Phoenix Maintenance back onto VHF frequencies. However, there are insufficient channels available to accommodate all the existing Maintenance talk groups currently on the 800 MHz trunked system. This would also remove the instant interoperability with Phoenix Construction District radios. A better solution is build a semi-permanent 800 MHz to VHF system gateway for stations around Phoenix, which would not require operator intervention through the TOC dispatch consoles. This could link any of the three VHF district frequencies on White Tanks Mountain, or the two on Mount Ord, to the trunked system Maintenance-Admin talk group.

2.2.5 Partner Agency Radio Systems

Urban Partner Radio Systems

The primary public safety organizations in Maricopa County are moving or have already moved to the 800 MHz band. The new Phoenix-Mesa 800 MHz trunked system will bring with it the entire Phoenix Fire Consortium, made up of users from across the entire Valley. Users whose systems are already on 800 MHz include Chandler, Gilbert, Tempe, Glendale, Scottsdale, Goodyear, Paradise Valley, Maricopa County, and ADOT's Phoenix Maintenance and Construction Districts.

The Arizona Regional Review Committee (ARRC) anticipated this movement in 1990, and set up a plan to strategically place mountaintop wide-area repeaters on the national Common-Calling channel, known as USA-1. These repeaters are in place on Thompson Peak and White Tanks Mountain. They are monitored by the Maricopa Sheriff's Office dispatchers, and can be cross-patched on demand to the VHF/UHF Interagency Radio

System (IARS). (Note: this system is currently being upgraded with a grant from the Department of Justice)

However, the other five designated 800 MHz interoperability channels are reserved for simplex car-to-car-only operations in Arizona. No acceptable plan has yet been put forth by users to establish fixed repeaters on these channels for emergency interoperability. It is recommended that the ARRC be encouraged to generate their own plan for better utilization of the interoperability channels, probably including some fixed-site infrastructure.

Some ADOT trunked radios can be programmed to operate on these channels, which will allow direct interoperability with most agencies in the Valley. However, many ADOT 800 MHz radios are older models that cannot be programmed on these channels until they are replaced as part of the planned 800 MHz system upgrade over the next few years. After reprogramming those ADOT radios that can operate on USA-1 and the interoperability channels, some limited testing should take place to communicate with Phoenix Police Department officers, Maricopa County transportation personnel, and Maricopa County Sheriff's officers.

Rural Partner Radio Systems

Over 75% of the rural public safety radio systems in Arizona still operate on conventional VHF channels. In general, these are all compatible with the current ADOT VHF mobile and portable radios. Channel trading, that is, programming some of ADOT's VHF channels into a partner agency's mobile/portable radios, or vice-versa, will resolve most rural interoperability problems on a case-by-case basis. This only requires the written agreed consent of both parties, and a few minutes of programming time per radio to effect instant interoperability.

On a broader scale, the IARS system operates on many rural mountaintop sites in the State, and could be accessed by both ADOT Maintenance and MVD radios. Even without a local mountaintop VHF/UHF crossband repeater, ADOT Maintenance mobile and portable radios could be programmed on the simplex VHF-IARS channel for short-range car-to-car universal interoperability with the agencies that also have it programmed.

2.3 EARLY INTEROPERABILITY

Radio interoperability among agencies in the early days of Low-Band operation consisted of simultaneous sharing of the same primary operating channel by as many users as possible. This led to serious congestion of the very few available channels. Worse, periodic ionospheric reflections of radio waves during sunspot cycle peaks caused reception of unwanted signals from thousands of miles away, adding to the congestion and confusion.

After conversion by most users in Arizona to VHF High-Band, this so-called ionospheric skip problem went away. As more channels became available, users tended to split their

operations onto different parts of the VHF sub-bands. Unfortunately, most VHF radios manufactured between 1960 and 1990 were not capable of operating over a wide transmit-or-receive bandspread. This severely limited interoperability to users whose frequencies were within 1-2 MHz of each other. Since 1990, most VHF mobile and portable radios have been constructed to operate over the entire 150-174 MHz band.

Until 2002, the only designated public safety interoperability channels in the VHF spectrum were 155.475 MHz simplex, which was reserved nationwide for police-only interoperability, and 154.280 MHz, which was reserved for fire mutual aid operations. Year 2002 brought several changes that affected radio interoperability in the State. First, the State's Association of Public Safety Communications Officials (APCO) interoperability plan was modified to allow *all* eligible public safety users to have access to the 155.475 MHz channel for interoperability operations. Secondly, the FCC designated five new VHF nationwide interoperability channels on split half-channel offsets. However, these are not usable in Arizona due to the presence of adjacent channel systems still in operation.

2.4 INTEROPERABILITY CHANNELS

There are no nationally or state-designated interoperable channels in the lower 800 MHz spectrum in which the ADOT trunked system operates. However, there are five nationally designated, and one state-designated interoperable channel in *nearby* 800 MHz spectrum known as "NPSPAC" channels. Only an estimated 25 percent of ADOT's mobile and portable radios can operate in this spectrum. This would require a reduction of the radios' modulation bandwidth to legally operate on these channels.

One 800 MHz NPSPAC channel, called USA-1, is the national Common-Calling channel. All public safety users are eligible to access this frequency. In Arizona, ADOT's user interoperability is restricted to USA-1 and Channel 6; a state-designated channel. (See Appendix E for excerpt of the Region 3 NPSPAC Plan).

All of the ADOT radio systems are dependent upon the DPS statewide microwave network for control of the base/mobile-relay stations at their dispatch control points in the district offices, and the Phoenix TOC. Although DPS and ADOT both share this microwave system, their radio systems are not interconnected directly in the network. Also, since the DPS statewide radio network is on UHF frequencies, it is not directly interoperable with any of the ADOT radio systems that operate on VHF and 800 MHz frequencies.

3. PARTNER AGENCY INPUT

3.1 INTRODUCTION

Six focus groups and a targeted survey were conducted between November 2003 and January 2004 to help document radio system information in all corners of the state and to gain a better understanding of the agencies' operational issues, practices, and partnerships related to interoperable radio communications.

The invitation to participate in the project survey was sent out to individuals initially identified by the research Technical Advisory Committee, with additional respondents identified later at the focus groups. The survey was made available by invitation via a secure web site, by mail, and through handouts provided at the focus group meetings. The questions asked in the survey and at the focus groups revolved around topics such as:

- What type of radio equipment do you have? What is its age and condition?
- What radio frequencies does it use?
- Is the radio coverage adequate in your area?
- What radio communications-related problems are you currently having?
- Which other transportation agencies do you need to communicate with?
- What does radio interoperability mean to you?
- What are the typical circumstances that would benefit from having interoperable radios?

A copy of the mailed survey instrument may be found in Appendix B; the online survey content and response summary are provided in Appendix G.

3.2 FOCUS GROUP FINDINGS

Six focus groups were conducted throughout the state to gather input from ADOT districts and from partner agencies. Workshop schedules and locations are noted below:

Date	Location
November 18, 2003	ADOT Administration Building, 206 S 17th Avenue, Phoenix
December 2, 2003	ADOT Kingman District Training Center, 3660 E. Andy Devine
December 3, 2003	ADOT Flagstaff District Equipment Shop Conference Room, 5701 E. Railhead Avenue
December 4, 2003	Holbrook Volunteer Fire Department, 100 W. Airport Road
January 13, 2004	ADOT Safford District Training Center, 2082 E. Highway 70
January 14, 2004	ADOT Tucson District Conference Room, 1221 S. 2nd Avenue

Each focus group event consisted of a morning session reserved solely for ADOT and DPS, and an afternoon session for ADOT and its other local and regional partner agencies. Some of the ADOT and DPS staff who participated in the morning session were asked to remain for the afternoon meeting, if possible. In addition to the invitations

distributed directly by the project team, each ADOT district hosting a focus group invited representatives of the partner agencies or organizations in the region. The focus groups were open to any party that expressed the need or interest in interoperable radio communications with ADOT. The following agencies were represented at each of the workshops:

Phoenix Focus Group (20 attending):

- Arizona Department of Transportation Homeland Security Communications Team
- ADOT Yuma Maintenance District
- ADOT Motor Vehicle Division – Enforcement Services
- Arizona Department of Public Safety
- Federal Highway Administration
- Maricopa County Department of Transportation
- City of Mesa
- City of Phoenix
- City of Peoria
- City of Tempe, including Tempe Police Department

Kingman Focus Group (7 attending):

- Arizona Department of Transportation
- Arizona Department of Public Safety
- Mojave County Emergency Management Department

Flagstaff Focus Group (11 attending):

- Arizona Department of Transportation
- Arizona Department of Public Safety
- Town of Prescott Valley
- Northern Arizona University

Holbrook Focus Group (18 attending):

- Arizona Department of Transportation
- Arizona Department of Public Safety
- Ganado Fire Department
- Puerco Valley Fire District
- Navajo County Public Works
- Navajo Department of Law Enforcement – Window Rock

Safford Focus Group (10 attending):

- Arizona Department of Transportation
- ADOT MVD Enforcement (two ports of entry represented)
- Arizona Department of Public Safety
- New Mexico Department of Transportation
- Safford Police Department
- Graham County Sheriff and Local Emergency Planning Committee

Tucson Focus Group (18 attending):

- Arizona Department of Transportation
- Arizona Department of Public Safety
- City of Tucson Streets & Traffic Maintenance, Traffic Engineering, Operations
- Pima Association of Governments
- Pima County Radio Communications
- Pinal County Emergency Management

Each focus group event was moderated using the following meeting structure:

1. Introductions.
2. Overview of project scope and objectives.
3. Review of interoperability definitions typically used by public agencies.
4. Project survey: participants were strongly encouraged to complete the this survey.
5. Review of the types of communications equipment that was the focus of the survey.
6. Discussion of issues and problems related to radio communications in the region.

The initial topic review (Items 2 – 5) was followed by a general discussion of the particular interoperability needs and circumstances of the focus group participants. The purpose of the discussion was to identify and understand the various conditions that create a need for radio interoperability, how those needs have been addressed in the past, and the desired extent and characteristics of interoperable communications within ADOT and among its partner agencies.

Emphasis was also placed on trying to define any established and ad-hoc interagency communications protocols used by each partner, when some level of interoperability was necessary. The majority of the participants agreed that following a well-designed protocol was a critical element of effective interoperable radio communications systems.

The group discussion addressed both routine situations such as construction and maintenance activities as well as emergencies that might necessitate or benefit from interoperable radio communications. Other circumstances discussed included special events and task forces, sharing of road condition information, and other triggering events brought up by the participants.

Each meeting also included an overview of technologies and practices supporting interoperability. At the end of each session, an effort was made to reach a level of consensus within the group regarding what is needed and what can or should be done to further the cause of regional and statewide interoperability.

The six focus groups and approximately 100 survey responses provided significant insights into the needs assessment process. One particular benefit of both was an improved ability to discern local and regional patterns of circumstances that create the need for interoperability and of typical practices employed to circumvent the current lack of interoperable radio systems.

3.2.1 Primary ADOT Partners

The primary interoperability partners for ADOT's highway operations were identified as the Motor Vehicle Division's Enforcement Services Program, the Department of Public Safety, and the highway contractors actively engaged in current projects for ADOT. The rural MVD officers, particularly those at ports-of-entry, often need to report situations they see and encounter at the ports, and on the highways nearby, but they use a separate radio system. This issue applies to both highway safety and law enforcement situations.

The bulk of the interagency radio communications occurs between ADOT and DPS. DPS patrol officers provide a safe work environment for the maintenance and construction crews operating on the state highways. Communications typically occur face-to-face and via cellular telephone. Some DPS vehicles, especially in northern Arizona, are equipped with ADOT radios that provide a high level of interoperable communications between these two agencies. In a few cases, DPS UHF radios have been placed in some ADOT supervisor vehicles, primarily in the Flagstaff area.

3.2.2 Incidental Partners

Incidental interoperability partners are public safety or public service agencies that work with ADOT on an as-needed basis. The incidental partner relationship is dynamic and varies from agency to agency. These partners include fire, police, county and municipal highway and street maintenance departments, other public works officials, and federal agencies. This group of partners also includes transportation and safety officials in the neighboring states of New Mexico, Utah, Nevada, and California.

One of the most common situations where ADOT needs to be able to communicate with incidental partners via radio occurs when traffic must be detoured from an ADOT-managed highway. When an immediate need arises to reroute traffic onto county or city roads and streets, especially when the detour must be established quickly, it is necessary to coordinate with, or at least inform, the local agency about the detour as quickly as possible. In those situations, the current lack of interoperable radio communications can be a major problem.

Another common example is when ADOT requests the assistance of another agency or responds to another agency's request for assistance. This generally requires radio interoperability between the agencies since most of the coordination needs to occur between field crews, in areas where cell phone coverage may be poor or nonexistent. ADOT's current radio systems and infrastructure do not support the ability to communicate with its incidental partners. As a result, this frequently creates the need to dedicate time and staff resources to physically meet or attempt to locate each other. After meeting and agreeing upon a work plan for the requested support, the ability to dynamically change the work plan is not possible, as the joint resources cannot contact each other remotely, and must suspend operations to make any changes.

In summary, because of the prevalent lack of interoperable radio communications, ADOT staff and incidental partners are often required to physically locate each other and meet face-to-face to coordinate any joint activities. This is an inefficient method of logistical control and presents a significant operational cost to ADOT in the loss of valuable time with assigned resources. This also extends into emergency situations where constant or frequent need for coordination requires that an ADOT employee be in physical contact with the emergency partner, in order for direct communications to occur. The major interoperability needs revealed through the interaction with partner agency representatives are captured in more detail in Chapter 4.

4. NEEDS ASSESSMENT

4.1 INTRODUCTION

This chapter provides an assessment of interagency radio interoperability needs in Arizona, which were identified by working directly and indirectly with the various project stakeholders (ADOT partner agencies). The primary sources of the information used to identify the needs were the radio interoperability survey and focus groups. A complete list of project participants is provided in Appendix H.

4.2 SURVEY OF PRIMARY AND INCIDENTAL PARTNERS

The project survey received 117 responses, with 96 surveys completed thoroughly. Summaries of completed survey responses are provided in Appendix G. The physical distribution of survey participants is illustrated in Figure 1. Responding agencies varied in size from 7 to 12,000 employees. Of these, from 20% to 100% use mobile radios, with an average employee radio usage of 73% per agency, amounting to over 26,000 Arizona radio users.

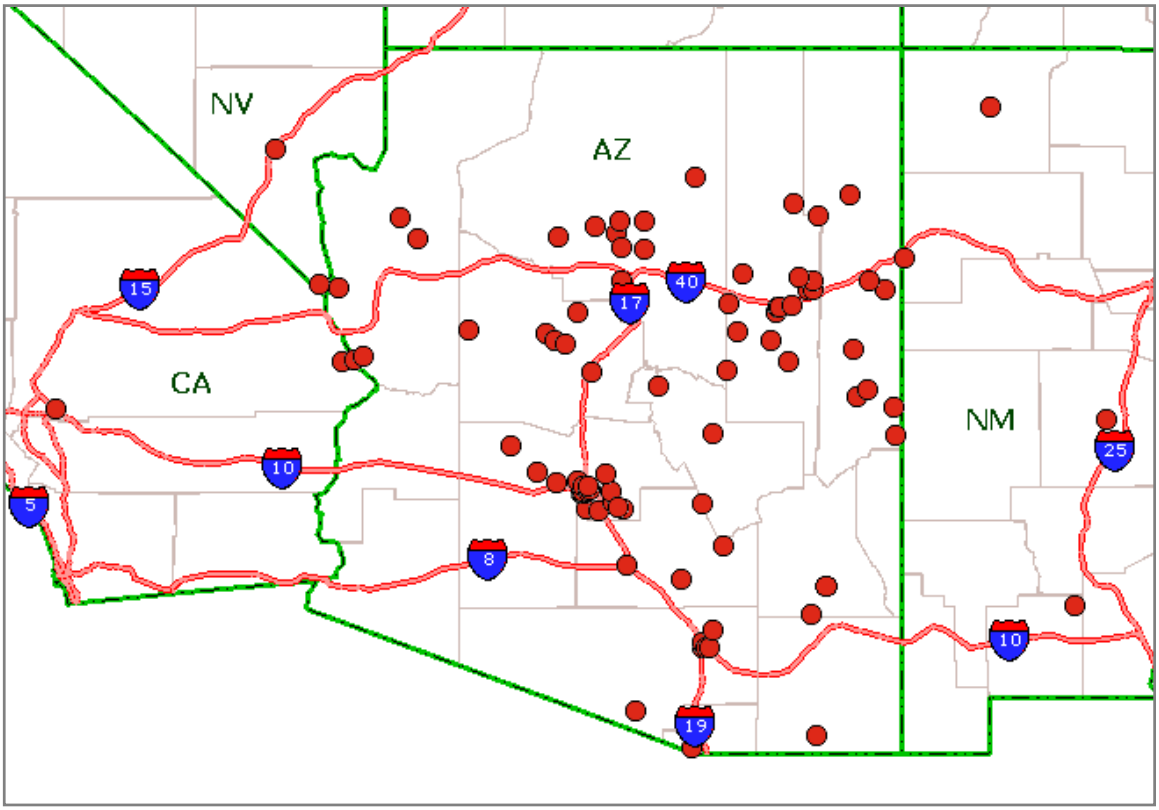


Figure 1 – Distribution of Survey Respondents, by Location

Local topography tends to influence the quality of radio communications. As anticipated, the survey responses indicate that the need for radios communications arises in all types of terrain, with mountainous and hilly terrain noted most frequently.

The most popular devices in use are vehicle-mounted land mobile radios, followed closely by cellular phones and hand-held radios (Figure 2). Pagers are used by approximately 55% of the respondents. Use of other means of wireless communications (satellite phones, Nextel phones, mobile data terminals, and laptop-based terminals) was reported to be between 10% to 15% on average. Radios providing narrowband communications are more readily capable of supporting interoperable systems. Of those respondents who were familiar with the technology used in their radio devices, the split between narrowband and wideband radios was approximately 50:50. Figure 2 shows the combined ADOT and non-ADOT responses.

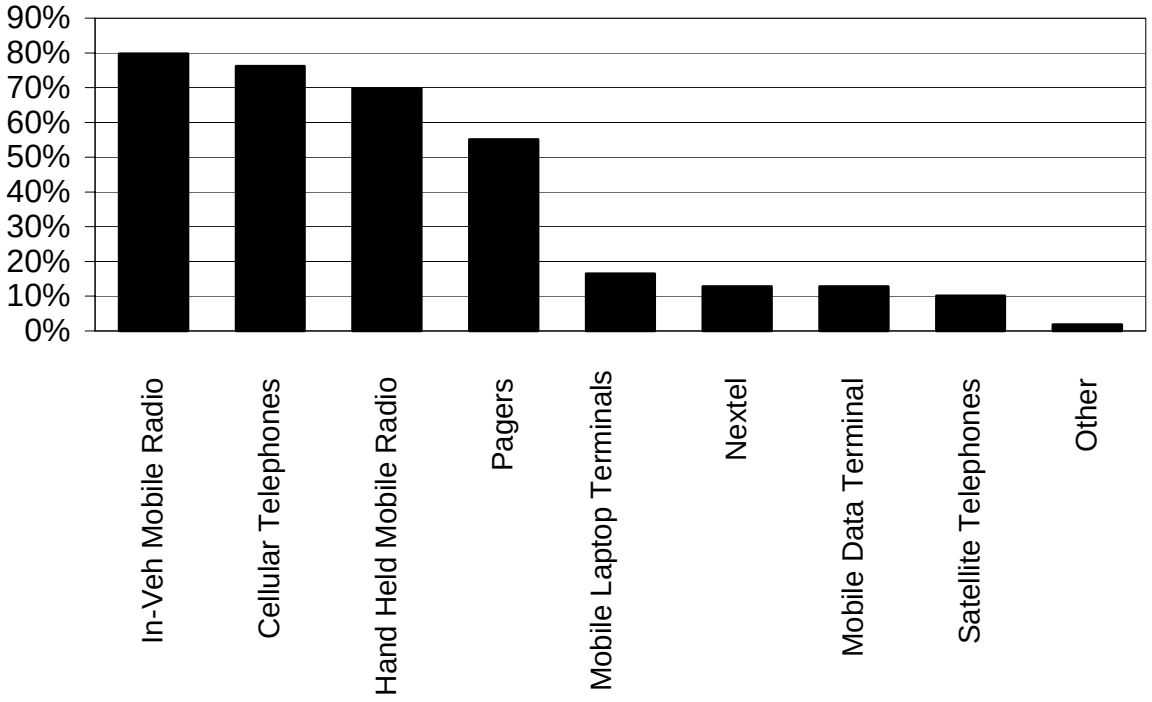


Figure 2 – Device Use by ADOT and Partner Agencies

The following are additional statistics derived from the survey. It should be noted that in many cases the numeric values of the responses do *not* add up to 100 percent. This is because the majority of the questions were structured to allow the respondents to place a value in or check off more than one category. For example, Figure 2 clearly shows that it is typical for any given respondent to regularly use, own or depend on several communication devices, i.e., a radio, a cellular phone, and other means. Additionally, some of the response data appears to reflect uncertainty as to question intent or the particular respondent's roles in his or her agency.

- Between 58 to 66 % of respondents report lack of capability to communicate by radio with ADOT's Maintenance, Construction, HAZMAT, and/or MVD units. Combined ADOT and non-ADOT responses, illustrated in Figure 3, suggest a clear need for improved ability to communicate with the various ADOT divisions. Review of individual responses indicates that the majority of the "yes" answers came from ADOT staff while the bulk of the "no" answers was given by ADOT's partners. The total responses also appear to point out a pattern of decreasing ability to communicate via radio as one moves towards the right side of the chart.

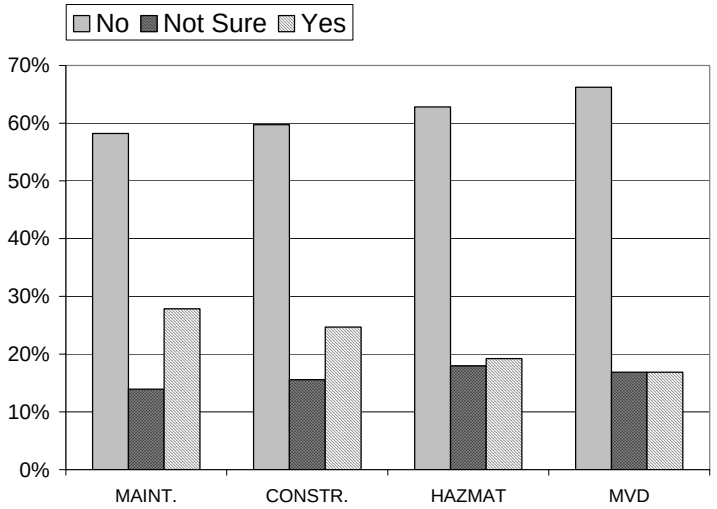


Figure 3 - Ability to Communicate with ADOT via Radio

- One percent of ADOT and 55% of non-ADOT respondents indicated <u>having</u> land mobile radio interoperability with other agencies. At the same time, 13% of ADOT and 63% of non-ADOT respondents said they <u>needed</u> interoperability (Figure 4).

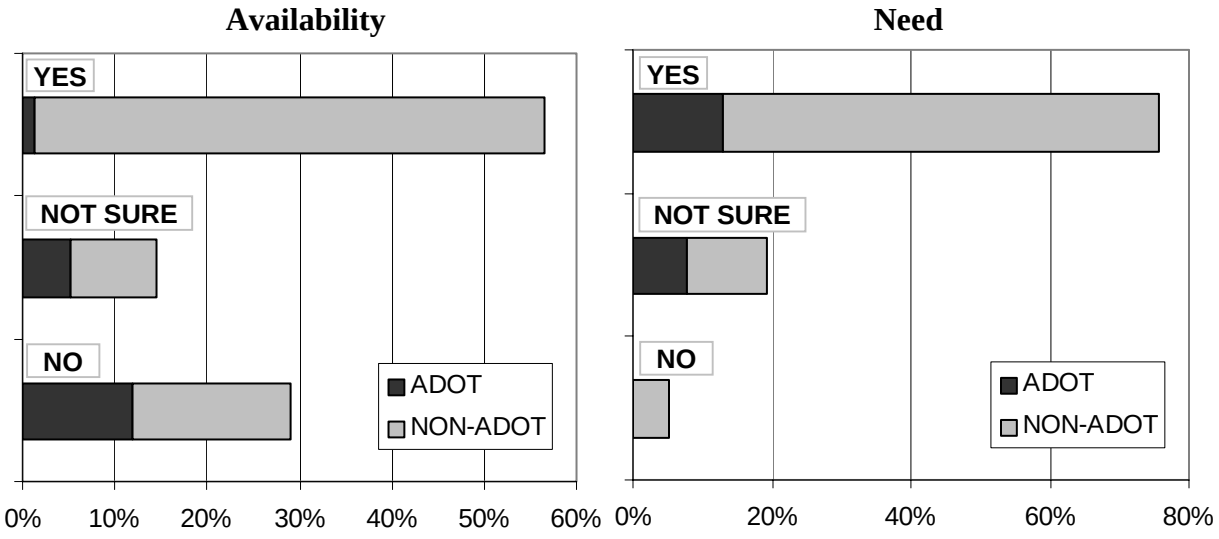


Figure 4 - Availability of and Need for Radio Interoperability with Other Agencies

The ADOT and non-ADOT responses depicted on the two charts making up Figure 4 suggest that agencies outside of ADOT seem to enjoy good availability of radio communications with other agencies (top of the left chart) and consider it an important need (top of the right chart). At the same time, ADOT responses indicate, predictably, a relative deficiency in the availability of radio communications with other agencies, confirmed by a clearly stated need for such communications.

- Nearly 50% of respondents have access to at least one interoperable radio channel, while almost 40% do not. Figure 5 summarizes the combined responses from ADOT and ADOT partner agencies.

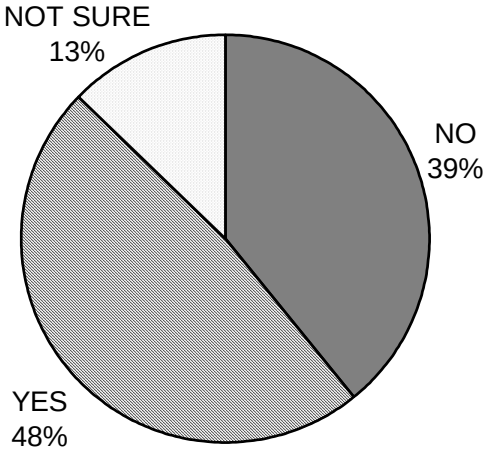


Figure 5 – Availability of Interoperable Radio Channels

- The most common reported reason for interoperability is Infrequent Mutual Aid (Caltrans, Nevada DOT, New Mexico DOT, USDA-Forest Service, various county Public Works), followed by Recurring Mutual Aid (regional transportation, law enforcement and fire agencies) as well as daily communications between ADOT and DPS and within ADOT (Figures 6a and 6b).

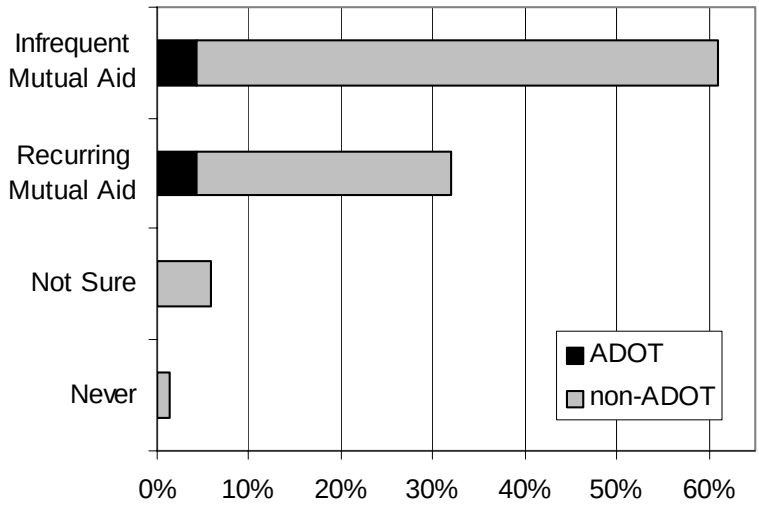


Figure 6a – Do You Communicate with ADOT (and for What Purpose)?

The relatively small number of responses by ADOT recorded in Figure 6a may be the result of the question being misunderstood or unexpected; however, the significance of the other responses is clear in terms of the prevalent reasons for partner agencies to communicate with ADOT via radio. The top bar of Figure 6b seems to indicate that internal ADOT radio communications occur at significant frequency, and so mobile radios can be considered a primary means of communications among ADOT staff during daily operations. At the same time, non-ADOT responses suggest a non-negligible regularity or rate of radio calls between the partner agency staff and ADOT.

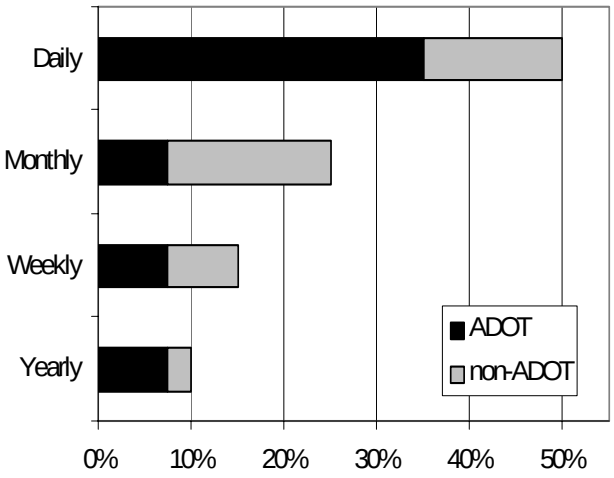


Figure 6b – How Often Do You Communicate with ADOT?

- The three major obstacles to radio interoperability reported by ADOT and non-ADOT respondents are, in descending order: (a) technical issues, (b) gaps in training and planning, and (c) inadequate coverage area. Minor obstacles also include less-then-frequent perceived needs, and licensing, with opinions split 50:50 whether regulatory or licensing issues are an obstacle at all (Figure 7).

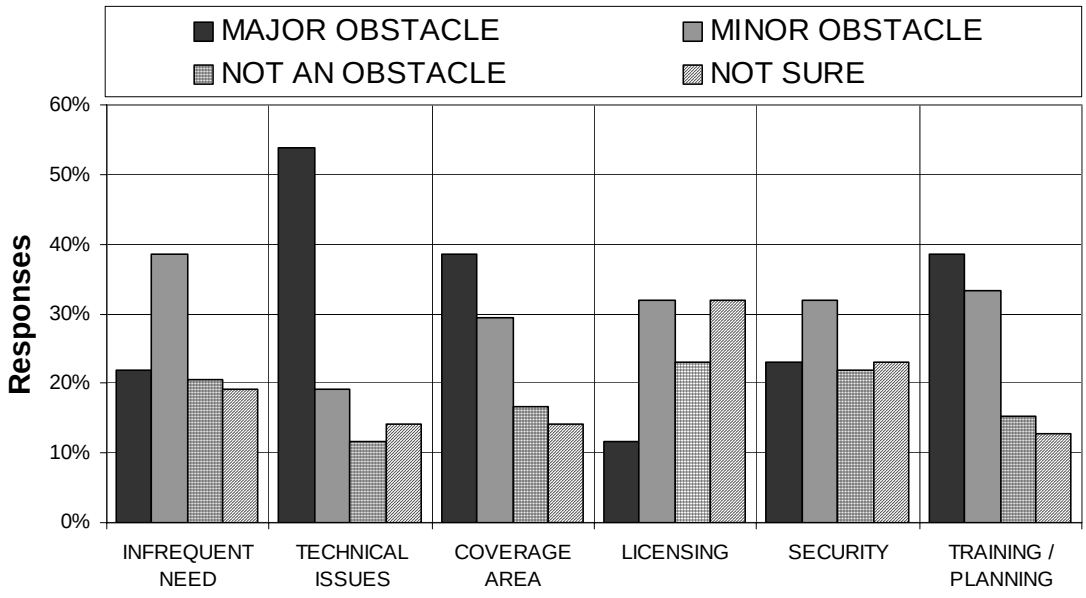


Figure 7 – Perceived Obstacles to Interoperability

- Combined ADOT and non-ADOT responses suggest that interoperable radio should be available 24/7 and most especially during any emergency situation. The desired interoperable radio systems would be easy to use and would be funded outside of the agency's regular budget (Figure 8).

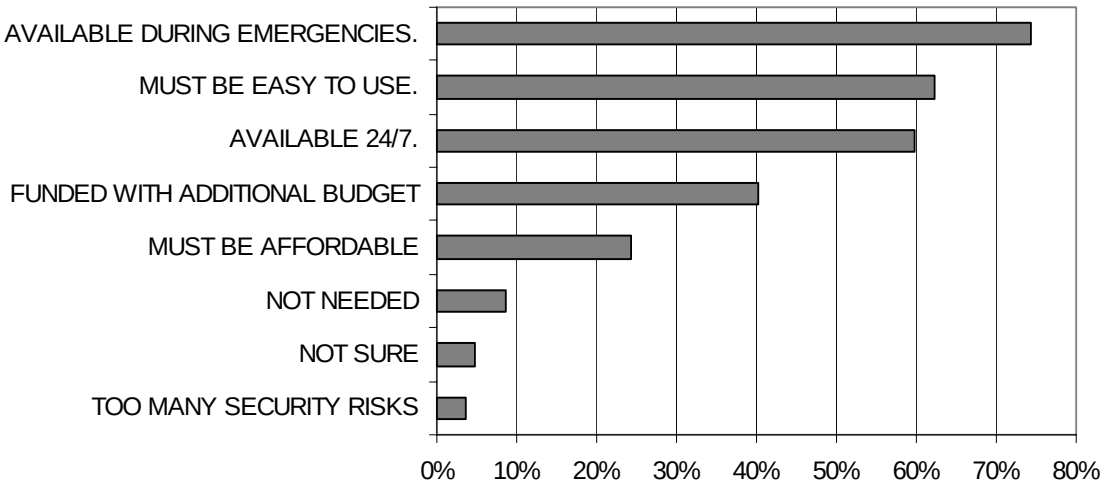


Figure 8 – Qualities of Desirable Solutions

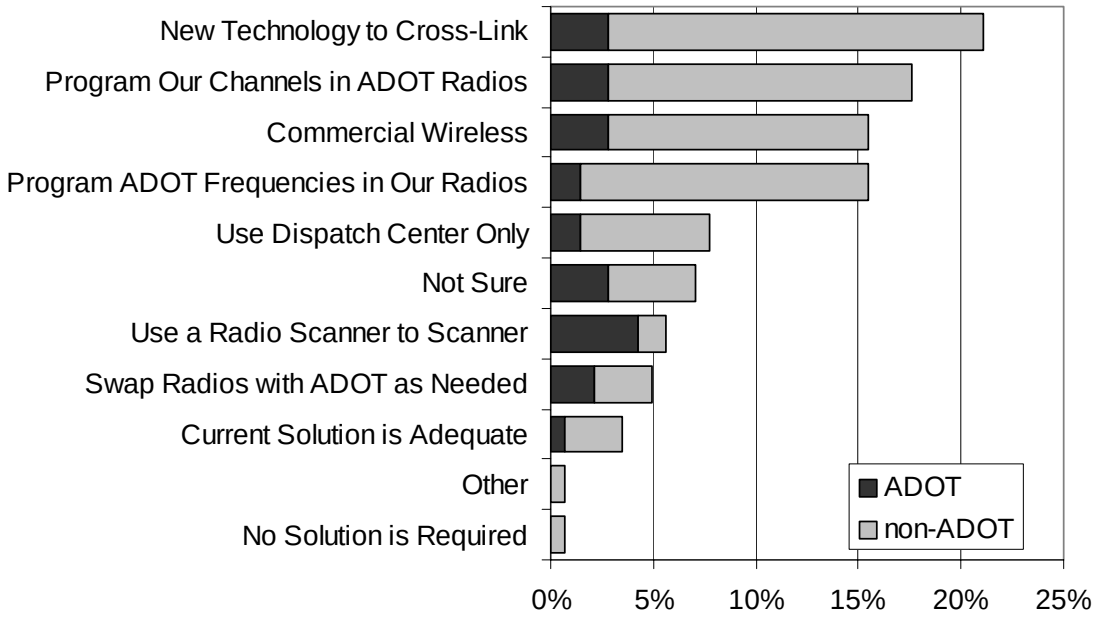


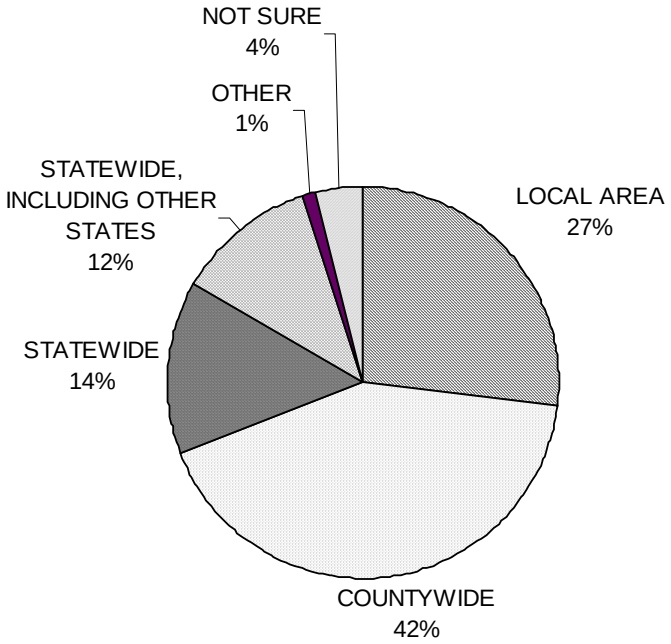
Figure 9 – Suggested Solutions

- While the majority of the respondents look to new technologies as a solution to their interoperability needs, most would also consider programming their channels in ADOT radios and vice-versa (Figure 9). The least popular solutions are: using the

dispatch centers only, using scanners to monitor each other's channels, and swapping radios with ADOT. Figure 9 also distinguishes between ADOT and non-ADOT responses, thus providing additional insight into overall perceptions of the potential technical and procedural solutions within ADOT and its partners. This insight, viewed together with the feedback received from the focus groups, serves to better estimate the likelihood of success of the recommended short-term actions and long-term strategies presented in Chapter 7 of this report.

- Approximately 42% of respondents believe that radio interoperability efforts should begin with and encompass their entire county, while 27% were focused on their local area only. Another 14% opined that interoperability planning should focus on the entire state, and 12% desired to include partner agencies in adjoining states. Figure 10 summarizes the combined responses from ADOT and non-ADOT respondents.

Figure 10 – Desired Level of Interoperability Planning with ADOT



- The voting was split approximately 50:50 between those who indicated that their agency was <u>not</u> willing or able to issue a letter of authorization to incorporate agency-designated frequencies into ADOT's land mobile radio system and those who responded "yes."

4.3 MAJOR NEEDS AND ISSUES REPORTED AT FOCUS GROUPS

4.3.1 Coverage and Reliability Issues of ADOT's Radio System

A common issue reported by ADOT focus group attendees was that of poor radio system coverage. Although no significant system reliability issues were stated, there is a general agreement among ADOT staff that the radio system does not provide coverage in many

areas that are the responsibility of ADOT, or in areas in which ADOT staff travels while on-call. Coverage problems are often an issue near construction sites.

4.3.2 Need to Develop Communication Plans for each District

It is apparent that each ADOT district office needs to be able to communicate with its incidental partners. Each district should be authorized to develop and implement a regional communications plan with its primary and incidental partners that will allow for ADOT units to communicate on coordinated radio channels. As each district office is responsible for a specific regional part of Arizona, the districts' communications plans should remain flexible.

4.3.3 Access to Common VHF, UHF, and 800 MHz Interoperability & Interagency Radio Channels

Currently, ADOT does not have access to statewide or nationwide interagency channels with its mobile radios. The interagency channels on VHF and UHF that have been established and are utilized by other partner agencies are not viewed as appropriate for statewide, routine ADOT interoperability, but can provide temporary resolution to many of the problems experienced with message delivery between ADOT and its partners.

Nationwide 800 MHz interoperability channels (other than Common-Calling) are not currently supported by any agencies in Arizona. The present Arizona 800 MHz Regional Plan does not allow for permanent stations to be installed for this purpose. Without being able to install a base station or repeater, ADOT's typical daily needs for 800 MHz interoperability channel access in the Phoenix District will not be met.

4.3.4 Need to Establish Detailed Communications Protocols

In all regions of the State, various informal and formal protocols for interagency radio communications have been established. These are generally verbal and not in a policy format and are not always followed by each member of a partnering agency. The partnering agencies' representatives generally recognize the need to at least create and distribute phone lists (including cell phone numbers) with names as well as call signs to be able to monitor or communicate with (when possible) another agency.

4.3.5 Need for Reliable and Efficient Methods for Accurate Message Delivery

Frequently, the accuracy of the message initiated by ADOT that is to be delivered to another agency deteriorates before it is received at its final destination. As most of the communication between the originator and the recipient is verbal, key details may be unintentionally left out, causing unnecessary delays and potentially additional effort to either or both parties. Improvements need to be made on how messages are handled and how quickly they are delivered to their end destination. District offices must work with the TOC staff to keep accurate information about how to contact partner agencies. Additionally, the Phoenix TOC, which is often used to relay radio messages between

ADOT and other agencies, needs to create measurable standards and quality control practices to evaluate how communications are handled, and what they can do to improve "origination to end point" delivery times.

4.4 SUMMARY OF NEEDS AND SUGGESTED SOLUTIONS

The overwhelming portion of the feedback provided through the survey and focus group meeting discussions indicates that radio communications interoperability is needed with primary and incidental partners. Direct interoperability between ADOT and its partners is not limited to special events or major emergencies but is needed on a daily basis to ensure efficient use of State resources, and to improve the safety of the Department's employees and contractors.

ADOT focus group participants agreed that interoperable radio communications lies at the foundation of more efficient and effective operations, and can and should be implemented with minor technical changes, better protocol definitions, common radio channels, and interagency agreements. The majority of ADOT partners identified the need to communicate with almost all levels of ADOT personnel under various conditions, from routine activities to emergency situations. This need was expressed by personnel representing a wide spectrum of positions, from supervisory levels to field staff.

4.4.1 Communications with ADOT's Primary Partners

Several typical scenarios that were discussed show that ADOT cannot communicate reliably, or in some cases not at all, with its primary partners. This has been determined as not acceptable and is in need of immediate improvement. Currently available technologies allow for a variety of possible solutions that can be deployed in the short-term to competently address the majority of the identified interoperability needs.

4.4.2 Communication with Contractor Partners

ADOT's contractor partners often employ DPS highway patrol personnel to provide a critical safety service at construction sites; however, the contractors are not required to provide a radio communication link between the DPS officers and the contractor's on-site personnel. This communications link would serve to advise either party of any changing conditions, emergency situation, or potential threats to safety that may exist. Direct communications needs to become a standard practice and part of the scope of work of any contracts that will utilize an off-duty law enforcement officer for site safety or security.

4.4.3 Wide Area vs. Short-Range Radio Interoperability

Wide area interoperability, typically achieved with repeaters, cross-patching systems or advanced technology, is generally not viewed by ADOT as a critical and immediate need. When discussing the implementation of fixed infrastructure that would provide ADOT interconnectivity between agencies, the general consensus was that this would become

cumbersome, require more training, and not provide support in all areas as needed for basic vehicle-to-vehicle communications.

It is believed that providing more means of relatively short-range interoperable communications would address the needs created by the more frequent and prevalent circumstances of daily operations. It is generally preferred that ADOT identify or obtain a channel for VHF communications interoperability. This result could be achieved by implementing new VHF radio channels on existing mobile radio equipment. This effort would need to start with mutual agreements between the various district offices and the agencies that they frequently communicate with.

One possible alternative is nonexclusive use of the old DPS VHF statewide channel. The largest percentage of incidental partners utilizes VHF radios that can be programmed to add more channels.

At this time, the internal ADOT communications statewide plan specifies radio channels in each ADOT radio. It is also ADOT policy that other radio channels may be added to these radios only after exchange of letters of authorization, which have been reviewed by management. Even in this case, the objective is not to create a fixed statewide communications plan. This restricts the ability of the district offices to communicate with its incidental partners, by not making all local channels accessible. ADOT should allow each district office to develop a regional communications plan to supplement the statewide communications plan. The current mobile radio system equipment obtained and installed by ADOT allows for additional channels to be implemented.

4.4.4 Radio Swapping

In some districts, ADOT has supplied DPS with a small inventory of VHF mobile radios (DPS uses UHF radios). DPS representatives at the focus groups generally agreed that installing VHF radios or combined VHF/UHF radio equipment would allow for much needed interoperability. As these radios are not installed into every vehicle, interoperable communications between DPS and ADOT is random and not reliable. DPS officers generally prefer to use a vehicle with a VHF radio. However, the radio channels and communications that are necessary between ADOT and DPS are not always appropriate for the DPS law-enforcement channels.

4.4.5 ADOT Central Dispatching

The Phoenix TOC serves as the designated and only communications hub for ADOT and DPS after the normal hours of operation of the districts' dispatchers. Feedback from the focus groups suggests that delays sometimes occur when relating messages through the TOC. Further discussions with the TOC staff confirm occasional delays, which are caused primarily by the time consuming process of locating the party or parties being called after hours and, once the party is located, of connecting back to the party that initiated the call. If the call is originated by a DPS officer in the field, it first goes to the DPS dispatcher, who in turn calls the ADOT TOC operator, who then attempts to locate

the appropriate ADOT district staff to respond to the call. This is then repeated in reverse, which often takes more time than is perceived as necessary.

As can be expected, sometimes parts of the content of the original message may become slightly altered through these multiple “relays.” These drawbacks of a central communications hub are systemic in nature and are not perceived to be caused by the current level of training or staffing at the Phoenix TOC.

5. INTEROPERABILITY SCENARIOS

5.1. INTRODUCTION

The focus groups served as the primary forum for reviewing scenarios where a dedicated ADOT interoperable system would be a critical factor in an agency's operation. The direct interaction with many ADOT and non-ADOT radio users generated a wealth of information on numerous circumstances that would benefit from interoperable radio systems. Section 5.2 summarizes the more salient examples that were discussed. In addition, an important case study was conducted with a cross-section of ADOT partners through a table-top exercise, which took place in Phoenix in March 2004.

5.2 ANECDOTAL ACCOUNTS FROM FOCUS GROUPS

5.2.1 DPS Support at ADOT Construction and Maintenance Sites

DPS provides safety and traffic control at highway construction sites. Currently, in order for the assigned, off-duty, DPS officer to communicate with ADOT personnel or contractor's employees, the officer must physically locate the individual he needs to contact. This happens under all circumstances involving simple relocation, information updates, or emergencies. In situations where an emergency has occurred or is developing, lack of direct field radio contact can introduce a significant delay into the officer's attempt to communicate a possible threat to life or safety to ADOT employees or contractors. Inversely, the same latency exists when ADOT or contractors need to contact the assigned DPS officers.

In a similar scenario, DPS provides safety and traffic control services to ADOT during routine or incidental maintenance or repairs. The only opportunity to communicate is when no activity is taking place and a face-to-face discussion can take place, or when an ADOT supervisor is physically located near the DPS officer and relays needed actions to other ADOT employees. Several incidents have occurred in the past where a DPS officer maintaining a fixed location is unaware that ADOT has relocated from its initial position to another one several miles away. In order to inform the DPS officer providing support, it is generally necessary to go back and make physical contact to advise the officer to reposition. There have also been other situations in which the DPS officer was not aware that ADOT had completed its work and was already working on a different project or had left the site.

5.2.2 Message Accuracy when using the Phoenix TOC as a Message Relay

The Phoenix TOC is utilized by all regional ADOT offices and personnel to communicate with DPS when the district's communications dispatch console is unattended (after hours). As the TOC is the focal point for all statewide communications support, it has been noted that messages between DPS and ADOT may frequently be delayed, with delays as high as 15 to 45 minutes or more. When a message is originated by a DPS officer in the field, it will be sent to the DPS communications center, over phone lines to a TOC staff member, and then to an ADOT employee who is responsible for handling that message. The same method is used in reverse order to communicate

from ADOT to DPS. The measured time for message delivery has been monitored by DPS and ADOT employees in the field by using radio scanners. As recommended in Chapter 7 of this report, a private line automatic ringdown (PLAR) line should be established between DPS dispatch and the TOC. This type of line immediately rings the other end as soon as the phone is picked up at the near end.

5.2.3 Highway Closures and Traffic Detours

Members of ADOT field crews and local/county agencies expressed a need to be able to directly communicate with any agency that could be involved with an ADOT road closure and assisting in any dynamics involved with re-routing traffic. This will also occur when adjacent states have closed the interstate and wish to advise ADOT regional offices of the closure status and period, and any preferred routes into their states.

5.2.4 Coordination of Highway Debris Removal

DPS officers generally do not have the ability to directly contact ADOT regional offices or supervisors to advise of debris that needs to be removed as quickly as possible, and coordinate the exact location with an incoming, assigned unit. Similarly, other partner agencies that may encounter and remove debris from a roadway managed by ADOT do not have the ability to communicate with an ADOT communication center to advise of actions taken or needed.

5.2.5 Notification during Highway Incidents

All partners have expressed a need to communicate with ADOT to advise of any road conditions that may require ADOT's immediate attention. Activities that trigger this need are usually related to highway accidents or destructive events involving weather.

5.2.6 Coordination and Messaging Between ADOT and DPS Field Personnel

In many situations that involve DPS and ADOT field personnel, there is a need to physically locate each other or report to a specific location. There are frequent occurrences in which the location given, e.g., a milepost, is misunderstood or relayed incorrectly which requires either party to attempt to get a clarification. This is sometimes complicated when the TOC and the DPS dispatch center are utilized as relay points for message delivery, further delaying the crew's ability to find the location.

5.2.7 Emergency Coordination between ADOT and DPS

From time to time an emergency condition will occur in which ADOT may need to communicate with a DPS officer to request assistance or notify DPS of a potential threat to life or safety. Depending on the situation, it is preferable to communicate with an ADOT employee that can advise of what is being observed. One of the communication systems that are already established for this purpose is the Interagency VHF/UHF Radio System. ADOT and DPS should jointly review the potential use of this system as a means to communicate these situations.

5.2.8 Coordination between ADOT and Local Agencies on Highway Maintenance

ADOT frequently needs to communicate with local agencies to advise of needed repairs to fence lines and signs, and for updates on changing road conditions. While this is generally routine when the regional communication centers are providing support, this becomes more problematic when those offices are closed. The current practice of the TOC is to contact the local police agency responsible for the area, which in turn contacts that city's operator or any known call-back person.

5.2.9 Emergency Coordination between ADOT and Local Agencies

On occasion, ADOT has the need to report or support emergency situations with local agencies. When this occurs, the local agency requesting support does not have the ability to contact or coordinate with ADOT in an efficient or effective manner using radio. It has been expressed that interagency agreements and mutual aid channels should be sought and obtained to provide a means to create radio interoperability. Here too the use of the Interagency VHF/UHF Radio System may be appropriate (see Section 5.2.7).

5.2.10 Cellular Telephones as Alternative Means of Communications

Cellular telephones are utilized to a limited extent and only in parts of ADOT districts, due to lack of adequate coverage of the rural areas. As can be expected, sparsely populated areas along rural highways have either spotty or no cellular coverage at all. Cellular coverage often varies from area to area along the same highway or interstate within the district, making it difficult or impossible to rely on this means of communications for incident notification or coordination between ADOT, DPS, and other agencies. In most situations, cell phones are not considered reliable in incident management outside of the more populated areas. It is also recognized that under heavy or extended emergency conditions, cellular telephone reliability drops even further due to high volume of calls.

5.2.11 Availability of Radio Cross-Patching

While technically feasible, this approach is not a popular means of interoperability due to lack of frequent use and training. Radio system patching, as currently configured, will only support ADOT operations, and not cross-agency communications.

5.2.12 MVD Communications Support

MVD radio dispatch is not staffed after 5:00 PM, which prevents MVD Enforcement personnel in rural areas from communicating with any agency, or reporting emergencies via their mobile radios. ADOT, DPS, and MVD should consider developing an interagency communications plan that would include the use of the statewide Interagency VHF/UHF Radio System. This system is already established and would support MVD communications after hours as needed.

5.2.13 DPS and ADOT District Offices Find Alternate Solutions

In most districts, ADOT and DPS share internal inventories of mobile radio equipment and cellular telephones to supplement their standard means of interagency communications. These solutions, used to varying extent by the districts, should not be considered permanent or reliable. Radio swapping and temporary loans of cellular phones, as well as the use of private cellular phones, are not formally budgeted for, consistently maintained, or a part of the normal configuration of a person or vehicle. These measures are implemented out of a defined and agreed-upon need between an ADOT district office and the DPS units that they frequently need to communicate with.

5.2.14 Radio Communications between ADOT District Offices

Communication problems exist between ADOT districts along the I-40 (Interstate 40) corridor, as reported by local ADOT supervisors. Radio communication between district offices is a necessity when managing joint operations such as snow removal or traffic control near district borders.

5.2.15 ADOT's Involvement in Major Emergency Management Events

In 2003, the Arizona Office of Homeland Security staged a multi-agency response to a simulated emergency along the Arizona-Sonora border in Nogales. Nogales has a very limited number of access options in and out of the city, and only via transportation arteries managed and maintained by ADOT. However, ADOT was not invited to participate in this exercise.

As of the writing of this report, ADOT radio systems were not a part of the radio patching systems created to assist in emergency management in the State. It is anticipated that if an emergency of the type that was simulated actually occurred, ADOT would need to be significantly involved in any evacuation and transportation management. At a minimum, ADOT should proactively begin modifications to its communications plan and radios, to implement the use of the Interagency VHF/UHF Radio System in anticipation of any large-scale emergencies requiring evacuation or other uses of the highway system requiring traffic control.

5.2.16 ADOT Field Units Monitor Commercial Vehicle Traffic

Although not widely deployed, various ADOT regional offices and some fleet vehicles have installed and are using Citizen's Band radios to listen to traffic and communicate with commercial vehicles. This allows ADOT personnel to monitor changing traffic or road conditions during severe storms, and to give information or directions to truckers.

5.2.17 Radio Communication "Dead Spots"

Internal ADOT and interagency coordination of field efforts is often impeded by inadequate radio coverage. ADOT mobile radio users experience "dead spots" in coverage that do not allow for any mobile radio communications with the regional communication centers or with the Phoenix TOC. These are generally found to be

problematic during fixed-site activities and not a major concern when a vehicle is moving. The “dead spots” are considered unacceptable and improvements in radio coverage need to be made.

5.2.18 Direct Radio Communications Preferred by ADOT and Partners

The majority of agency radio users believe that radio interoperability outside of the Phoenix should be resolved by providing direct communication channels and not using patching networks, repeaters managed by an individual agency, or other fixed infrastructure. Partner agencies represented at the focus groups also expressed an interest in a common channel to coordinate joint operations, instead of relying on the main communication channels on VHF or UHF systems.

5.2.19 DPS Not Aware of ADOT Lane Closures

DPS is not made aware of various lane closures that are implemented by ADOT, with the lack of direct radio communications between ADOT and DPS being considered a major part of the problem. This information is important to DPS so that it may plan for possible delays when responding to emergencies, along with other reasons. DPS prefers to be informed of closures when they occur.

5.2.20 Regional Communication Committees

It was generally agreed that ADOT should host or coordinate regional communication committee meetings with its partners to develop and monitor logistical communication protocols and contact lists.

5.2.21 ADOT Field Crews a Good Source of Road Condition Information

Interoperable communications among snow plow operators, ADOT supervisors, and DPS will improve efficiency in traffic management during extreme weather conditions.

5.2.22 Arizona Forest Fires

ADOT focus group participants reported that, despite the availability of an Incident Command system that was set up during the 2002 forest fires in Arizona, they were not supported with communication equipment, system access, or radio channels that would allow direct coordination between the fire incident command center and assigned ADOT personnel. There were frequent issues regarding road closures or changing conditions due to the rapidly changing situation of the fire fighting activities, about which ADOT staff were not advised.

5.3 TABLE-TOP EXERCISE

As part of this research, a static table-top exercise was constructed to test procedures in place to handle difficult situations. This took place on March 19, 2004 in Phoenix at the ADOT-East facility. Eleven role-players took part in the exercise as DPS officers, ADOT

employees, ambulance operators, contractor's employees, and a county sheriff deputy. All role-players were physically present in the room.

A scenario was developed involving a motor home (recreational vehicle) turnover on a remote rural highway in a construction zone. The crash location was on U.S. Highway 93 in Mohave County. For this exercise, radio interoperability between public safety first-responders and ADOT personnel was assumed to be very limited. Also, commercial cell phone service is very spotty and unreliable in the area.

There were four goals to be achieved:

1. Medical transport, both air and ground, is needed as quickly as possible to the scene.
2. The victims must be treated as best as possible at the scene.
3. Traffic control must be effected immediately.
4. Accident investigation must be started.

In a follow-up scenario, radio interoperability was assumed to be greatly enhanced through cross programming of public safety channels in public safety first-responder and ADOT radios. A comparison of the time required to achieve the goals was made, and of the difficulties encountered (see Appendix D).

The non-interoperability scenario took 3.25 hours to achieve all four goals of the exercise. The roadway was re-opened within about an hour, by taking the unanticipated shortcut of pushing the damaged motor home off the road with a construction vehicle. This step was taken prior to completing the accident investigation. The current ADOT and DPS policy is to clear both private and commercial wreckage as soon as possible, unless special circumstances prevent it. This exercise was completed in about 16 operational steps.

If the motor home had been a commercial tour bus, it might not have been feasible to clear the roadway right away in this manner, since the Federal Motor Carrier Safety Administration (FMCSA) would want to investigate the crash before disturbing the scene. In this particular rural location, it would have required an hour or more for an FMCSA officer to arrive from Kingman and do the investigation before the wreckage could be removed from the road.

A replay of the motor home scenario with enhanced radio interoperability indicated that the goals could be achieved in a total of eight steps; a saving of eight functional steps, with a minimum time saving of fifteen minutes. This time saving would probably have been considerably higher if the damaged vehicle had been a commercial bus. However, in a medical emergency, beginning triage and the time to on-scene arrival of professional medical care are particularly critical performance measurements.

6. INTEROPERABILITY TOOLS AND CONCEPTS

6.1 INTRODUCTION

This chapter introduces several key technology concepts that are helpful to the understanding the recommended short and long-term solutions described in Chapter 7.

Two-way radio system interoperability can mean different things to different users depending on circumstances. In the context of this research, radio interoperability means the ability to communicate from the radio unit of one person to the radio unit of another, typically not in the same day-to-day radio talk group or channel. This includes the full spectrum of communications technologies and operating policies and procedures.

The two major kinds of interoperability are Infrastructure Independent (I-I) and Infrastructure Dependent (I-D). An example of Infrastructure Independent interoperability is when ADOT units talk car-to-car on the district talk-around channels. Conversely, an example of Infrastructure Dependent interoperability is when two ADOT units, perhaps a hundred miles apart, communicate through a mountaintop repeater. In general, both of these types have both a technical (hardware) component, and an operational training component. Both are critical to successful interoperability.

6.2 INFRASTRUCTURE INDEPENDENT COMMUNICATIONS

In the I-I mode, two or more radios must operate in the same band, and on the same frequencies, using the same kind of modulation. Since about 70% of the public safety radio users in Arizona are still on VHF High-Band (150-174 MHz), as is ADOT and the MVD, this type of interoperability is easily accomplished, by merely reprogramming additional channels into radios with available blank channels. This is typically preceded by user agreements between agencies, stating their desire to mutually share channels, and assigning call signs to users. I-I systems are also limited in range between units, from a few miles for portable radios, to 10 to 20 miles for high-power mobile radios.

Unfortunately, few users in the metro Phoenix area are remaining on VHF (Phoenix and Mesa are in the process of converting their systems to 800 MHz this year and into 2005). ADOT's major interoperability partner in rural areas, the DPS, began converting the Highway Patrol radio network to UHF frequencies 30 years ago. Still, interoperability with NMDOT, and county road departments outside of Maricopa and Pima Counties, can be accomplished with this type of inexpensive interoperability. It should be noted that the Coconino County Public Works Department operates in the 450 MHz band (UHF), which presents yet another interoperability issue for ADOT similar to the problems with DPS using the 460 MHz band (UHF).

6.3 INFRASTRUCTURE DEPENDENT COMMUNICATIONS

I-D systems are typically much more complex and expensive than I-I systems. They also are more flexible, and can generally operate over a much wider geographic area. The classes of I-D systems range from simple accessing of a single shared repeater, to fixed or portable cross-band repeaters utilizing two or more radio bands, to simple console cross-patching of any channels available for control at the console, to more sophisticated programmable radio cross patching devices. These computerized patch devices may be at a fixed location, or made portable to handle longer-term disaster/emergency situations.

The most sophisticated I-D systems are multi-site trunked systems. These allow for wide area roaming, instant talk-group set-ups, and unit identification and emergency button features. Like basic I-I systems, these multi-site systems require that all subscriber (mobile/portable) radio units be compatible, that is, on the same band, programmed with the same frequencies, and with the same modulation type. The system itself is also the most expensive type, and the subscriber units are two to three times more expensive than common conventional analog two-way radios. Generally, these systems are shared platforms in metropolitan areas in order to provide wide areas of coverage, and good building penetration, which is essential in municipal networks.

If the cost of the platforms themselves is not shared, the systems are typically linked between controllers to make their use transparent to a subscriber unit user. Phoenix and Mesa have constructed such a system. Maricopa County built its own system, which will eventually be interconnected to the Phoenix-Mesa systems. Pima County also has a trunked system, which is not compatible with Maricopa County's. The City of Tucson is contemplating constructing its own trunked system.

ADOT operates such a system in the metro parts of Maricopa County for the Phoenix Construction and Maintenance Districts. However, the system is somewhat obsolete in that it is all analog, and the equipment is 14 years old. It cannot be easily integrated or linked with any of the other 800 MHz trunked digital systems in the metro Phoenix area. The only 800 MHz interoperability currently available would be through the National Common-Calling Channel (USA-1), either simplex or through the White Tanks and Thompson Peak repeaters. This is only possible with some, not all, of the mobile and portable radios in the ADOT system.

6.4 OFF-THE-SHELF CROSS-PATCHING

For several years now, portable cross-patching systems have been used to provide interoperable radio communications during incident conditions. This infrastructure-dependent technology allows ad-hoc and as-needed cross-connectivity to multiple, normally incompatible, radio systems. The Raytheon (formerly JPS) ACU-1000 is the most popular device that is being used to connect basic analog radio systems. While deployed by many agencies in the United States, these devices have been shown to be problematic when connected to digital or trunked radio systems

The State of Arizona Department of Emergency and Military Affairs (ADEMA) is installing these units in high-threat areas where analog non-trunked systems are used. They are also being used in several local public-safety agency communication & command vehicles, where trained staff can configure the device as needed for a specific incident response situation. Technically, these units provide a superior capability compared to standard cross-patching features available in radio consoles used at most dispatch centers; however, their operation requires well trained staff.

Figure 11 – ACU-1000

These units are not typically utilized in fixed locations but are deployed as a part of a communications & command system for major emergencies. The ACU-1000 works in tandem with the TRP-1000 Transportable Radio Interconnect System, and both can be mounted inside a vehicle or trailer. The TRP-1000 includes the ACU-1000 electronic console in a shock-resistant casing with preconnected mobile radios and power supplies. The TRP-1000 unit as shown in Figure 12 below is mounted in the back of a converted ambulance, reconfigured for communications technicians. A laptop and radio frequency monitoring equipment are connected to TRP-1000 system.

Figure 12 – Typical ACU-1000 System Configuration for Mobile Operations

Despite appearances, this type of device is not considered to be a practical ready-made interoperability solution for ADOT. In its current configuration, the device is intended for portable, incident command use. Perhaps as a result of its intended use, it does not appear to offer the range required for implementing permanent regional interoperability. Finally, its operation requires complex skills and constant presence of the cross-patching operator, resulting in high operations and maintenance cost.

As a result of these factors, the ACU-1000 and similar devices are not considered to be good radio interoperability solutions for ADOT and its partner agencies. In addition, these units are expected to be available from ADEMA and / or County government partners, which is another reason for ADOT not to acquire them independently.

7. RECOMMENDED INTEROPERABILITY SOLUTIONS AND STRATEGIC PLANNING

7.1 INTRODUCTION

Strategic planning for communications interoperability enhancements will involve a number of short and long-range recommendations aimed at providing improved radio interoperability within ADOT and among ADOT and its partners, in the context of the various agency systems and plans discussed earlier in the report. Projects varying in impact from partial solutions to statewide interoperability strategies are presented. In addition, several pilot projects are described, designed to test the recommended concepts while advancing the implementation of incremental interoperability steps through low-cost initial investment. The recommendations are based on the four master goals refined through the course of this research:

I. Interoperability Among All ADOT Highways Division (ITD) Radios
II. Interoperability Among Every MVD Enforcement Vehicle Radio and Every Highways Division Radio
III. Interoperability Among Every ADOT Radio and Every DPS Radio
IV. Interoperability Among Any ADOT Units Responding to Incidents and Other Agency Responders

7.2 GOAL I: INTEROPERABILITY AMONG ALL ADOT HIGHWAYS DIVISION (ITD) RADIOS

There are two primary areas of focus in achieving this goal:

- Improved interoperability among ADOT Maintenance units in the Phoenix District, which operate on 800 MHz, and Maintenance units of surrounding districts, which use VHF radio.
- Improved communications among VHF Maintenance units, which are too widely separated to communicate through a single mountaintop-site repeater.

The following sections describe both the technical and procedural aspects of the recommended actions aimed at achieving these objectives. Table 2 at the end of this Section presents a planning-level estimate of the costs associates with the key recommendations.

7.2.1 Technical Solutions

Each of the two objectives can be addressed technically through dispatch console cross-patching. Interoperability between the Phoenix District and the rural districts can be achieved by cross-patching on the Phoenix TOC console. This can be either "soft" patching, under constant control of the operator, or by establishing a more permanent "hard" patch.

The soft patch requires no additional hardware or software, but entails additional operator training. The "hard" cross-patch would require minor hardware additions for the Motorola dispatch consoles.

Likewise, communications between VHF Maintenance units statewide can be accomplished statewide through the Phoenix TOC dispatch consoles, or on a more limited, regional basis through the rural district office remote dispatch. Most console setups would require additional hardware to accommodate cross-patching across district boundaries.

7.2.2 Procedures to Route Radio Traffic through Dispatch Consoles

Any cross-patching solution involving the dispatch consoles will require operator intervention to effect the correct set-up and disabling of the patch, upon request. These procedures do not currently exist and will need to be developed. This should be done with the involvement of ADOT shift supervisors, a training consultant, and experts from Motorola and Orbacom Systems. The ADOT *Radio Operations Manual*, last updated by DPS Engineering almost 15 years ago, will need to be updated and revised to cover these new functions.

7.2.3 Monthly Test and Training Exercises to Maintain Familiarity

Special inter-district ADOT Maintenance communications training will provide the operators with initial instruction and familiarity on effecting requested cross-patches. Without continued frequent (e.g., monthly) exercises hardware can eventually fail undetected, and operators can forget the proper techniques and procedures.

New operators must receive the same training when brought into the TOC, or assigned to operate the dispatch consoles at district offices. This must be an on-going, continuing effort to maintain the effectiveness of this interoperability solution – otherwise, this operational capability will slowly dwindle, until it is no longer usable. This has occurred in the past with other interoperability situations that relied on cross-patching.

Equipment vendors such a Motorola, who have staff dedicated to the training function, could be contracted to train the TOC dispatchers. While DPS has staff that is familiar with the technology and radio programming and advanced operations, it is likely that they could not offer certified trainers. The rural district offices use Orbacom consoles. For these, a local DPS technician could deliver the training; alternatively, the equipment vendor, Durham Communications of Mesa, could provide it. The user manual update would be the responsibility of DPS Engineering.

7.2.4 Implementation Cost of Recommended Goal I Solutions

The following are planning-level cost estimates, not based on actual vendor quotations, for implementing the interoperability strategies proposed in Section 7.2.

Table 2 - Estimated Cost to Achieve Goal I:
Interoperability Among All ADOT Highways Division Radios

ACTION ITEM	COST
1. Develop operator training program for cross-patching	$10,000
2. Provide statewide district office training to users on cross-patching	$10,000
3. Modifications to Traffic Operations Center's Motorola Centracom Gold Elite console to allow for "hard" semi-permanent patches	$20,000
4. Additional channels for statewide Orbacom Systems Calida consoles (16 consoles X 7 additional channels each @ $2,000/channel including multiplex equipment)	$224,000
4(a) Upgrade Flagstaff's obsolete dispatch console ($15,000 to $105,000)*	$105,000
TOTAL	$369,000

* Flagstaff District options are: $15,000 for a self-contained 15-channel console, similar to what most ADOT districts are using now, with a commercial telephone line to DPS dispatch; $75,000 to $100,000 for a remote-electronics console; or $105,000 for a combination console ($15,000) and a microwave link to DPS via Mt. Elden ($90,000).

7.3 GOAL II: INTEROPERABILITY AMONG EVERY MVD ENFORCEMENT VEHICLE RADIO AND EVERY HIGHWAYS DIVISION (ITD) RADIO

7.3.1 Technical Solutions

A single basic technical solution is recommended to achieve this goal: MVD vehicular radios statewide should have the Highways Division channels programmed into them. This will allow both direct unit-to-unit short-range communications, and longer distance communications through ADOT repeaters. It will also allow MVD enforcement units to have access to the TOC operators after 5 PM and on weekends for emergency situations. The reprogramming would only involve 140 radios.

Note: To meet the intent of Goal II, only the MVD channels need to be reprogrammed to include some ADOT frequencies. The old ADOT District 1 frequency on the ADOT Maintenance radios is not compatible with the MVD Southern Regional Channel of the same frequencies since the PL access tones were set up to be different. However, the ADOT Maintenance radios will need to be reprogrammed to meet other goals.

7.3.2 Procedures to Route Radio Traffic through Dispatch Consoles

As in Goal I, developing procedures and proper training will be essential to successful interoperability of MVD with ADOT Highways units, whether or not cross patching through dispatch consoles is involved. The MVD portion of the ADOT *Radio Operations Manual* will need to be revised to accommodate the new interoperability functions. This should be integrated with the operator training program.

7.3.3 Monthly Test and Training Exercises to Maintain Familiarity

Continued operator and user training, testing and exercising of the procedures and equipment is necessary to ensure proper operation when needed. This can be integrated under a program proposed in Section 7.2.3 of this report.

7.3.4 Integration of MVD Radio Dispatch at the Phoenix TOC

While the technical solution proposed in Section 7.3.1 solves the immediate interoperability problem, it does not address the issue of whether MVD should have access to all other services of dispatch radio, which are available to ADOT Highways units 24/7 through the Phoenix TOC.

This issue can only be resolved by combining MVD dispatch at the TOC on one or more dispatch consoles. As noted previously, this involves several operational problems that have not been resolved to date regarding MVD's security requirements and access to the dispatch area. However, it is recommended that ADOT continue to study this issue, and combine MVD dispatch operations at the TOC as soon as practical. The TOC Motorola console central electronics would need to be expanded by 23 channels to accommodate the combined operations.

7.3.5 Implementation Cost of Recommended Goal II Solutions

The following are estimated costs of implementing the interoperability strategies proposed in Section 7.3. These are planning level estimates, and are not based upon actual vendor quotations or equipment lists.

Table 3 - Estimated Cost to Achieve Goal II: Interoperability Among Every MVD Enforcement Vehicle Radio and Every Highways Division Radio

ACTION ITEM	COST
1. Reprogram MVD's 140 VHF mobile radios statewide at $25 per radio, if private contractor is used	$3,500
2. Develop new TOC operator training program for cross dispatching of both ADOT Highways and MVD traffic	$10,000
3. Provide operator training at the TOC on MVD/ADOT dispatch	$10,000
4. Rewrite ADOT radio operations manual (private contractor)	$10,000
5. Upgrade TOC consoles to dispatch MVD	$50,000
TOTAL	$83,500

* *TOC* is ADOT's Phoenix Traffic Operations Center

7.4 GOAL III: INTEROPERABILITY AMONG EVERY ADOT RADIO AND EVERY DPS RADIO

7.4.1 Technical Solutions

Two technical solutions are recommended as part of this goal:

- Provide a ring-down telephone circuit from DPS Phoenix, Flagstaff, and Tucson dispatch centers to the ADOT TOC in order to effect much more rapid transfer of critical information. These circuits can be carried over the DPS microwave system from Tucson and Flagstaff, linked with the dark fiber between the TOC and Phoenix DPS communications. Though not a radio solution, this recommendation utilizes the State microwave network to bypass commercial land-line circuits. It is also a recommended part of the overall solution, as are the recommended microwave circuit links between the DPS dispatch consoles in Phoenix, Tucson, Flagstaff, and the TOC.

- Establish several unassigned cross-patch circuits over the fiber between the TOC and the DPS Phoenix microwave room. This will allow for cross-patching of DPS circuits dispatched out of the Phoenix, Flagstaff, and Tucson operations centers, to any ADOT statewide Highways channel, through the ADOT TOC consoles. At least three unassigned circuits to blank channels at each end are recommended: the three circuits are a minimum requirement and include one circuit each for the consoles at Phoenix, Flagstaff, and Tucson. A more realistic solution would be two to three circuits for each location.

7.4.2 Procedures to Route Radio Traffic through Dispatch Consoles

Establishing policies, procedures, and training are even more critical in achieving Goal III than for the first two goals because multiple dispatch centers and agencies are involved in the cross-patching. Each agency's personnel must recognize and understand the call sign system of the other. Dispatch operators at both ends must know how and when to establish a cross-patch, on which authorized channels, and when it should be disabled. Since this effort involves DPS, their dispatch trainer should be involved early in developing these policies and procedures.

With cooperation from DPS, ADOT could also access the old VHF "State" channel on a shared (occasional, nonexclusive) basis to have direct access to a DPS dispatcher. Most MVD radios already have this channel programmed into their vehicular radios. This would allow, in some limited areas of the State, quicker access to a console cross-patch to a DPS officer.

7.4.3 Monthly Test and Training Exercises to Maintain Familiarity

Monthly test and training exercises are critical to maintaining the knowledge, skills, and equipment necessary to ensure that a cross-patch can be successfully made when

emergency circumstances demand. These exercises should be integrated with the test exercises developed as recommended in Section under 7.2.3 and 7.3.3.

7.4.4 Implementation Cost of Recommended Goal III Solutions

The following are estimated costs of implementing the interoperability strategies as proposed in Section 7.4. These are planning level estimates, and are not based upon actual vendor quotations or equipment lists.

Table 4 - Estimated Cost to Achieve Goal III: Interoperability Among Every ADOT Radio and Every DPS Radio

ACTION ITEM	COST
1. Establish ring-down circuits from ADOT's Traffic Operations Center to all DPS dispatch centers	$3,000
2. Fiber multiplexing equipment for TOC-DPS link	$25,000
3. Reprogram 2000 ADOT VHF radios with IARS and VHF "State"	$50,000
TOTAL	$78,000

7.5 GOAL IV: INTEROPERABILITY AMONG ANY ADOT UNITS RESPONDING TO INCIDENTS AND OTHER AGENCY RESPONDERS

Reaching this goal is much more complex than the first three since it involves a multitude of agencies statewide, with different protocols, procedures, and operating many different types of radio systems on various VHF, UHF, and 800 MHz bands.

To deploy an interoperability solution for the majority of the ADOT districts, common communications planning practices used by public safety agencies on a daily and emergency basis should be adopted. These practices are successful as they provide quantifiable goals for each participant when developing a fixed, long term, static communications plan.

A communications plan is defined as a list of frequencies, radio channels, CTCSS tones, and mnemonics or acronyms that have been agreed upon between the participating agencies for an agency or activity that will be universally implemented at a specific date and time, within a defined region or area. Effective as of that date and time within that region, the agency (or agencies) that have agreed to the communications plan will utilize only that plan. No other allowed variances from that plan will be authorized without deploying a new communications plan. The reason for needing to do this is to gain complete control of the radio communications systems used by an agency or agencies.

Communications plans are also developed dynamically during emergency incidents in which acronyms or mnemonics are used to identify channel numbers for the identified emergency command staff. It is their responsibility to determine if the existing

communications equipment brought by a supporting agency will be used, or if they will be required to use other communications equipment provided by the designated Incident Command agency. This is important to understand and practice, as recent forest fire support problems were more likely the result of both ADOT and the Incident Command staff not finalizing and disseminating a clear communications plan to follow. As this becomes a part of the daily practice with ADOT, these types of problems will be eliminated, and less dependence will be needed for reliable communications support. To complete statewide deployment of all finalized ADOT communication plans, it is recommended that ADOT identify either a primary statewide communications manager or consultant for management of all facets of implementation.

7.5.1 Direct Link Ring-Down Circuits

Telephone direct ring-down circuits between ADOT's Phoenix TOC and the dispatch centers of ADOT's core partners are recommended. The installation of these lines will initially bring ADOT up to the same level as other key communication centers within Arizona, allowing for immediate contact and identification of telephone calls from and to those agencies that need a higher priority of response than standard incoming telephone calls. Additionally, this eliminates any telephone company central office overloading situations that may are experienced at each center due to a regional emergency. The ring-down lines should be established between the TOC and at least these dispatch centers:

- ADOT district offices
- ADOT MVD
- DPS
- ADEMA Communications Center

It is essential that ADOT meet with ADEMA to revise any current communications plans to actively include ADOT channels that can be mutually agreed upon, for use in major emergencies. Clearly, ADOT will always play a significant role in the event of any major disaster, as transportation system management is key to successful incident management and to protecting life and safety. Therefore, it is difficult to overstate the importance of addressing the operational issues of interoperability both with ADOT's core partners and the incidental partners.

7.5.2 Reprogramming of ADOT Radios with Partner Channels

ADOT can communicate with its regional partners who use VHF radios merely by exchanging channels in vehicular radios after an Intergovernmental Agreement has been signed. This has been done to a limited extent in northern Arizona, and should be extended to other parts of the State under a master plan to be developed with these agencies, and DPS Telecommunications Engineering. No additional licensing or hardware is required by ADOT to effect this interoperability solution.

It is furthermore necessary to provide authorization to each district office to add supplemental channels to the current statewide ADOT VHF communications protocol. It is emphasized that that each district's communications plan must be approved by a central communications manager or committee, with appropriate documentation. All such communications plans should be published, updated, and distributed to each district when established or when changes are made. No ADOT radios should be authorized to vary from the approved communications plan or channel assignments, which should be "enforced" by ADOT technical support and DPS Telecommunications.

A further and critical step should also be taken as emphasized in the tabletop scenarios for this project. All future construction contracts that require the use of ADOT or DPS personnel or equipment should be modified to include VHF radio communications equipment that is programmed to a specific district ADOT communications plan. Additionally, the contractor must supply a communications plan identifying which radio channels will be used at the sites. Any radio communication coverage holes are required to be filled by using temporary repeater systems within the contracted areas for the times when State of Arizona employees are present.

This is a deployment of a static plan. In a dynamic environment such as Arizona, ADOT should host and meet on a regular basis with district partner agencies to review interoperability issues to allow modifications to protocols and procedures.

The bulk of the cost to successfully implement this solution is in personnel and time. It is expected that by creating efficient communications between partner agencies, these costs and time are recoverable within the first year. Data to verify this is not quantifiable as there are no current measurement systems or incident tracking systems in place to provide the time lost to poor communications. It is only based on the significant, repetitive statements and interviews through the focus groups that have identified this substantial loss of time and resources that ADOT has been incurring.

7.5.3 DPS-ADOT Interoperability is Critical

It is essential that any mnemonics, acronyms, or any other channel identifiers are consistent between DPS and ADOT. DPS should also provide similar controls over its communications plan.

It is essential that any references to radio sites, or previous channels names or numbers are eliminated. *Only* the new names/acronyms/mnemonics should be used and strictly practiced, and employees should be corrected whenever possible by each other to allow for consistency.

7.5.4 Use of the VHF IARS Radio System

ADOT should reprogram its VHF vehicular radios to operate on the national Interagency Radio System channel (155.475 Mhz). This will allow access to many other VHF agencies statewide, on at least a short-range direct unit-to-unit basis. In addition, it will

provide access to several county sheriff dispatch centers. IARS was recently used quite successfully between ADOT, Gila County Sheriff's Office and DPS during road closures of State Route 87 in support of the Willow Fire suppression efforts (July 2004).

Most MVD vehicular units already have the IARS channel programmed into their radios. Many of the IARS stations appear on DPS dispatch consoles and could be cross-patched from DPS through the TOC to ADOT radios statewide on demand. While this is a complicated cross-patch, it is technically possible.

7.5.5 Procedures to Route Radio Traffic through Dispatch Consoles

The development of operational policies, procedures, and training are key to the reliability of any of these IARS cross-patches and should be integrated with the other training programs described in this report in Sections 7.2 through 7.4.

7.5.6 Monthly Test and Training Exercises to Maintain Familiarity

Monthly exercises and testing are most important with this solution as it involves many agencies and diverse systems and equipment and should be integrated with other exercises and testing recommended in Sections 7.2 through 7.4.

7.5.7 Phoenix 800 MHz Construction & Maintenance Interoperability with Incidental Partners

ADOT is presently using systems and equipment that are not compatible with incidental or key partner radio systems within the Phoenix area. In order to use the channels that have been designated and are supported for interoperability, ADOT would need to replace a majority of its 800 MHz mobile radio equipment. This would be excessively expensive, and is not recommended in the short term.

Instead, it is recommended that representatives of both the Phoenix Maintenance and Construction Districts kickoff regular discussions with key ADOT partners to work on potential solutions based on inter-system technologies that are available to interconnect incompatible radio systems. Given that each partner agency utilizes different technologies, specific interoperability solutions would need to be decided on a case-by-case basis. The technologies available and applicable for short-term interoperability would be managed through the TOC, and installed and administered using ADOT and DPS telecommunications support.

Interoperability within the 800 MHz range used in the Maricopa County region can only be accomplished on a case-by-case basis with each partner, as there is no continuity in the multiple 800 MHz technologies currently used by all ADOT partner agencies. Agencies using 800 MHz have not yet identified how they would prefer to implement a cross- system interconnection, and this will require further definition with each partner.

The Phoenix District 800 MHz Motorola trunked radio system is aging, and should be replaced in the next two to three years. This step will cost between $4.5M and $6.5M, depending upon the particular trunking solution selected. One alternative is to look at the possibility of sharing either the Maricopa countywide 800 MHz trunked system or the Phoenix-Mesa 800 MHz trunked system. Each has its advantages and disadvantages but both offer a much greater degree of interoperability within Maricopa County than does the current system. The cost of buy-in with either system will be high. Beside the initial buy-in cost, the Phoenix-Mesa system would require the complete, immediate replacement of all mobile and portable radios.

Because of high cost, short-term interoperability solutions requiring modifications to the 800 MHz radio system infrastructure or major changes in ADOT mobile radio equipment, are not recommended at this time.

7.5.8 Implementation Cost of Recommended Goal IV Solutions

The following are estimated costs of implementing the interoperability strategies proposed in Section 7.5. These are planning level estimates, and are not based upon actual vendor quotations or equipment lists.

Table 5 - Estimated Cost to Achieve Goal IV: Interoperability Among Any ADOT Units Responding to Incidents and Other Agency Responders

	ACTION ITEM	COST
1.	Additional ring-down lines to ADOT district offices and ADEMA (9)	$9,000
2.	Fiber multiplex equipment to link other Phoenix/Maricopa County 800 MHz systems to the ADOT Traffic Operations Center	$25,000
3.	Reprogram 2000 ADOT VHF radios statewide with other incidental partner channels (*This also may be accomplished as part of Goal III)	$50,000*
	TOTAL	$84,000

7.6 LONG TERM STRATEGIC INTEROPERABILITY PLANNING

ADOT's long-term interoperability strategy should focus on developing, together with partner agencies in Arizona, a new radio communications network that would provide a common mobile radio platform and allow for interoperability with partners who choose to continue using VHF and UHF frequencies.

Presently, agencies comprising Arizona's Public Safety Communications Committee (PSCC) are involved in creating a statewide plan for an interoperable public safety radio system. This system could be based on a new 700 MHz public safety spectrum, or combinations of 700 MHz and existing VHF, UHF, and 800 MHz spectrums. ADOT should clearly define its operational communication needs to both the PSCC and to DPS directly. As is currently practiced, DPS provides the technical and engineering oversight

on radio communications in the state. ADOT should clearly express its operational needs for statewide communications to DPS as their key partner, including where and what type of communications is needed.

The preliminary focus of a State interoperable radio network will be a new digital microwave system to connect the various sites and systems. Without this digital microwave network, no digital radio system interconnection, via packet-switched VoIP TCP/IP, or digital trunking, is possible. Also, the current DPS analog microwave network is not only technically obsolete, but is no longer maintainable due to lack of replacement parts.

If the existing DPS network is not replaced in the next few years, ADOT will lose its current level of statewide communications control and interoperability. It has been estimated that statewide replacement of the DPS analog microwave system with a digital network will cost up to $60 million. ADOT should support this DPS request for funding in the legislature, and can help identify sources of possible funding. This system replacement must precede development of a new statewide two-way mobile radio system.

As a major stakeholder in the statewide radio communications system, ADOT should require that the new interoperability capabilities that are achieved through the short- and medium-term improvements with VHF radio systems and through interagency agreements, remain minimum operational requirement for any long term communication system planning. ADOT should support new system designs or infrastructure planning that would allow newly acquired communication capabilities with key and incidental partner agencies to continue. This does not necessarily indicate that ADOT should maintain a VHF radio system. ADOT should require any new system design to provide a connection to those radio channels that are agreed to have been of mutual benefit, and within the same operational areas.

7.6.1 LONG-TERM INTEROPERABILITY COSTS

The long-term solution to statewide interoperability, envisioned by the PSCC, is a new integrated statewide digital system. The PSCC's draft recommendation is for a statewide 700 MHz digital trunked radio system conforming to the APCO Project 25 standard (see Glossary). The system, with options of 90% and 95% geographic-area coverage, would include (among many other features) interoperability improvements between existing modern 800 MHz trunking systems, as well as legacy conventional VHF and UHF systems. Total costs are estimated to be in excess of $300 million, and the design-construction time frame is six years at a minimum. The first step in implementing this solution is the rebuilding of the State microwave network .The all-700 MHz system would require new sites to fill in gaps in coverage, and immediate replacement of all ADOT mobile and portable radios. The costs shown here represent only an overall order of magnitude, and are not based on system design. They should be refined significantly before incorporation into any budgetary planning process.

Table 6 - Estimated Cost to Achieve Long-Term Interoperability in Arizona

ACTION ITEM	COST
1. Replace Statewide DPS Microwave Network (DPS estimate)	$60,000,000
2. Construct a new statewide 700 MHz interoperable radio system, including many new radio sites	$300,000,000
3. Procure 3000 new ADOT Highways and MVD 700 MHz mobile/portable units at $3,000 each	$9,000,000
TOTAL	$369,000,000

7.7 PILOT PROJECT CONCEPTS

Five pilot projects, consistent with the recommended action items for the established interoperability goals, are proposed to help ADOT take early steps towards resolving some of its interoperability concerns. Each of the pilot projects constitutes a validation test of a recommended solution, and will move ADOT along the path toward short- and medium-term improvements in statewide interoperability. These pilot projects address interoperability for ADOT Highways Division, MVD, and DPS, the core partner.

The proposed pilots are:

1. Expand VHF Infrastructure-Independent, car-to-car interoperability with other transportation and public safety agencies along the Interstate 40 corridor.
2. Reprogram the MVD mobile radios to provide access to ADOT's VHF statewide channels. Allow for emergency MVD access to the TOC dispatch center after 5 PM.
3. Install several "hard" cross-links on the TOC console between specific 800 MHz Maintenance talk-groups, and adjacent district VHF Maintenance channels.
4. Install a number of inexpensive VHF mobile radios in DPS patrol vehicles for all squads that operate along Interstate 40 from border to border.
5. Provide for dispatch console gateways to link DPS channels, to ADOT's VHF and 800 MHz Maintenance systems.

7.7.1 Pilot Project 1: Enhanced Car-to-Car Interoperability

A Northern Arizona regional pilot is proposed which consists of reprogramming all ADOT supervisor and heavy-equipment radios with additional channels of local agencies, in their normal operating area, for VHF-to-VHF interoperability. This involves a three-step process.

First, the target local partner agencies need to be identified, along with the frequencies to be programmed into ADOT radios. Suggested agencies at this time include New Mexico DOT, the Navajo, Coconino, Yavapai, and Mohave County transportation agencies, and the Navajo, Coconino, Yavapai, and Mohave County sheriff's offices.

Second, letters of intergovernmental agreement are needed to make use of these channels legal in ADOT radios. These letters should include specific instructions on how to use the radios in various situations, including use of call signs and other protocols. Operational procedures and test programs also need to be specified.

Third, the ADOT mobile radios which are identified (MA/Com units only) will need to be reprogrammed for the additional channels. In addition to the other agency frequencies, the State IARS frequency and fire department call channels should also be programmed into the ADOT radios. This will involve a cost of about $25 per radio if done by a commercial shop. If done by one of the DPS radio shops, cost will be on a per-hour basis.
Assuming a total of 25 mobile radios in each ADOT Maintenance district belonging to supervisors, or in heavy snowplow equipment, this will cost about $25 X 30 radios for three I-40 districts equaling $2,300 of base costs, or about $3,300 including incidentals.

7.7.2 Pilot Projects 2 and 3

Pilot Project 2, to provide MVD mobile radio access to ADOT statewide VHF channels, corresponds exactly to Action Item 1 of the Goal II implementation plan. It involves the reprogramming of MVD's 140 VHF mobile radios statewide at a cost of about $3,500.

Pilot Project 3, a Maricopa regional project to provide dedicated console cross-patches to 800 MHz channels for VHF Maintenance corresponds exactly to Action Items 1 and 3 of the Goal I implementation plan. These steps are to develop an operator training program for cross-patching ($10,000), and to modify the TOC console to allow for "hard" semi-permanent patches between specific 800 MHz Maintenance talk groups ($20,000).

7.7.3 Pilot Project 4: DPS Radio Interoperability

Both ADOT and DPS have identified interoperability between local units as a high priority, particularly along the I-40 corridor because of the winter snow conditions and maintenance issues that prevail there. Therefore, an I-40 corridor project would be appropriate to enhance ADOT-DPS interoperability across the State.

Since ADOT operates a VHF system, and DPS uses a UHF system, direct interoperability is not possible, except if each other's radios are exchanged, or one agency has a second radio in their vehicle. This has been done on a limited basis along I-40, with some DPS supervisors getting obsolete ADOT radios in their vehicles. In some cases, older DPS UHF radios have also been installed in ADOT supervisor vehicles.

Unfortunately, these are typically older radios, which are no longer maintainable with spare parts. This type of operation has worked well. However, since only DPS highway patrol supervisors have been given the radios due to DPS maintenance limitations, many situations arise, particularly in construction zones, where DPS officers cannot reliably communicate with ADOT construction personnel.

It would be more appropriate to purchase modern inexpensive VHF radios in the $500-$800 range to install in each DPS vehicle which operates in a squad patrolling I-40. Assuming that about half of the 50 patrol vehicles in each of DPS districts 1, 2, 3, and 12 operate at least occasionally on I-40, there are about 100 VHF mobile radios needed. This translates to a basic cost of about $50,000 to $80,000 for this pilot, or $65,000 to $100,000 with antennas and other incidentals. Funding for this could come from either DPS or ADOT, since both agencies are benefiting.

7.7.4 Pilot Project No. 5: DPS Gateway Interoperability

This statewide interoperability pilot project, which is closely related to Pilot Project No. 2, will involve installing several non-specified channel links from the DPS console electronics in Phoenix, to the TOC console electronics. This will allow for virtually any ADOT VHF channel or 800 MHz talk group to be linked to any Central Area DPS operational channel, or the IARS channels. The use of linked operational channels is preferable since they can be used for routine coordination operations, which do not fall under the category of priority or emergency traffic for the IARS.

This would also make it possible to link the old DPS VHF channels along I-40 to the ADOT TOC consoles. These would include VHF State channels from Hualapai Mountain, Mount Elden, and Greens Peak. These three stations already exist at DPS sites. However, additional base stations will need to be installed on Juniper Mountain and Robert's Ranch to completely cover I-40. This may not be necessary unless DPS and ADOT jointly determine that ADOT access to the DPS console via direct VHF is a high priority.

DPS Flagstaff consoles could also have access to patched channels. This will give ADOT field personnel direct access to DPS Northern Area dispatch in an emergency, bypassing the need to pass messages through the ADOT TOC. The dispatchers can also cross-patch, on demand, to the UHF State channel for direct communications. Though there is some redundancy of this operation with Pilot Project No. 2, it would be valuable to see which type of operation functions better in both routine and emergency situations.

The estimated cost of this pilot is approximately $50,000 for the Phoenix ADOT TOC console equipment and the DPS Phoenix/Flagstaff dispatch consoles. This includes expansion and reprogramming of the TOC console central electronics and additional microwave multiplex control equipment, and expansion and reprogramming of the DPS central electronics. The total estimated basic cost of this pilot project is approximately $70,000 with incidental expenses.

It should be emphasized that this type of interoperability solution places a great deal of responsibility and work on the dispatchers at both the DPS and TOC dispatch centers. Operators *must* be well trained in the process of setting up channel cross-patches, when busy and under pressure. If they are not well trained, this solution will definitely fail when needed most. History has shown that on similar systems where the operators are

not well trained, the system has not functioned well. However, according to DPS, their current console link with Coconino County is functioning well.

7.7.5 Summary - Estimated Costs of Pilot Projects

The following table summarizes the estimated costs to implement the five pilot projects. These figures are planning level estimates only, which are not based upon actual vendor quotations or equipment lists.

Table 7 – Estimated Costs of Pilot Projects

No.	Pilot Project	Estimated Cost
1.	Expand VHF Infrastructure-Independent, car-to-car interoperability with other transportation and public safety agencies along the I-40 corridor.	Under $5,000
2.	Reprogram the MVD mobile radios to provide access to the ADOT VHF statewide channels. Allow for emergency MVD access to the TOC dispatch center after 5 PM.	Under $5,000
3.	Install several "hard" cross-links on the TOC console between specific 800 MHz Maintenance talk groups, and adjacent district VHF Maintenance channels.	Under $50,000
4.	Install a number of inexpensive VHF mobile radios in DPS Highway Patrol vehicles for all squads operating along I-40 from border to border.	Under $100,000
5.	Provide for dispatch console gateways to link DPS channels to ADOT's VHF and 800 MHz maintenance systems.	Under $100,000

8. CONCLUSIONS

This research evaluated challenges to radio interoperability for ADOT and its partners and recommended incremental solutions supporting both routine operations and incident response and command. The research methodology considered the needs of a cross-section of key radio stakeholders in Arizona. Input was obtained from ADOT and its partners through focus groups, online and mailed stakeholder surveys, and through a multi-agency table-top exercise. Stakeholder feedback was analyzed, resulting in an assessment of the existing interoperability conditions, formulation of needs, and recommendations of viable radio systems configurations supporting both ADOT's internal needs and its partnership responsibilities. The results of this project will help define effective transportation interoperability throughout Arizona, and support ADOT's planning and future tests and deployments, for operations and for local and regional incident response and command.

8.1 SHORT- AND MID-TERM SOLUTIONS

The recommended short- and mid-term solutions and long-term strategies aim to further these four goals, which were crystallized through this research. The goals, summarized below, are directed toward achieving radio interoperability for, between and among:

I. All ADOT Highways Division (ITD) Radios
II. Every MVD Enforcement Vehicle Radio and Every Highways Division Radio
III. Every ADOT Radio and Every DPS Radio
IV. Any ADOT Units Responding to Incidents and Other Agency Responders

Goal I: Interoperability Among All ADOT Highways Division Radios

Goal I focuses on improved interoperability for ADOT's Phoenix Maintenance District radios, operating on 800 MHz, and the Maintenance units of surrounding districts, which use VHF radio; and on improved communications between VHF Maintenance units, which are too widely separated to communicate through a single mountaintop site repeater. The range of total planning-level estimated costs for the recommended Goal I action items would approximate $369,000.

Goal II: Interoperability Among Every MVD Enforcement Vehicle Radio and Every Highways Division Radio

Immediate interoperability between MVD and the Highways Division can be achieved by programming the Highways Division channels into MVD vehicular radios statewide. As in every goal, developing procedures and proper, ongoing training will be essential to successful interoperability. Allowing MVD 24/7 access to other services of dispatch radio through the Phoenix TOC can be accomplished by combining MVD dispatch at the TOC on one or more dispatch consoles. It is recommended that ADOT continue to study this recommendation and combine MVD dispatch operations at the TOC as soon as practical. The total planning-level estimated cost Goal II actions is $83,500.

Goal III: Interoperability Among Every ADOT Radio and Every DPS Radio

Accomplishing Goal III will involve: (a) providing a ring-down telephone circuit from DPS Phoenix, Flagstaff, and Tucson dispatch centers to the Phoenix Traffic Operations Center, to speed transfer of critical information and (b) establishing cross-patch circuits over the fiber between the TOC and the DPS Phoenix microwave room, which would allow for cross-patching of DPS circuits dispatched out of the Phoenix, Flagstaff, and Tucson dispatch centers to any ADOT statewide Highways channel through the TOC consoles. In addition, ADOT could also access the old VHF "State" channel on a shared basis to enable direct access to a DPS dispatcher, as most MVD radios already have this channel programmed into their vehicular radios. This would allow, in some areas of the State, quicker access to a console cross-patch to a DPS officer, since the ADOT TOC would not need to be directly involved. The planning-level estimated cost of Goal III actions is $78,000.

Goal IV: Interoperability Among Any ADOT Units Responding to Incidents and Other Agency Responders

Goal IV presents significant challenges as it involves a multitude of agencies statewide, with different protocols, procedures, and operating many different types of radio systems on various bands. The recommended solutions are based on carefully coordinated planning and technology deployments. Plan-level recommendations include:

- Public safety agencies should adopt common communications planning practices for daily and emergency operations. These include lists of frequencies, radio channels, CTCSS tones, and mnemonics or acronyms that will be universally implemented at a specific date and time, within a defined region or area.
- The set up of interoperable radio communications under emergency situations should be practiced frequently.
- ADOT should identify either a primary statewide communications manager or consultant for management of all facets of the common plan implementation.
- ADOT should exchange existing VHF mobile radio channels with its partners.
- ADOT should enable the national Interagency Radio System channel on its radios.
- ADOT district offices should add channels to the current Communications Plan.
- Adherence to the communications plan or channel assignments should be enforced.
- Highway contractors should provide ADOT-compatible VHF radios and repeaters.
- All partner agencies should periodically update common plans and protocols.
- ADOT and DPS should work out mnemonics, acronyms, and channel identifiers.
- The Phoenix Construction District and Maintenance District should seek out suitable cross-patching technologies to develop regional short-term interoperability with ADOT partners.

From the hardware perspective, direct telephone ring-down circuits between ADOT's Phoenix TOC and the dispatch centers of ADOT's core partners should be installed.

These lines will allow ADOT immediate contact and identification of telephone calls from and to those agencies that need a higher priority of response than standard incoming telephone calls. The direct lines will also eliminate any communications delays associated with the overloading of the telephone company's central that may be experienced during regional emergencies. The lines should be established, at the minimum, between the TOC and the dispatch centers of ADOT district offices, the MVD, the DPS, and the ADEMA Statewide Communications Center. The success of this task will rely on ADEMA's willingness to revise any current communications plans to actively include selected ADOT channels for use in major emergencies. The total planning-level estimated cost of the Goal IV actions is $84,000.

8.2 LONG-TERM INTEROPERABILITY STRATEGIES

It is recommended that ADOT support the long-term solution to statewide interoperability proposed by the PSCC, of a new, integrated digital system based on 700 MHz radio. The breakdown of the high-level planning estimate cost to deploy the new 700 MHz system statewide includes:

- $60 Million to replace the statewide DPS microwave network.
- $300 Million to construct a new statewide 700 MHz interoperable radio system.
- $9 Million to procure 3000 new 700 MHz mobile and portable radios.

8.3 LOW-COST PILOT PROJECTS

To begin advancing toward the stated interoperability goals, five low-cost pilot projects, consistent with the recommended action items, are recommended. Each of the projects constitutes a test of a recommended solution and moves ADOT along the path toward short- and medium-term improvements in statewide interoperability. These pilot projects, listed below, address interoperability for ADOT Highways Division, MVD, and one of its core partners – DPS.

1. Expand VHF Infrastructure-Independent interagency interoperability along the I-40 corridor for ADOT mobile radios (under $5,000).
2. Reprogram MVD mobile radios with ADOT VHF statewide channels, and set up emergency after-hours access to the TOC dispatch center for MVD (under $5,000).
3. Install "hard" cross-links on the TOC console between specific 800 MHz Maintenance talk groups, and adjacent district VHF Maintenance radio channels (under $50,000).
4. Install low-cost VHF mobile radios in DPS Highway Patrol vehicles for all squads that operate along I-40 (under $100,000).
5. Provide for dispatch console gateways to link DPS channels, to ADOT's VHF and 800 MHz Maintenance radio systems (under $100,000).

APPENDIX A

GLOSSARY OF TERMS

GLOSSARY OF TERMS

700	
700 MHz Band:	A new radio band approved by the FCC in 1998, which allocates the spectrum of television channels 63, 64, 68, and 69 to public safety. The spectrum is not usable in areas where high-power broadcasters are still on the air. It will be available as soon as existing TV stations vacate the spectrum, which is targeted for no later than December 31, 2006. (This date may be extended under particular circumstances set forth in 47 U.S.C. § 309(j)(14)(B) including for those markets where 15 percent or more households do not have access to either DTV-equipped receivers or multi-channel video). It is adjacent to the current 800 MHz land mobile radio band.
A	
Access Method	The ability and means necessary to store data, retrieve data, or communicate with a system. FDMA, TDMA and CDMA are examples in common use.
Analog Modulation Technique	Process whereby message signal, which is the analog of some physical quantity, is impressed on a carrier signal for transmission through a channel (e.g. FM).
Analog Radio System	A conventional two-way radio system that transmits voice signals with Frequency or Phase Modulation (FM or PM) in the public safety spectrum.
Analog Signal	1. A signal that has a continuous nature rather than a pulsed or discrete nature. *Note:* Electrical or physical analogies, such as continuously varying voltages, frequencies, or phases, may be used as analog signals. 2. A nominally continuous electrical signal that varies in some direct correlation with another signal impressed on a transducer. *Note:* For example, an analog signal may vary in frequency, phase, or amplitude in response to changes in physical phenomena, such as sound, light, heat, position, or pressure.
Antenna	Any structure or device used to collect or radiate electromagnetic waves.

GLOSSARY OF TERMS

APCO Project 25	APCO 25 brings together representatives from many local, state and federal government agencies who evaluate basic technologies in advanced land mobile radio. The objective is to find solutions that best serve the needs of the public safety marketplace. In addition, the committee has encouraged the participation of numerous international public safety organizations, making this a truly worldwide recommended standard-setting initiative. APCO 25 is co-chaired by APCO International and the National Association of State Telecommunications Directors (NASTD). The steering committee, which makes the decisions, consists of APCO International and NASTD representatives, along with federal representatives from the National Telecommunications and Information Administration (NTIA), National Communications System (NCS), and the Department of Defense (DoD). The steering committee is supported by several subcommittees that research specialized areas. Every aspect of APCO 25 is designed to benefit public safety professionals who seek a new level of performance, efficiency, capabilities, and quality in two-way radio communications. Four key objectives guided the steering committee through this open process: (a) provide enhanced functionality with equipment and capabilities focused on public safety needs, (b) improve spectrum efficiency, (c) ensure competition among multiple vendors through Open Systems Architecture, and (d) allow effective, efficient, and reliable intra-agency and inter-agency communications. By adhering to these objectives, APCO 25 makes it easier for users to make the most informed decision possible when planning to convert existing system to digital. Each vendor's system will begin on a level playing field determined by an agreed upon base line set of specifications. This allows users to more accurately compare the direct features and benefits of both entire systems and individual radio products. This will make bidding processes more competitive among prospective vendors. Plus, users have the opportunity to mix and match equipment among APCO 25-compliant suppliers since their equipment will follow all basic standards.
Audio Throughput Delay	Waiting time delay from audio input at sending unit until audio output at receiving unit.

B

Backward Compatibility	Ability of new units to operate within an "old" system infrastructure or to directly intercommunicate with an "old" unit.
Bandwidth	The difference between the limiting frequencies of a continuous frequency band. Typically measured in kilohertz. May be considered the amount in kilohertz required for a single communications channel.

GLOSSARY OF TERMS

Base Station	1. A land station in the land mobile service. 2. In personal communication service, the common name for all the radio equipment located at one fixed location, and that is used for serving one or several calls.
Baseband	The original band of frequencies produced by a transducer, such as a microphone, telegraph key, or other signal-initiating device, prior to initial modulation. *Note 1:* In transmission systems, the baseband signal is usually used to modulate a carrier. *Note 2:* Demodulation recreates the baseband signal. *Note 3:* Baseband describes the signal state prior to modulation, prior to multiplexing, following demultiplexing, and following demodulation. *Note 4:* Baseband frequencies are usually characterized by being much lower in frequency than the frequencies that result when the baseband signal is used to modulate a carrier or subcarrier.

C

Call Congestion	The ratio of calls lost due to a lack of system resources to the total number of calls over a long interval of time.
Call Delay	The delay experienced when a call arriving at an automatic switching device finds no idle channel or facility available to process the call immediately.
Call Setup Time	The overall length of time required to establish a circuit-switched call between users or terminals.
Call Sign (or Callsign)	A combination of letters and numbers that identify an FCC license. Also: A station or address designator represented by a combination of characters or pronounceable words that is used to identify such entities as a communications facility, station, command, authority, activity, or unit.
Carrier	1. A wave suitable for modulation by an information-bearing signal. 2. An unmodulated emission. *Note:* The carrier is usually a sinusoidal wave or a uniform or predictable series of pulses. *Synonym:* carrier wave.
Carrier Frequency	1. The nominal frequency of a carrier wave. 2. In frequency modulation, *synonym* center frequency.
Carrier Sense Multiple Access (CSMA)	A network control scheme in which a node verifies the absence of other traffic before transmitting.

GLOSSARY OF TERMS

Catastrophic Degradation	The rapid reduction of the ability of a system, subsystem, component, equipment, or software to perform its intended function. *Note:* Catastrophic degradation usually results in total failure to perform any function.
Channel	A single unidirectional or bidirectional path for transmitting or receiving, or both, of electrical or electromagnetic signals.
Channel Capacity	The maximum possible information transfer rate through a channel, subject to specified constraints.
Channel Rate	The data rate at which information is transmitted through the channel, typically stated in bits per second (bps).
Channel Spacing	Typically measured in kilohertz from the center of one channel to the center of the next-adjacent-channel. May, or may not, be identical to bandwidth.
Channelization	The use of a single wideband, *i.e.,* high-capacity, facility to create many relatively narrowband, *i.e.,* lower capacity channels by subdividing the wideband facility.
Code-Division Multiple Access (CDMA)	A coding scheme, used as a modulation technique, in which multiple channels are independently coded for transmission over a single wideband channel. *Note 1:* In some communication systems, CDMA is used as an access method that permits carriers from different stations to use the same transmission equipment by using a wider bandwidth than the individual carriers. On reception, each carrier can be distinguished from the others by means of a specific modulation code, thereby allowing for the reception of signals that were originally overlapping in frequency and time. Thus, several transmissions can occur simultaneously within the same bandwidth, with the mutual interference reduced by the degree of orthogonality of the unique codes used in each transmission. *Note 2:* CDMA permits a more uniform distribution of energy in the emitted bandwidth.
Collision	In a transmission system, the situation that occurs when two or more demands are made simultaneously on equipment that can handle only one at any given instant.

GLOSSARY OF TERMS

Common-Calling Channel	A standardized channel/frequency designated by the FCC, or by the mutual consent of a group of users, to establish radio communications with other units within their own agency, or from other agencies. Once a communications link is established on a Common Calling Channel, units typically move to a different channel to refine details of the need for coordination or assistance. Some Common Calling Channels are established only locally or statewide, by users; others may be established by the Federal Communications Commission. This is the case with the 155.475 MHz VHF frequency, and the 821/861.025 MHz frequencies. The latter is also known as "USA-1."
Communications System	A collection of individual communications networks, transmission systems, relay stations, tributary stations, and data terminal equipment usually capable of interconnection and interoperation to form an integrated whole. Note: The components of a communications system serve a common purpose, are technically compatible, use common procedures, respond to controls, and operate in unison.
Comparator	In land mobile service, a functional unit that compares strengths of a signal received by different receiving stations and selects the strongest for further processing.
Conventional Radio System	Non-trunked, similar to telephone party-line in that the user determines availability by listening for an open channel.
Coverage	1. In radiocommunications, the geographical area within which service from a radiocommunications facility can be received. 2. The geographic area included within the range of, or covered by, a wireless radio system. Two systems cannot be made compatible through patching unless the coverage areas overlap.
CTCSS tones	"Continuous Tone Coded Squelch System", a system that is used to avoid interference between different agencies within close proximity to each other using the same frequency. Each radio for a particular agency is programmed with a CTCSS code so that only those radios can hear and talk with each other and not a neighboring agency. The system involves an industry standard set of sub-audible tones for controlling radios and associated equipment. The sub-audible tone is added to the transmitted signal. The receiving radio is then set up to listen for this specific tone in the received and demodulated audio. If the matching tone is present, the squelch is opened up, allowing the audio to pass through to the speaker. If the tone is not present, then the radio remains silent, even though there is a signal on the frequency. This allows two or more agencies to use the same frequency (generally on a repeater), but not hear each other's conversations.

D

Data	Representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means. Any representations such as characters or analog quantities to which meaning is or might be assigned.
Data Communication	The transfer of information between functional units by means of data transmission according to a protocol. *Note:* Data are transferred from one or more sources to one or more sinks over one or more data links.
De-Key	Turn the transmitter off (release the Push-to-Talk switch).
Delay Time	The sum of waiting time and service time in a queue.
Demodulation	The recovery, from a modulated carrier, of a signal having substantially the same characteristics as the original modulating signal.
Demultiplexing	The separation of two or more channels previously multiplexed; *i.e.,* the reverse of multiplexing.
Desensitization	The reduction of desired signal gain as a result of receiver reaction to an undesired signal. *Note:* The gain reduction is generally due to overload of some portion of the receiver resulting in desired signal suppression because the receiver will no longer respond linearly to incremental changes in input voltage.
Digital	Characterized by discrete states.
Digital Modulation Technique	Technique for placing a digital data sequence on a carrier signal for subsequent transmission through a channel.
Digital Radio System	A two-way radio system which transmits voice or data signals with some form of digital modulation; typically FDMA (Frequency-Division Multiple Access), TDMA (Time-Division Multiple Access), or CDMA (Code-Division Multiple Access) modulation.
Digital Signal	A signal in which discrete steps are used to represent information. *Note 1:* In a digital signal, the discrete steps may be further characterized by signal elements, such as significant conditions, significant instants, and transitions. *Note 2:* Digital signals contain many significant conditions.
Digital Speech Interpolation	In digital speech transmission, the use of periods of inactivity or constant signal level to increase the transmission efficiency by insertion of additional signals.

Digitalization	The migration from analog to digital communications technologies.
Duplex Operation	Allowing communication in opposite directions simultaneously
Duplexer	A device that isolates the receiver from the transmitter while permitting them to share a common antenna. *Note 1:* A duplexer must be designed for operation in the frequency band used by the receiver and transmitter, and must be capable of handling the output power of the transmitter. *Note 2:* A duplexer must provide adequate rejection of transmitter noise occurring at the receive frequency, and must be designed to operate at, or less than, the frequency separation between the transmitter and receiver. *Note 3:* A duplexer must provide sufficient isolation to prevent receiver desensitization.

E

Encipher	[To] Convert plain text into an unintelligible form by means of a cipher.
Encode	1. To convert data by the use of a code, frequently one consisting of binary numbers, in such a manner that reconversion to the original form is possible. 2. [To] convert plain text to equivalent cipher text by means of a code. 3. To append redundant check symbols to a message for the purpose of generating an error detection and correction code.
Encrypt	1. [A] generic term encompassing encipher and encode. 2. To convert plain text into unintelligible forms by means of a cryptosystem. Note: The term *"encrypt"* covers the meanings of *"encipher"* and *"encode."*
End-To-End Encryption	The encryption of information at its origin and decryption at its intended destination without any intermediate decryption.
Erlang	A dimensionless unit of the average traffic intensity (occupancy) of a facility during a period of time, usually a busy hour. *Note 1:* Erlangs, a number between 0 and 1, inclusive, is expressed as the ratio of *(a)* the time during which a facility is continuously or cumulatively occupied to *(b)* the time that the facility is available for occupancy. *Note 2:* Communications traffic, measured in erlangs for a period of time, and offered to a group of shared facilities, such as a trunk group is equal to the average of the traffic intensity, in erlangs for the same period of time, of all individual sources, such as telephones, that share and are served exclusively by this group of facilities. *Synonym* traffic unit.
Erlang-B Distribution	Erlang distribution of the first kind, or erlang loss formula.

Erlang-C Distribution	Erlang distribution of the second kind, or erlang delay formula.

F

Fail-Safe Operation	1. Operation that ensures that failure of equipment, process, or system does not propagate beyond the immediate environs of the failing entity. 2. A control operation or function that prevents improper system functioning or catastrophic degradation in the event of circuit malfunction or operator error.
Failure	The temporary or permanent termination of the ability of an entity to perform its required function.
Fault	1. An accidental condition that causes a functional unit to fail to perform its required function. 2. A defect that causes a reproducible or catastrophic malfunction. *Note:* A malfunction is considered reproducible if it occurs consistently under the same circumstances. 3. In power systems, an unintentional short-circuit, or partial short-circuit, between energized conductors or between an energized conductor and ground.
Federal Communications Commission	An independent regulatory commission which includes a board of Commissioners, nominated by the President and confirmed by the Senate, having the power to regulate non-Federal wire and radio telecommunications in the United States.
Format	In data transmission, the arrangement of contiguous bits or frame sequences which make a group, word, message or language.
Frequency	For a periodic function, the number of cycles or events per unit time.
Frequency Assignment	1. Authorization, given by an Administration, for a radio station to use a radio frequency or radio frequency channel to use a radio frequency or radio frequency channel under specified conditions. 2. The process of authorizing a specific frequency, group of frequencies, or frequency band to be used at a certain location under specified conditions, such as bandwidth, power, azimuth, duty cycle, or modulation. *Synonym* radio frequency channel assignment.
Frequency Assignment Subcommittee (Fas)	An NTIA Interdepartment Radio Advisory Committee subcommittee responsible for reviewing individual agency requests for frequency assignment. It analyzes individual frequency applications for electromagnetic compatibility with existing frequency authorizations.

Frequency Assignment Authority	The power granted an Administration, or its designated or delegated leader or agency via treaty or law, to specify frequencies, or frequency bands, in the electromagnetic spectrum for use in systems or equipment. Note: Primary frequency assignment authority for the United States is exercised by the National Telecommunications and Information Administration (NTIA) for the Federal Government and by the Federal Communications Commission (FCC) for non-Federal Government organizations. International frequency assignment authority is vested in the Radiocommunication Board of the International Telecommunication Union.
Frequency Bands	Frequency bands where land mobile radio systems operate in the United States including the following: ❑ High HF (25-29.99 MHz) ❑ Low VHF (30-50 MHz) ❑ High VHF (150-174 MHz) ❑ Low UHF (450-470 MHz) ❑ UHF TV Sharing (470-512 MHz) ❑ 700 MHz (764-776/794-806 MHz) ❑ 800 MHz (806-869 MHz)
Frequency Hopping	[The] repeated switching of frequencies during radio transmission according to a specified algorithm, to minimize unauthorized interception or jamming of telecommunications. Note: The overall bandwidth required for frequency hopping is much wider than that required to transmit the same information using only one carrier frequency.
Frequency Modulation	Modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the center frequency by an amount proportional to the instantaneous value of the modulating signal. *Note 1:* In FM, the carrier frequency is called the center frequency. *Note 2:* FM is a form of angle modulation.
Frequency Sharing	The assignment to or use of the same radio frequency by two or more stations that are separated geographically or that use the frequency at different times. *Note 1:* Frequency sharing reduces the potential for mutual interference where the assignment of different frequencies to each user is not practical or possible. *Note 2:* In a communications net, frequency sharing does not pertain to stations that use the same frequency.
Frequency-Division Multiple Access (FDMA)	1. The use of frequency division to provide multiple and simultaneous transmissions to a single transponder. 2. A channel access method in which different conversations are separated onto different frequencies. FDMA is employed in narrowest bandwidth, multiple-licensed channel operation.
Full-Duplex Operation	An operating method in which transmission is permitted, simultaneously, in both directions of a telecommunications channel.

G

Gateway	1. An interface that provides the necessary protocol translation between disparate networks. 2. A type of network relay that attaches two networks to build a larger network. A translator of message formats and addresses, gateways typically make connections through a modem to other mail systems or services.
Graceful Degradation	Degradation of a system in such a manner that it continues to operate, but provides a reduced level of service rather than failing completely.
Grade Of Service (GOS)	1. The probability of a call's being blocked or delayed more than a specified interval, expressed as a decimal fraction. *Note:* Grade of service may be applied to the busy hour or to some other specified period or set of traffic conditions. Grade of service may be viewed independently from the perspective of incoming versus outgoing calls, and is not necessarily equal in each direction. 2. In telephony, the quality of service for which a circuit is designed or conditioned to provide, e.g., voice grade or program grade. *Note:* Criteria for different grades of service may include equalization for amplitude over a specified band of frequencies, or in the case of digital data transported via analog circuits, equalization for phase also.

H

Half-Duplex Operation	Operation in which communication between two terminals occurs in either direction, but only one direction at a time. *Note:* Half-duplex operation may occur on a half-duplex circuit or on a duplex circuit, but it may not occur on a simplex circuit. *Synonyms* one-way reversible operation, two-way alternate operation.
Handoff	In mobile systems, the process of transferring a call in progress from one site transmitter and receiver and frequency pair to another site transmitter and receiver using a different frequency pair without interruption of the call.
Height Above Average Terrain (HAAT)	The Height of the radiating antenna center above the average terrain which is determined by averaging equally spaced data points along radials from the site or the tile equivalents. Only that portion of the radial between 3 and 16 km should be averaged.
Heterodyne	1. To generate new frequencies by mixing two or more signals in a nonlinear device such as a vacuum tube, transistor, or diode mixer. *Note:* A superheterodyne receiver converts any selected incoming frequency by heterodyne action to a common intermediate frequency where amplification and selectivity (filtering) are provided. 2. A frequency produced by mixing two or more signals in a nonlinear device.

Hybrid	A functional unit in which two or more different technologies are combined to satisfy a given requirement. *Note:* Examples of hybrids include *(a)* an electric circuit having both vacuum tubes and transistors, *(b)* a mixture of thin-film and discrete integrated circuits, and *(c)* a computer that has both analog and digital capability.

I

Interdepartment Radio Advisory Committee (IRAC)	A committee of appointed Federal agency representatives that serve in an advisory capacity to the Assistant Secretary of Commerce for Communications and Information, and Administrator, NTIA, in carrying out its spectrum management activities. The IRAC comprises a main committee, four subcommittees, and an international group.
Interference	The effect of unwanted energy due to one or a combination of emissions, radiation, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.
Intermodulation	The production, in a nonlinear element of a system, of frequencies corresponding to the sum and difference frequencies of the fundamentals and harmonics thereof that are transmitted through the element.
Interoperability	1. The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. 2. The condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. The degree of interoperability should be defined when referring to specific cases.
Interoperability Standard	1. A document that establishes engineering and technical requirements that are necessary to be employed in the design of systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. 2. Established protocol that provide common interface.
Interoperation	The use of interoperable systems, units, or forces.

Intersymbol interference	1. In a digital transmission system, distortion of the received signal, which distortion is manifested in the temporal spreading and consequent overlap of individual pulses to the degree that the receiver cannot reliably distinguish between changes of state, *i.e.,* between individual signal elements. *Note 1:* At a certain threshold, intersymbol interference will compromise the integrity of the received data. *Note 2:* Intersymbol interference attributable to the statistical nature of quantum mechanisms sets the fundamental limit to receiver sensitivity.

K

Key	The parameter defining an encryption code or method.
Kilohertz (KHz)	A unit of frequency denoting one thousand (10^3) Hz.

L

Lost Call	A call that has not been completed for any reason other than cases where the call receiver (termination) is busy.

M

Megahertz (MHz)	A unit of frequency denoting one million (10^6) Hz.
Modulation	The process, or result of the process, of varying a characteristic of a carrier, in accordance with an information-bearing signal.
Modulation Scheme	The technical process used for transmitting messages through a wireless radio channel.
Multicast	To transmit identical data simultaneously to a selected set of destinations in a network. In a land mobile radio system, a technique in which identical baseband information is transmitted on multiple frequencies. Cf: simulcast.
Multipath	The propagation phenomenon that results in radio signal's reaching the receiving antenna by two or more paths. *Note 1:* Causes of multipath include atmospheric ducting, ionospheric reflection and refraction, and reflection from terrestrial objects, such as mountains and buildings. *Note 2:* The effects of multipath include constructive and destructive interference, and phase shifting of the signal. *Note 3:* In facsimile and television transmission, multipath causes jitter and ghosting.
Multiplexing	The combining of two or more information channels onto a common transmission medium. *Note:* In electrical communications, the two basic forms of multiplexing are time-division multiplexing (TDM) and frequency-division multiplexing (FDM).
Mutual Aid Channel	A national or regional channel that has been set aside for use only in mutual aid interoperability situations, usually with restrictions and guidelines governing usage.

N

Narrowband	Radio channels which with less than a 15 KHz bandwidth; typically 12.5 KHz as required by the FCC for new systems.
Narrowbanding	The migration to systems operating using narrower bandwidths.
National Telecommunications And Information Administration	The Executive Branch agency that serves as the President's principal advisor on telecommunications and information policies and is responsible for managing the Federal Government's use of the radio spectrum.
Network	An interconnection of three of more communicating entities.
NPSPAC	National Public Safety Planning Advisory Committee (see also Appendix E)

O

Operation	The method, act, process, or effect of using a device or system.

P

PL Tone Squelch	A squelch system (used in wireless equipment) whereby the transmitter emits a tone at an inaudible frequency. The receiver, upon detecting any signal checks to see if that tone is present. If so, it allows the main signal to be heard, otherwise it stays muted. PL is the Motorola abbreviation for "Private Line."
Packet	A sequence of binary digits, including data and control signals, that is transmitted and switched as a composite whole. The data, control signals and possibly error control information, are arranged in a specific format.
Packet Switching	The process of routing and transferring data by means of addressed packets so that a channel is occupied during the transmission of the packet only, and upon completion of the transmission the channel is made available for the transfer of other traffic.
Patch	A control center subsystem that permits a mobile or portable radio on one channel to communicate with one or more radios on a different channel through the control center console.

Private Land Mobile Radio Services	Private land mobile radio systems are used by companies, local governments, and other organizations to meet a wide range of communication requirements, including coordination of people and materials, important safety and security needs, and quick response in times of emergency. These systems, which often share frequencies with other private users, make possible many day-to-day activities that people across the United States have come to rely on, whether directly or indirectly. Public safety agencies, utilities, railroads, manufacturers, and a wide variety of other businesses - from delivery companies to landscapers to building maintenance firms - rely on their business radio systems every day. The services included in Private Land Mobile are Public Safety, Industrial/Business, Private Land Mobile Paging, and Radiolocation. [FCC]
Priority	1. Priority, unless specifically qualified, is the right to occupy a specific frequency for authorized uses, free of harmful interference from stations or other agencies. 2. In voice communications systems, one of the levels of precedence assigned to a user unit for the purpose of preemption of communication services.
Private Line Automatic Ringdown (PLAR)	A dedicated telephone circuit or “hot line” connecting two locations to provide immediate voice connection automatically.
Propagation	The motion of waves through or along a medium. *Note:* For electromagnetic waves, propagation may occur in a vacuum as well as in material media.
Protocol	A set of unique rules specifying a sequence of actions necessary to perform a communications function.
PTT	Abbreviation for "Push-to-Talk," the switch on a subscriber unit which, when pressed, causes the subscriber unit to transmit.
Push-To-Talk (PTT) Operation	In telephone or two-way radio systems, that method of communication over a speech circuit in which the talker is required to keep a switch operated while talking. *Note:* In two-way radio, push-to-talk operation must be used when the same frequency is employed by both transmitters. For use in noisy environments, or for privacy, some telephone handsets have push-to-talk switches that allow the speaker to be heard only when the switch is activated. *Synonym* press-to-talk operation.

Q

Quantization	A process in which the continuous range of values of an analog signal is sampled and divided into non-overlapping (but not necessarily equal) subranges, and a discrete, unique value is assigned to each subrange. *Note:* An application of quantization is its use in pulse-code modulation. If the sampled signal value falls within a given subrange, the sample is assigned the corresponding discrete value for purposes of modulation and transmission.
Quantization Noise	Noise caused by the error of approximation in quantization. *Note:* Quantization noise is dependent on the particular quantization process used and the statistical characteristics of the quantized signal. *Synonym* quantizing noise.
Queue	A set of items, such as telephone calls or packets, arranged in sequence. *Note:* Queues are used to store events occurring at random times and to service them according to a prescribed discipline that may be fixed or adaptive.
Queueing	The process of entering elements into or removing elements from a queue.
Queueing Delay	In a radiocommunication system, the time between the completion of signaling by the call originator and the arrival of a permission to transmit to the call originator.

R

Radio Channel	An assigned band of frequencies sufficient for radio communication. *Note 1:* The bandwidth of a radio channel depends upon the type of transmission and the frequency tolerance. *Note 2:* A channel is usually assigned for a specified radio service to be provided by a specified transmitter.
Radio Equipment	As defined in *Federal Information Management Regulations,* any equipment or interconnected system or subsystem of equipment (both transmission and reception) that is used to communicate over a distance by modulating and radiating electromagnetic waves in space without artificial guide. This does not include such items as microwave, satellite, or cellular telephone equipment.
Radio Frequency (RF)	Any frequency within the electromagnetic spectrum normally associated with radio wave propagation.
Radiocommunication	Telecommunication by means of radio waves.
Refarming	An FCC effort to develop a strategy for using private land mobile radio (PLMR) spectrum allocations more effectively so as to meet future communications requirements. This is to be accomplished primarily by dividing channel bandwidths (*i.e.* narrowbanding).

Relay	Base station that typically receives signals on one frequency, processes and retransmits out on another frequency in order to extend talkout range.
RF Repeater	1. An analog device that amplifies an input signal regardless of its nature, *i.e.,* analog or digital. 2. A digital device that amplifies, reshapes, retimes, or performs a combination of any of these functions on a digital input signal for retransmission. *Note:* The term *"repeater"* originated with telegraphy and referred to an electromechanical device used to regenerate telegraph signals. Use of the term has continued in telephony and data communications.

S

Service Area	The boundary of the geographic area of concern for a user. Usually a political boundary such as a city limits, county limit, or similar definition for the users business. Can be defined relative to site coordinates or an irregular polygon where points are defined by latitude and longitude.
Signal	The detectable transmitted energy, which carries information from a transmitter to a receiver.
Simplex Operation	Operating method in which transmission is made possible alternately in each direction of a telecommunication channel, for example by means of manual control. *Note:* In general, duplex operation and half-duplex operation require two frequencies in radiocommunication; simplex operation may use either one or two.
Simulcast	In a land mobile radio system, a technique in which identical baseband information is transmitted from multiple sites operating on the same assigned frequency. Quasi-synchronous transmission. Cf: multicast.
Spectrum	The usable radio frequencies in the electromagnetic distribution. Specific frequencies have been allocated to the public safety community. They include: ❑ High HF (25-29.99 MHz) ❑ Low VHF (30-50 MHz) ❑ High VHF (150-174 MHz) ❑ Low UHF (450-470 MHz) ❑ UHF TV Sharing (470-512 MHz) ❑ 700 MHz (764-776/794-806 MHz) ❑ 800 MHz (806-869 MHz)
Spectrum Planning Subcommittee (SPS)	A subcommittee of the Interdepartment Radio Advisory Committee that reviews agency requests for new, or major modifications to, communications or space systems for electromagnetic compatibility and regulatory compliance.

Spread Spectrum	1. Telecommunications techniques in which a signal is transmitted in a bandwidth considerably greater than the frequency content of the original information. *Note:* Frequency hopping, direct sequence spreading, time scrambling, and combinations of these techniques are forms of spread spectrum. 2. A signal structuring technique that employs direct sequence, frequency hopping or a hybrid of these, which can be used for multiple access and/or multiple functions. This technique decreases the potential interference to other receivers while achieving privacy and increasing the immunity of spread spectrum receivers to noise and interference. Spread spectrum generally makes use of a sequential noise-like signal structure to spread the normally narrowband information signal over a relatively wide band of frequencies. The receiver correlates the signals to retrieve the original information signal.
Squelch	A radio circuit that eliminates noise from the speaker when no transmitted signal is present.
Subcarrier	A carrier used to modulate another carrier, and so on, so that there can be several levels of subcarriers, *i.e.,* several intermediate carriers.
Subscriber Unit	A mobile or portable radio unit used in a radio system. *Synonym* user unit, user radio.
System	Any organized assembly of resources and procedures united and regulated by interaction of interdependence to accomplish a set of specific functions.
System Robustness	The measure or extent of the ability of a system, such as a computer, communications, data processing, or weapons system, to continue to function despite the existence of faults in its component subsystems or parts. *Note:* System performance may be diminished or otherwise altered until the faults are corrected.

T

Talk Group	A subgroup of radio users who share a common functional responsibility and, under normal circumstances, only coordinate actions among themselves and do not require radio interface with other subgroups.
Talk In	From the “mobile equipment” inbound to the fixed equipment. Also referred to as a reverse link or up link.
Talk Out	From the fixed equipment outward to the “mobile” units. Also referred to as a forward link or down link.

TCP/IP	Transmission Control Protocol/Internet Protocol; an agreed upon set of rules that tells computers how to exchange information over the Internet. Other Internet protocols like FTP, Gopher, and HTTP sit on top of TCP/IP.
Telemetry	The use of telecommunication for automatically indicating or recording measurements at a distance from the measuring equipment.
Terminal	A device capable of sending, receiving, or sending and receiving information over a communications channel.
Throughput	The number of bits, characters, or blocks passing through a data communication system, or portion of that system. *Note 1:* Throughput may vary greatly from its theoretical maximum. *Note 2:* Throughput is expressed in data units per period of time.
Throughput Delay	The total time in ms between the initiation of a voice or data signal, *i.e.,* push-to-talk, until the reception and identification of the identical signal at the received output speaker or other device.
TIA/EIA-102 Standards	A joint government/industry standards-setting effort to develop technical standards for the next generation of public safety radios, both voice and data.
Time Division Multiple Access (TDMA)	1. A communications technique that uses a common channel (multipoint or broadcast) for communications among multiple users by allocating unique time slots to different users. *Note:* TDMA is used extensively in satellite systems, local area networks, physical security systems, and combat-net radio systems. 2. A channel access method in which different conversations are separated into different time slots.
Transceiver	A device that performs, within one chassis, both transmitting and receiving functions.
Transducer	A device for converting energy from one form to another for the purpose of measurement of a physical quantity or for information transfer.
Transmission Delay	The time in ms required for transmission of a voice frame or data packet through a communication channel.
Transponder	An automatic device that receives, amplifies, and retransmits a signal on a different frequency. *Synonym* RF repeater.
Trunk	A single transmission channel between two points that are switching centers or nodes, or both.

Trunked (System)	Systems with full feature sets in which all aspects of radio operation, including RF channel selection and access, are centrally managed.
Trunking	An infrastructure dependent technique where communications resources, comprised of more than one logical channel (trunk) are shared amongst system users by means of an automatic resource allocation management technique based upon statistical queueing theory and resident in the system's fixed infrastructure. Typically usage requests follow a Poisson arrival process and the resource allocator assigns communications resources in response to requests from system users. As demand for service exceeds system capability at that time, service must be increasingly denied immediate access. This action is termed "blocking," with the blocked service request being queued for a later service response. The offered grade of service of the system is inversely proportional to the probability of blocking (e.g. lower probability of blocking offers a higher grade of service potential). The dynamic resource allocation methodology of trunking results in the establishment of functional channels defining resource availability by means of dynamically allocating logical channels both to particular subscribers and for specific functions. These functional channels can be used for the conveyance of payload information, system control or a combination thereof.
Trunked Radio System	A system that integrates multiple channel pairs into a single system. When a user wants to transmit a message, the trunked system automatically selects a currently unused channel pair and assigns it to the user, decreasing the probability of having to wait for a free channel for a given channel loading.
Type 1 Product	[A] classified or controlled cryptographic item endorsed by the National Security Agency for securing classified and sensitive U.S. Government information, when appropriately keyed. *Note:* The term refers only to products, and not to information, key, services, or controls. Type 1 products contain classified National Security Agency algorithms. They are available to U.S. Government users, their contractors, and federally sponsored non-U.S. Government activities subject to export restrictions in accordance with International Traffic in Arms Regulation.

Type 2 Product	Unclassified cryptographic equipment, assembly, or component, endorsed by the National Security Agency, for use in telecommunications and automated information systems for the protection of national security information. *Note:* The term refers only to products, and no to information, key, services, or controls. Type 2 products may not be used for classified information, but contain classified National Security Agency algorithms that distinguish them from products containing the unclassified data algorithm. Type 2 products are subject to export restrictions in accordance with the International Traffic in Arms Regulation.
Type 3 Algorithm	[A] cryptographic algorithm that has been registered by the National Institute of Standards and Technology and has been published as a Federal Information Processing Standard for use in protecting unclassified sensitive information or commercial information.
Type 4 Algorithm	[An] unclassified cryptographic algorithm that has been registered by the National Institute of Standards and Technology, but is not a Federal Information Processing Standard.

U

UHF 800 MHz System	A two-way radio system operating in the spectrum between 806-869 MHz. (821-824 and 866-869 MHz, is commonly called "NPSPAC 800"). Also see “Frequency Bands” in this Glossary.
UHF System	A two-way radio system operating in the spectrum from 450-470 MHz.
USA-1	The designated National Common-Calling channel in the 800 MHz NPSPAC spectrum.
User	A person, organization, or other entity (including a computer of computer system), that employs the services provided by a telecommunication system, or by an information processing system, for transfer of information. *Note:* A user functions as a source of final destination of user information, or both. *Synonym* subscriber.

V

Validated Service Area Reliability	The number of test locations successfully measured with the desired parametric value divided by the total number of locations tested.
VHF High-Band System	A two-way radio system operating in the spectrum from 150-174 MHz.
VHF Low-Band System	A two-way radio system operating in the spectrum from 30-50 MHz
VHF High-Band System	A two-way radio system operating in the spectrum from 150-174 MHz.

Vocoder	*Abbreviation for* voice-coder. A device that usually consists of a speech analyzer, which converts analog speech waveforms into narrowband digital signals, and a speech synthesizer, which converts the digital signals into artificial speech sounds. *Note 1:* For communications security purposes, a vocoder may be used in conjunction with a key generator and a modulator-demodulator to transmit digitally encrypted speech signals over narrowband voice communications channels. These devices are used to reduce the bandwidth requirements for transmitting digitized speech signals. *Note 2:* Some analog vocoders move incoming signals from one portion of the spectrum to another portion.
Voice over Internet Protocol (VoIP)	(Voice over IP) This is the practice of using an Internet connection to pass voice data using IP instead of using the standard public switched telephone network. This can avoid long distance telephone charges, as the only connection is through the Internet. A category of hardware and software that enables people to use the Internet as the transmission medium for telephone calls. For users who have free, or fixed-price Internet access, Internet telephony software essentially provides free telephone calls anywhere in the world. To date, however, Internet telephony does not offer the same quality of telephone service as direct telephone connections. There are many Internet telephony applications available. Some, like Cooltalk and NetMeeting, come bundled with popular Web browsers. Others are standalone products. Internet telephony products are sometimes called IP telephony, Voice over the Internet (VOI) or Voice over IP (VoIP) products.
Voting	The process of comparing received signals and selecting the instantaneous best value and incorporating it into the system.

W

Waveform	The representation of a signal as a plot of amplitude versus time.
Wideband	Radio channels which operate on channels of 15 KHz -30 KHz bandwidth; those in operation in the past 40 years on VHF and UHF frequencies.
Wireless Terminal	Any mobile terminal, mobile station, personal station, or personal terminal using non-fixed access to the network.

APPENDIX B

ADOT RADIO INTEROPERABILITY MAILED SURVEY

ADOT-ATRC RADIO INTEROPERABILITY SURVEY

Contact Name: _____
Title: _____

Agency:
_____

Street Address:
_____

City: _____ **State:** _____ **Zip:** _____

Phone: (_____)_____ FAX: (_____)_____ E-Mail Address:_____

Contact Preference: ☐ E-Mail ☐ FAX ☐ U.S. Mail ☐ Telephone

How many employees does your agency have? _____

How many of your agency's employees regularly use the radio communications system?_____

Which of the following best describes the topography where your agency operates? (select all that apply)

☐ Relatively Flat
☐ Rolling Hills
☐ Mountainous
☐ Suburban Buildings
☐ Not Sure

Which types of communications equipment are used by your agency? (select all that apply)

☐ Vehicle Mounted Land Mobile Radio
☐ Hand Held Land Mobile Radio
☐ Cellular Telephones
☐ Satellite Telephones
☐ Nextel
☐ Pagers
☐ Mobile Data Terminal
☐ Mobile Laptop Computer Terminals
☐ Other
☐ Not Sure

Is your land mobile radio system capable of narrow band operation?

☐ Yes ☐ No ☐ Not Sure

Identify the relative percentage of traffic on your agency's land mobile radio system: (results should total 100%)

Field Unit to Field Unit _____% Dispatcher to Field Unit _____% Other _____%

Rank each communications technology in order of importance for interoperability with the Arizona Department of Transportation: (use 1 to indicate the most important technology and 9 to indicate the least important technology)

Vehicle Mounted Land Mobile Radio		Nextel Pagers	
Hand Held Land Mobile Radio		Mobile Data Terminal	
Cellular Telephone		Mobile Laptop Computer Terminals	
Satellite Telephone		Other	

What commercial services (if any) does your agency use to supplement its land mobile radio system?

_____

If you use a commercial service provider to supplement your land mobile radio service provider, please identity the service provider by brand name:

_____

If you use a commercial service provider to supplement your land mobile radio system, does your commercial service provider offer a push-to-talk feature?

☐ Yes ☐ No ☐ Not Sure

At how many sites does your agency operate two-way radio base stations today?

_____

How many mobile vehicle mounted two-way radios does your agency operate today?

_____

How many portable hand-held two-way radios does your agency operate today?

_____

How many mobile data terminals does your agency operate today?

_____

Does your agency share its land mobile radio system base infrastructure system with other organizations?

☐ Yes ☐ No ☐ Not Sure

In which band does your agency operate land mobile radio systems? (select all that apply)

☐ None
☐ High Bank VHF (150-174 MHz)
☐ UHF (450-470 MHz)
☐ 800 MHz
☐ Not Sure
☐ Low Band VHF (25-50 MHz)
☐ Federal UHF (406-420 MHz)
☐ 700 MHz
☐ Other

Which type of land mobile radio systems does your agency currently operate? (select all that apply)

☐ Conventional Analog (non-trunked)
☐ Trunked Analog
☐ Trunked Digital (APCO 25 Compliant)
☐ Not Sure
☐ Conventional Digital (non-trunked)
☐ Trunked Digital (Vendor Specific)
☐ Other

Does your agency plan to upgrade its land mobile radio system within the next five years?

☐ Yes ☐ No ☐ Not Sure

Does your agency's land mobile radio system use wireless voice security? (select one)

☐ None ☐ Digital Encryption ☐ Scrambling Device ☐ Not Sure

Which of the following best describes your agency's arrangements for dispatching?

☐ Agency performs its own dispatching 24 hrs/day
☐ Agency performs its own dispatching 9 AM to 5 PM
☐ Agency uses a combined dispatch center
☐ Agency uses a contracted dispatching service

Do you currently have the ability to communicate with any of the following ADOT groups using radio communications?

	Yes	No	Not Sure
ADOT Maintenance	☐	☐	☐
ADOT Construction	☐	☐	☐
Haz-Mat	☐	☐	☐
MVD	☐	☐	☐

Under which circumstances does your agency have a need to communicate with the Arizona Department of Transportation? (select all that apply)

☐ None
☐ Routine Daily Operations
☐ For Road Construction
☐ For Task Forces & Unusual Planned Events Only (permit closures, major spectator events, etc).
☐ For Emergency Conditions Only (forest fires, floods, etc).
☐ For Homeland Security Emergencies (e.g. terrorist threats or acts)
☐ Not Sure

How often does your agency have need for direct radio communications with the Arizona Department of Transportation? (select all that apply)

☐ Daily ☐ Weekly ☐ Monthly ☐ Yearly ☐ During Recurring Mutual Aid Situations
☐ During Infrequent Mutual Aid Situations ☐ Never ☐ Not Sure

Does your agency currently have land mobile radio interoperability with any other agencies?

☐ Yes ☐ No ☐ Not Sure

Does your agency need land mobile radio interoperability with any other agencies?

☐ Yes ☐ No ☐ Not Sure

Does your agency have at least one radio channel designated for communicating with other agencies?

☐ Yes ☐ No ☐ Not Sure

Is your agency willing to issue a letter of authorization to incorporate agency-designated frequencies into ADOT's land mobile radio system?

- ☐ Yes
- ☐ No, but we are willing to consider other interoperability solutions
- ☐ No
- ☐ Not Sure

INSTITUTIONAL ISSUES

What is the primary job description of individuals who would be likely to use a land mobile radio system that interoperates with the ADOT radio system? (e.g. Roadway Maintenance Superintendent, Traffic Signal Technician, Law Enforcement Officer, Firefighter, Incident Commander, etc).

_____

What level of interoperability planning with ADOT would best serve your agency? (select one)

- ☐ Local Area
- ☐ County-wide
- ☐ State-wide
- ☐ State-wide including surrounding states
- ☐ Other
- ☐ Not Sure

How important on a scale of 1 to 5 do you consider land mobile radio interoperability with the following ADOT groups (circle one)

ADOT Maintenance	Not Important	1	2	3	4	5	Very Important
ADOT Construction	Not Important	1	2	3	4	5	Very Important
ADOT Motor Vehicle Division (MVD)	Not Important	1	2	3	4	5	Very Important
ADOT Haz-mat	Not Important	1	2	3	4	5	Very Important

Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.

	Not an Obstacle	Minor Obstacle	Major Obstacle	Not Sure
Lack of Frequent Need for Interoperability	☐	☐	☐	☐
Technical Issues (different bands and radio systems)	☐	☐	☐	☐
Different Coverage Area	☐	☐	☐	☐
Regulatory or Licensing Issues	☐	☐	☐	☐
Security Concerns	☐	☐	☐	☐
Lack of Training and Planning	☐	☐	☐	☐

What is your agency's overall opinion on land mobile radio interoperability? (select all that apply)

- ☐ It is not needed
- ☐ It must be funded outside our agency's normal budget
- ☐ It must be easy to use
- ☐ It must be available 24/7
- ☐ It would be nice but, must be affordable
- ☐ It would be nice but, could pose too many security risks
- ☐ It must be available during emergencies
- ☐ Not sure

What does your agency consider to be the optimal solution for interoperability with the Arizona Department of Transportation?

- ☐ No solution is required
- ☐ Current solution is adequate
- ☐ Swap handheld / mobile radios with ADOT as needed
- ☐ Use a radio scanner to scan each other's radio channels
- ☐ Program our agency's frequencies in ADOT's radios
- ☐ Program ADOT Frequencies in our radios
- ☐ Use commercial wireless services (e.g. cell phones or Nextel)
- ☐ Use new technologies to cross-link our channels together as needed
- ☐ Communicate via dispatch centers only
- ☐ Other
- ☐ Not Sure

Have you experienced a situation in which the ability to interoperate with ADOT was or could have been particularly helpful? (please describe)

_____

_____

_____

Please provide any additional comments you may have on a separate sheet. If the comments relate to a particular question, please provide the question number. Thank you for completing this survey!

APPENDIX C

FOCUS GROUP HANDOUTS AND MEETING AIDS

ADOT RADIO COMMUNICATIONS INTEROPERABILITY MEETING AGENDA

Nov. 17, 2003

I. INTRODUCTIONS & BACKGROUNDS (15 Min).

II. DISCUSSION ON INTEROP DEFINITIONS (15 Min).

III. INTEROPERABLE CIRCUMSTANCES (30 Min).

BREAK (15 Min).

IV. MEANS OF INTEROPERABILITY (45 Min).

V. AREAS OF PLANNING (15 Min).

VI. CONSENSUS OF GROUP (30 Min).

VII. WRAP-UP/COMMENTARY/ OPEN FORUM (15 Min).

VIII. ADJOURN

ADOT RADIO COMMUNICATIONS INTEROPERABILITY
DISCUSSION ISSUES

I. INTRODUCTION & BACKGROUND

Everyone tells a little bit about how they work with ADOT, and their background.

II. DISCUSSION ON INTEROPERABILITY DEFINITIONS

1. Unit-to-Unit (Known as Infrastructure Independent)
2. Through a fixed site system (Known as Infrastructure Dependent)
3. On-Scene; Short range; either independent or dependent
4. Wide-area; Infrastructure dependent
5. Type equipment typically used? Mobile vs. portable?
6. Levels of liaison with ADOT? Supervisor? Worker? Front Office? Responsible party?

III. INTEROPERABLE CIRCUMSTANCES

1. Day-to-day operations
2. Emergency situations
    a) Haz-Mat spill
    b) Terrorism
    c) Major fires/floods
    d) Explosions
    e) Severe Weather
3. Special events
4. Task forces
5. Road condition info

IV. MEANS OF INTEROPERABILITY

1. Unit-to-unit on personal radios (Pre-program channels)
2. Swap radios
3. Cross-scanning
4. Interoperability channel system in area
5. Commercial services; i.e. Nextel, cellular, CDPD, Blackberry, etc.
6. Cross-patch channels at several dispatch centers
7. Sophisticated, cross-patch device; i.e. JPS-ACU1000; fixed or portable
8. Common radio system - area-wide operations
9. Verbal exchange; then forward through individual radio systems
10. Text-based interoperability
    a) DPS statewide MDC system; several years in future
    b) Commercial services; CDPD or Blackberry, hot-spot wideband nodes
11. Internet connectivity to local radios

V. AREA OF PLANNING

1. Local, county-wide, district-wide, statewide, or statewide w/regional coordination
2. How to bring in other states into the planning process?

VI. CONSENSUS OF GROUP

1. What works best in your area of responsibility to communicate with ADOT?
2. Prioritize by categories
3. Who should control? ADOT? Other agency? Scene commander?
4. Should be infrastructure dependent, or independent?

VII. THANK PARTICIPANTS; ADJOURN

APPENDIX D

TABLE-TOP EXERCISE SCENARIOS

TABLE-TOP EXERCISE SCENARIOS

I. The Situation (Scenario)

It is nearly 7:30 AM on a warm, clear Monday morning in May. On US Hwy 93, centered about MP 150, near the Mohave-Yavapai County border, construction for widening is beginning for the day. This is a hilly area with blind spots remaining. Off-duty DPS officers are working the construction at each end, approximately 4 miles apart. The only other DPS officer on duty this morning is just south of Wikieup, about 15 miles away. There is also a County Sheriff deputy having coffee in the Wikieup Café. Private contractors are at work, using heavy equipment to prepare a new roadbed, and hauling tons of rock and gravel off-site. Two ADOT construction supervisors are on-site, one at the construction modular with the contractor foreman, near the south end of the construction, and the other parked in his truck near the middle of the construction.

Each DPS officer has a high-power UHF mobile radio, which they use to communicate with the Flagstaff dispatch center. They also each have a low-power UHF portable, which cannot communicate with their dispatch centers due to terrain blockage conditions. They can only be used for short-range (2-mile) unit-to-unit communications in this area. The ADOT supervisors have a high-power VHF mobile radio that they can communicate with through the Smith Peak repeater. However, their VHF portable radios are also only good for very short range, unit-to-unit communications.

At this time of morning, the Kingman ADOT dispatch is not open, so the Phoenix TOC is the only ADOT radio lifeline to the outside world. The contractor foreman, and lead and trailing guide vehicles each have a high-power VHF mobile radio in their truck on commercial frequencies, but there are no repeaters in the area to extend their range. They can only be used for car-to-car communications; about 5 miles. The private contractor foreman does not have ADOT frequencies in his radio. The County S.O. deputy has a VHF mobile radio in his car, with the outside speaker turned on so he can hear a call in the coffee shop. However, he also does not have either the ADOT frequencies or the contractor's frequencies in his vehicle. Cell phone coverage is spotty in the area. A specific spot must be picked to make a call. The contractor's flagpersons at each end of the construction zone do not have any radios at all.

II. The Event

At about 7:30, a line of traffic is passing northbound through the construction, and the trailing vehicle, a 30-foot motor home is lagging somewhat behind. Unfortunately, a large rock-hauling dump truck does not see the lagging vehicle and crosses the road at a high-speed with a full load of rock, striking the motor home on the left side, near the front. The motor home is ripped open and tipped over. Two unsecured passengers (children) inside are thrown clear, and knocked unconscious. The driver and passenger-side person were in their seat belts and remained in the vehicle, seriously injured. A 15-gallon propane tank on the motor home has its valve partially ruptured, and is leaking propane at a slow rate.

The rock-truck driver and trailing guide vehicle driver both stop to render assistance, and find that all four are breathing, but are seriously injured, with two unconscious, and one bleeding severely. All need immediate medical attention, or they could die. No DPS personnel see the accident happen, and the ADOT supervisor in the area was not in position to see it. The nearest ground ambulance is on station in Wickenburg, which has both the UHF State MEDS radio and a VHF private dispatch radio. (No ADOT frequencies)

II. The Goals

Goal #1: Medical transport, both air and ground, is needed as quickly as possible to the scene.

Goal #2: The victims must be treated as best as possible at the scene.

Goal #3: Traffic control must be effected immediately.

Goal #4: Accident investigation must be started.

III. The Personnel

1. DPS officer at south end of construction - Radio call #125
2. DPS officer at north end of construction - Radio call #126
3. DPS officer at Wickieup - Radio call #127
4. ADOT Supervisor #1 at construction modular; Radio call Kingman Construction 38
5. ADOT Supervisor #2 on road in truck - Radio call; Kingman Construction 39
5. Lead guide vehicle - Radio Call; Unit 1
6. Trailing guide vehicle - Radio Call; Unit 2
7. Private contractor foreman - Radio Call; Unit 3
8. County deputy in Wikieup - Radio Call; S.O. 21
9. Paramedic Ambulance from Wickenburg - Radio Call; Med 50
10. DPS Flagstaff Dispatch- Radio Call; Flagstaff DPS
11. DPS Phoenix Dispatch - Radio Call; Phoenix DPS
12. ADOT Phoenix TOC Dispatch - Radio Call; Phoenix TOC

IV. The Action

The player personnel interact with each other to effect the four goals as efficiently as possible, given the limited communications available. A time-line should be made as the action proceeds, estimating the time required for each event (based on knowledge of previous history), and the total elapsed time summarized at the end. The incident ends when all injured personnel have been picked up for transport, the accident investigation completed, and the road re-opened.

V. Revised Scenario

Repeat the above (Sec. IV) with the following different assumptions:

1. The private contractor foreman, lead, and trailing guide vehicles all have ADOT simplex and one ADOT local repeater channel in their VHF radios.
2. The two DPS officers at each end of construction also have ADOT VHF mobile radios in their vehicles, along with the DPS officer near Wikieup.
3. The County deputy in Wikieup has the local ADOT repeater and simplex frequencies in his VHF County mobile radio.
4. The Wickenburg ambulance VHF radio has several ADOT simplex car-to-car channels in it.

VI. Group Discussion

- Review the differences in the number of steps required to effect the four goals.
- Review and discuss the total time differences between the two scenarios.

APPENDIX E

NATIONAL PUBLIC SAFETY PLANNING ADVISORY COMMITTEE (NPSPAC) PLAN

Excerpt from Version 3. October 15, 2001

Note: NPSPAC (pronounced "nipspac") is an FCC sponsored group which functions through regional frequency advisory committees in coordinating channels in the upper 800 MHz public safety spectrum (821-824 MHz and 866-869 MHz)

4.0 COMMUNICATIONS REQUIREMENTS – REGIONAL INTEROPERABILITY

4.1 General

This part of the Arizona Regional Plan deals with the requirement for coordinated communications between various jurisdictions and functional entities within the Region. The intent is to ensure compatibility in the assignment of frequencies, especially calling and interoperability channels. The purpose of this plan is not to replace existing intercommunication plans or channels, but to supplement them at 800 MHz with a more detailed plan. In fact, the Regional Plan encourages continued use of VHF and UHF intercommunications presently in use for Police and Fire, including 155.475 MHz, 460.375 MHz, and 154.280 MHz. The plan also encourages cross patching these channels to the 800 MHz Common-Calling Channels, and others as appropriate, at the dispatch console level within regional operating subsystems.

4.2 Regional Calling and Interoperability Channels Authority

The Federal Communications Commission (FCC), in Docket 87-112, Sec. IV.C.50-52, released Dec. 18, 1987, mandated the use of a single, conventional, common-calling channel and four (4) tactical channels on a nationwide basis in the new 800 MHz Public Safety allocations. The FCC also strongly recommended the use of CTCSS tone squelch nationally on a frequency of 156.7 Hz.

The Arizona Regional Planning Committee has reviewed and implemented the five- (5) national channels, and added one (1) additional 800 MHz channel for interoperability strictly within the Arizona Region. The Arizona Plan also adopts the use of 156.7 Hz tone squelch as mandatory on all voice radio systems on the common-calling and interoperability channels.

4.3 Eligibility

Primary eligible users include Police, Fire, Local Govt., Highway Maintenance, Forestry Conservation, and providers of Basic and Advanced Life Support Services in Special Emergency Services, as defined in the FCC Rules and Regulations, and licensed to use the spectrum. These users are eligible to operate base stations on the five- (5) National and one- (1) Statewide interoperability channels.

In addition, Federal agencies may become eligible through the use of public safety agreements, whereby a licensee may permit federal use of a non-federal communications system. Such use, other than the five common-calling channels is to be in full compliance with the FCC's requirements for federal government use on state and local government frequencies (Title 47 CFR, Sec. 2.103).

Also, other eligibles such as school buses, volunteer emergency corps, Red Cross, Radio Amateur Civil Emergency Services (RACES), Amateur Radio Emergency Services (ARES), Salvation Army, etc., under the National Plan may also participate on a secondary basis in the support of the preservation of life and property during an emergency.

4.4 Application Procedures

All interoperability channel licensees for Mobile Relay (FB2), or Fixed Stations (FB) shall be obtained by and in the name of the entity authorized by the Arizona Regional Review Committee. Other base radios shall be licensed in the name of the applicant agency. In accordance with FCC Report and Order General Docket 87-112, vehicular, portable, and aircraft stations using either the five National channels or the Statewide interoperability channel (Channel 6) may operate without further FCC authorization. However, the prospective vehicular/portable/aircraft user must comply with 4.5.4 of this section.

4.5 Allocated Common-Calling/Interoperability Channels

The use and allocation of the calling and interoperability channels is broken down as follows:

Channel 1 (821/866.0125 MHz) - National Public Safety Calling and Rural Tactical Operations Interoperability.

Channel 2 (821/866.5125 MHz) - Primary Fire and Emergency Medical Service In Maricopa County; Secondary in Pima County.

Channel 3 (822/867.0125 MHz) - Primary Police in Maricopa County; Secondary in Pima County.

Channel 4 (822/867.5125 MHz) - Primary Fire and Emergency Medical Service in Pima County; Secondary in Maricopa County; Federal Govt.

Channel 5 (823/868.0125 MHz) - Primary Police in Pima County; Secondary in Maricopa County; Federal Govt.

Channel 6 (821/866.0375 MHz) - Primary Statewide for all Other Public Safety, including Highway/Forestry/Local Govt./Search & Rescue.

Although primary and secondary usage is defined above, this is not to preclude use by all other eligibles when appropriate in coordinated operations. (See 4.3)

4.5.1 Common-Calling Channel Monitoring Requirements

All new portable/mobile radios granted license authorizations in the 821-824 MHz and 866-869 MHz bands, as well as all replacement equipment in the 806-821 MHz and 851-866 MHz bands, shall be capable of and equipped to operate on Channels 1 - 5 calling and tactical frequencies in the conventional mode of operation. In addition, each portable/mobile radio shall have the repeater "talk-around" channel on Channel 1 (National Calling Channel) and on their primary and secondary service tactical channels. Also, a Public Safety eligible receiving a new 800 MHz license is required to be able to monitor and communicate in the repeater and "talk-around" modes at their primary communications site.

Use of Arizona Channel 6 is prohibited in some areas in the Counties bordering California; however, it shall be included in all portable/mobile equipment in all other areas. Use of Channel 6 in La Paz and Mohave Counties is subject to interference from a State of California transmitter located near Needles, California and use is prohibited within a 70 mile radius of the transmitter located at 34º 40’ 54”N, 114º 41’ 24”W.

The largest geographic Public Safety 800 MHz new system licensee in a geographic area may be required to place in operation, a Channel 1 calling channel repeater at one or more of their existing repeater sites. If notification is made to a prospective licensee as a condition of system plan acceptance by ARRC and the FCC, the station shall be placed in service at the same time with the rest of the authorized system. A suitable Calling Channel funding plan shall be submitted as part of the authorization request.

4.5.2 Tactical Channel Requirements

4.5.2.1 Monitoring Requirements

Each new licensee in the 800 MHz spectrum shall also have a base station radio at their primary station site, as a minimum requirement, capable of monitoring and operating on the primary and secondary tactical channels in their area, for which they are eligible service providers. This base station radio shall include frequencies for both simplex and repeater control.

4.5.2.2 Repeater Establishment

No permanent high power repeaters shall be established on any of the tactical channels. However, low power (<20 watts ERP) transportable repeaters may be employed by any eligible service agency for establishing emergency communications over a wider area than simplex communications would allow.

Such a repeater shall be turned off and removed as soon as practical after the event has passed. At no time will a tactical repeater be allowed to operate for more than a 30-day continuous period.

4.5.2.3 Voice Security/Privacy/Scrambling Equipment

Voice scrambling or encryption is NOT ALLOWED on the Common-Calling Channel, except in rural areas, where the calling channel is also used for tactical operations. In rural areas, each licensee is still required to monitor the calling channel in CLEAR mode, regardless of voice encryption.

Voice scrambling or encryption IS allowed on the other voice tactical channels, either unit to unit, unit to base or through a temporary repeater if all users of the temporary repeater also have access to the CLEAR mode, or the same encryption scrambling standard as required.

4.5.3 Attestation

Each prospective licensee shall include a standard signed statement form with their request for authorization, acknowledging they have read and are familiar with the

Arizona Regional Plan and agree to abide by its conditions, especially insofar as the Common-Calling and Tactical Channel operational requirements.

4.5.4 Priority Levels of Utilization
The established priority use levels for the six- (6) calling/tactical channels are described below. When a higher priority of use is required, all lower priority use must cease in ANY area where interference could occur.

The four priority levels are:

PRIORITY 1: Disaster and extreme emergency operations of large scale involving imminent safety of lives, for mutual aid and interagency communications.

PRIORITY 2: Emergency or urgent operations involving imminent safety of life or property.

PRIORITY 3: Special event control activities, generally of a preplanned nature, and generally involving joint participation of two or more agencies.

PRIORITY 4: Drill, maintenance, and test exercise of a civil defense or disaster nature.

4.5.5 Language and Radio Codes Standards
All communications on the Calling Channel will be conducted in "CLEAR TEXT", using the ENGLISH language, unless use of another language is clearly necessary to carry out emergency communications.

4.6 Federal Govt. Communications Interface Requirements
Federal Govt. agencies, operating within the borders of the Arizona region, may access the Common-Calling and Tactical Channels for the purpose of coordinating with and communicating with Public Safety eligibles. Federal agencies are exempt from the monitoring requirements set forth in Sec 4.2. However, their use of the Common-Calling and Tactical Channels shall otherwise be in complete conformance with the Regional Plan.

Before a federal agency is certified eligible to access the Common-Calling and Tactical Channels, there shall be established a formal agreement with the Public Safety eligible with whom they desire to have communications. This agreement shall be on the standard ARRC form. Each agreement shall be mailed to the ARRC for review and to be placed on file with the committee.

4.7 Public Switched Telephone Network
The use of automatic or operator-assisted connection on the Common-Calling and Tactical Channels to the public switched telephone network is strictly PROHIBITED.

4.8 Amateur Radio Intercommunications

It is the intent of the Arizona Regional Plan to encourage participation of the Amateur Radio community in public safety communications relating to emergency or disaster communications.

The following intercommunications of public safety radio communications systems are encouraged in emergency/disaster situations:

1. Loan of 800 MHz radios to qualified amateur radio emergency coordination groups, such as RACES, AREC, etc.
2. Allow amateur radio nets to operate out of Public Safety Command Centers.
3. Allow selective amateur to Public Safety cross patching under emergency conditions, at selected public safety communication centers, under control of a governmental entity

All Amateur/Public Safety communications shall continue to comply with applicable FCC Rules and Regulations, and rules and plans of the affected amateur group. It is strongly recommended that each Public Safety entity have an agreement in place with volunteer amateur groups, defining what level of intercommunications will be allowed and provided during an emergency situation. This plan should be filed with the ARRC coordinator for approval.

APPENDIX F

RADIO SYSTEM MAPS

Source: Arizona Department of Public Safety

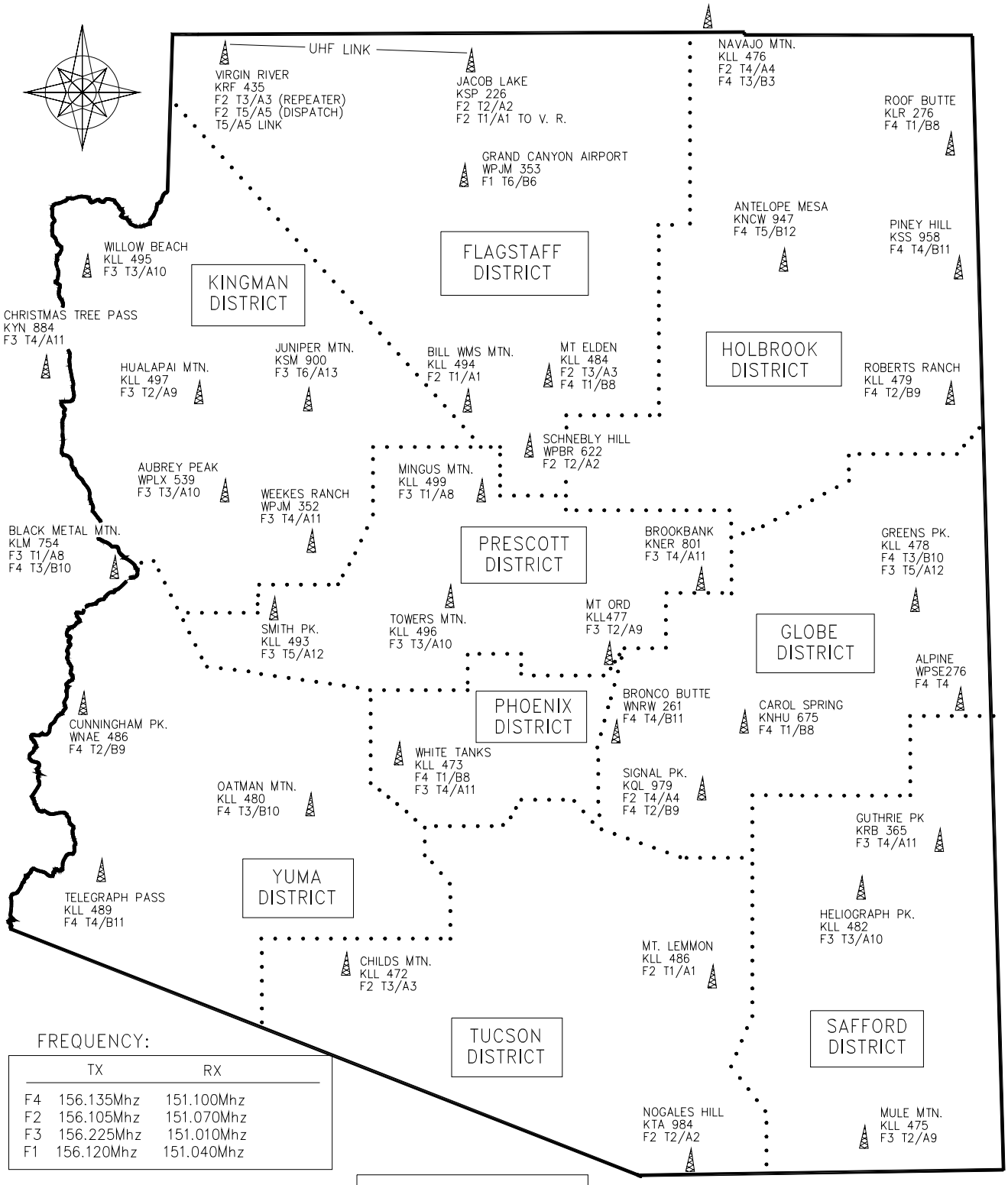
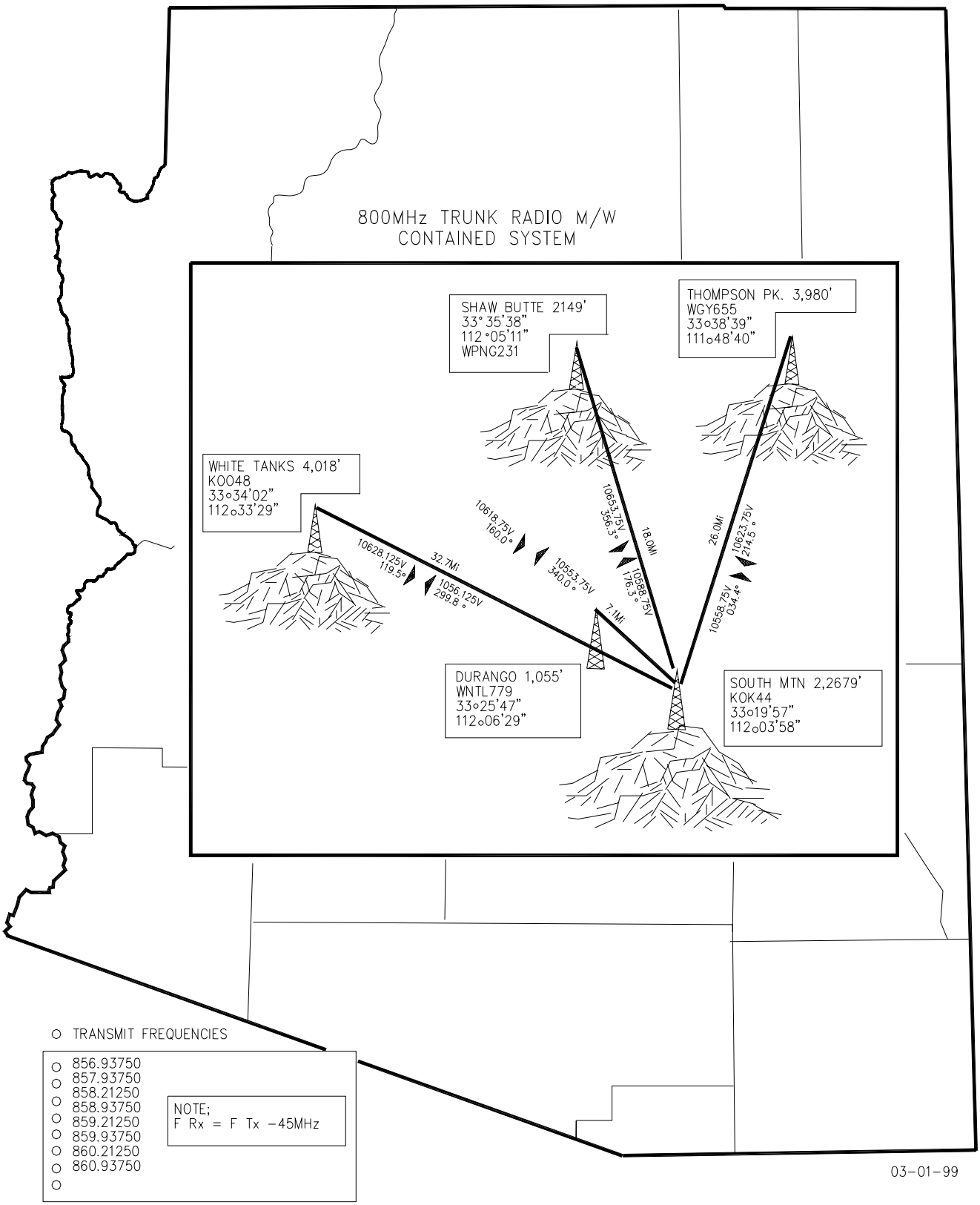


FIGURE F.1 – ADOT RADIO SYSTEM



ADOT-5

FIGURE F.2 – ADOT TRUNKING (MARICOPA COUNTY)

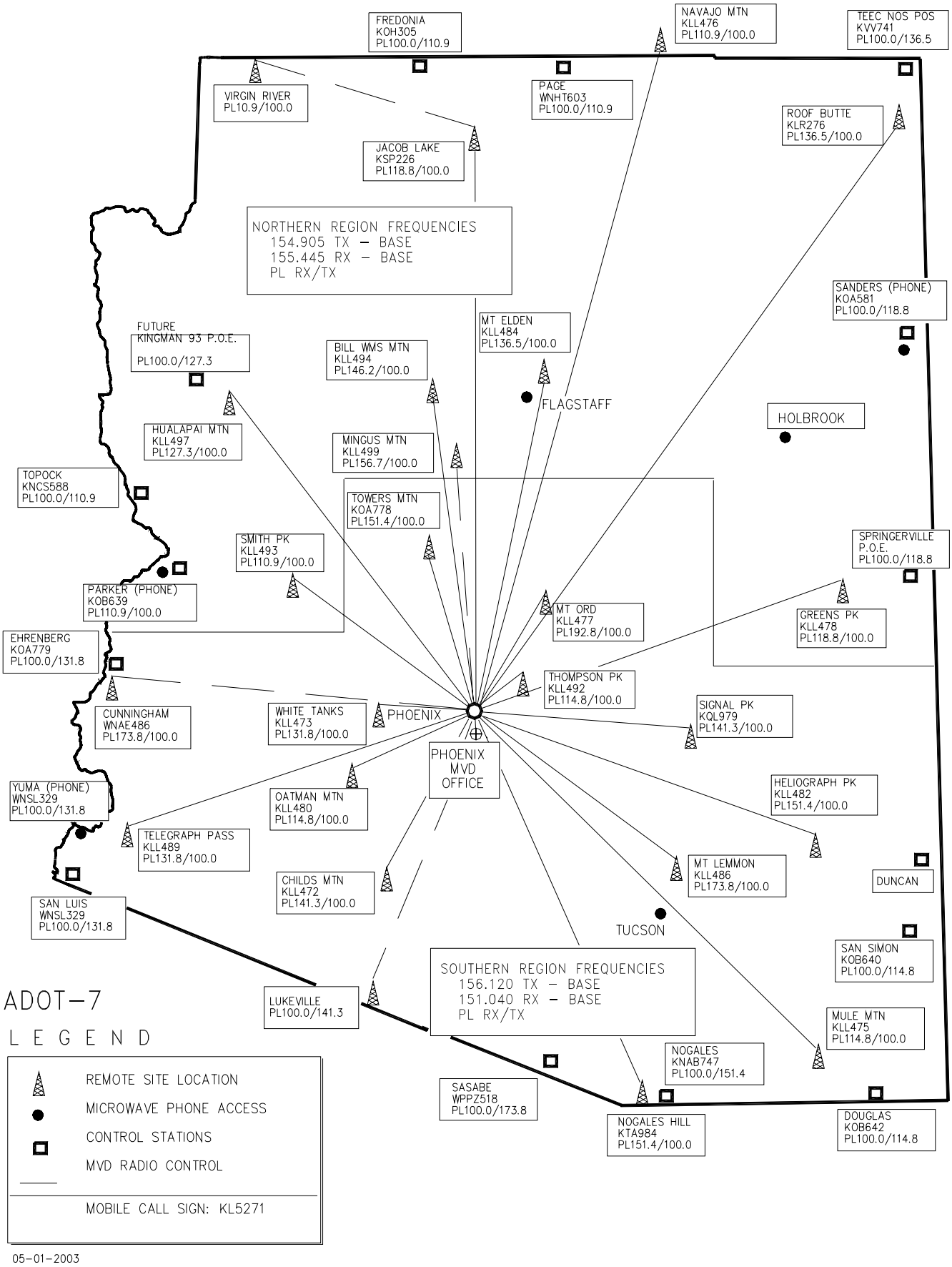


FIGURE F.3 – VHF MOTOR VEHICLE DIVISION RADIO SYSTEM

APPENDIX G

ONLINE SURVEY AND SURVEY RESPONSE SUMMARIES

SPR-561
ONLINE SURVEY QUESTIONS

1) Contact Information
   a) Contact Name:
   b) Agency:
   c) Title:
   d) Street Address:
   e) City:
   f) State:
   g) Zip:
   h) Telephone: (area code & number)
   i) FAX: (area code & number)
   j) E-Mail Address:
   k) Contact Preference: e-mail; FAX; U.S. Mail; Telephone
   l) How many employees does your agency have?

2) How many of your agency's employees regularly use the radio communications system?

3) Which of the following best describes the topography where your agency operates? (select all that apply)
   a) Relatively Flat
   b) Rolling Hills
   c) Mountainous
   d) Suburban Buildings
   e) Not Sure

4) Which types of communications equipment are used by your agency? (select all that apply)
   a) Vehicle Mounted Land Mobile Radio
   b) Hand Held Land Mobile Radio
   c) Cellular Telephones
   d) Satellite Telephones
   e) Nextel
   f) Pagers
   g) Mobile Data Terminal
   h) Mobile Laptop Computer Terminals
   i) Other
   j) Not Sure

5) Is your land mobile radio system capable of narrow band operation?
   a) Yes
   b) No
   c) Not Sure

6) Was the majority of your land mobile radio system equipment procured after January 1, 1998?
   a) Yes
   b) No
   c) Not Sure

7) Identify the relative percentage of traffic on your agency's land mobile radio system: (results should total 100%)

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
(a) Field Unit to Field Unit											
(b) Dispatcher to Field Unit											
(c) Other											

8) Rank each communications technology in order of importance for interoperability with the Arizona Department of Transportation: (use 1 to indicate the most important technology and 9 to indicate the least important technology)

	1	2	3	4	5	6	7	8	9	N/A
(a) Vehicle Mounted Land Mobile Radio										
(b) Hand Held Land Mobile Radio										
(c) Cellular Telephone										
(d) Satellite Telephone										
(e) Nextel										
(f) Pagers										
(g) Mobile Data Terminal										
(h) Mobile Laptop Computer Terminals										
(i) Other										

9) What commercial services (if any) does your agency use to supplement its land mobile radio system?

10) If you use a commercial service provider to supplement your land mobile radio service provider, please identify the service provider by brand name:

11) If you use a commercial service provider to supplement your land mobile radio system, does your commercial service provider offer a push-to-talk feature?
   a) Yes
   b) No
   c) Not Sure

12) At how many sites does your agency operate two-way radio base stations today?

13) How many mobile vehicle mounted two-way radios does your agency operate today?

14) How many portable hand-held two-way radios does your agency operate today?

15) How many mobile data terminals does your agency operate today?

16) Does your agency share its land mobile radio system base infrastructure system with other organizations?
   a) Yes
   b) No
   c) Not Sure

17) If you answered "Yes" to question 16, what are the other organizations with whom your agency shares its land mobile radio infrastructure?

18) In which band does your agency operate land mobile radio systems? (select all that apply)
   a) None
   b) Low Band VHF (25 - 50 MHz)
   c) High Band VHF (150 - 174 MHz)
   d) Federal UHF (406 - 420 MHz)
   e) UHF (450 - 470 MHz)
   f) 700 MHz
   g) 800 MHz
   h) Other
   i) Not Sure

19) Which type of land mobile radio systems does your agency currently operate? (select all that apply)
   a) Conventional Analog (non-trunked)
   b) Conventional Digital (non-trunked)
   c) Trunked Analog
   d) Trunked Digital (Vendor Specific)
   e) Trunked Digital (APCO 25 Compliant)
   f) Other
   g) Not Sure

20) Identify the vendor of your trunked radio system (if answered "Yes" to Question 19d)

21) Does your agency plan to upgrade its land mobile radio system within the next five years?
   a) Yes
   b) No
   c) Not Sure

22) What radio technology is your agency likely to choose for its radio upgrade program?

23) Is it likely that your agency will adopt the APCO 25 digital radio standard, as part of its next radio system upgrade?
   a) Yes
   b) No
   c) Not Sure

24) Does your agency's land mobile radio system use wireless voice security? (select one)
   None
   a) Digital Encryption
   b) Scrambling Device
   c) Not Sure

25) Which of the following best describes your agency's arrangements for dispatching?
   a) Agency performs its own dispatching 24 hrs/day
   b) Agency performs its own dispatching 9 AM to 5 PM
   c) Agency uses a combined dispatch center
   d) Agency uses a contracted dispatching service

26) Describe after-hours dispatch arrangements (if answered "Yes" to Question 25b)

27) Identify combined dispatch center: (if answered "Yes" to Question 25c)

28) Do you currently have the ability to communicate with any of the following ADOT groups using radio communications?

	Yes	No	Not Sure
(a) ADOT Maintenance			
(b) ADOT Construction			
(c) HAZMAT			
(d) MVD			

29) Under which circumstances does your agency have a need to communicate with the Arizona Department of Transportation? (select all that apply)
   a) None
   b) Routine Daily Operations
   c) For Road Construction
   d) For Task Forces & Unusual Planned Events Only (permit closures, major spectator events, etc).
   e) For Emergency Conditions Only (forest fires, floods, etc).
   f) For Homeland Security Emergencies (e.g. terrorist threats or acts)
   g) Not Sure

30) How often does your agency have need for direct radio communications with the Arizona Department of Transportation? (select all that apply)
   a) Daily
   b) Weekly
   c) Monthly
   d) Yearly
   e) During Recurring Mutual Aid Situations
   f) During Infrequent Mutual Aid Situations
   g) Never
   h) Not Sure

31) Does your agency currently have land mobile radio interoperability with any other agencies?
   a) Yes
   b) No
   c) Not Sure

32) With which agencies does your agency currently share land mobile radio system interoperability? (If answered "Yes" to Question 31)

33) Does your agency need land mobile radio interoperability with any other agencies?
   a) Yes
   b) No
   c) Not Sure

34) List Agencies with whom you need land mobile radio interoperability: (If answered "Yes" to Question 33)

35) Does your agency have at least one radio channel designated for communicating with other agencies?
   a) Yes
   b) No
   c) Not Sure

36) Describe your agency policies for use of any channels designated for interoperability: (If answered “Yes” to Question 35)

37) Identify the type of voice channel available for interoperability. (select all that apply) (If answered “Yes” to Question 35)
   a) Low Band VHF (25 -50 MHz)
   b) High Band VHF (150 -174 MHz)
   c) Federal UHF (406 - 420 MHz)
   d) UHF (450 - 470 MHz)
   e) 700 MHz
   f) 800 MHz
   g) Other Band
   h) Conventional Analog (non-trunked)
   i) Conventional Digital (non-trunked)
   j) Trunked Analog
   k) Trunked Digital (vendor specific)
   l) Trunked Digital (APCO 25)
   m) Other System
   n) Not Sure

38) Is your agency willing to issue a letter of authorization to incorporate agency designated frequencies into ADOT's land mobile radio system?
   a) Yes
   b) No, but we are willing to consider other interoperability solutions
   c) No

39) Who are the individuals who would be likely to use a land mobile radio system that inter-operates with the ADOT radio system?

40) What is the primary job description of those individuals (e.g. Roadway Maintenance Superintendent, Traffic Signal Technician, Law Enforcement Officer, Firefighter, Incident Commander, etc).

41) What level of interoperability planning with ADOT would best serve your agency? (select one)
   a) Local Area
   b) County-wide
   c) State-wide
   d) State-wide including surrounding states
   e) Other
   f) Not Sure

42) How important do you consider land mobile radio interoperability with ADOT Maintenance?

← Not Important	1	2	3	4	5	Very Important →

43) How important do you consider land mobile radio interoperability with ADOT Construction?

← Not Important	1	2	3	4	5	Very Important →

44) How important do you consider land mobile radio interoperability with the ADOT Motor Vehicle Division?

← Not Important	1	2	3	4	5	Very Important →

45) How important do you consider land mobile radio interoperability with ADOT HAZMAT?

← Not Important	1	2	3	4	5	Very Important →

46) Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.

	Not an Obstacle	Minor Obstacle	Major Obstacle	Not Sure
(a) Lack of Frequent Need for Interoperability				
(b) Technical Issues (different bands and radio systems)				
(c) Different Coverage Area				
(d) Regulatory or Licensing Issues				
(e) Security Concerns				
(f) Lack of Training and Planning				

47) What is your agency's overall opinion on land mobile radio interoperability? (select all that apply)

a) It is not needed.
b) It would be nice but, must be affordable.
c) It must be funded outside our agency's normal budget.
d) It would be nice but, could pose too many security risks.
e) It must be easy to use.
f) It must be available during emergencies.
g) It must be available 24/7.
h) Not sure.

48) What does your agency consider to be the optimal solution for interoperability with the Arizona Department of Transportation
   a) No Solution is Required
   b) Current Solution is Adequate
   c) Swap Handheld/Mobile Radios with ADOT as Needed
   d) Use a Radio Scanner to Scan Each Other's Radio Channels
   e) Program Our Agency's Frequencies in ADOT's Radios
   f) Program ADOT Frequencies in Our Radios
   g) Use Commercial Wireless Services (e.g. cellphones or Nextel)
   h) Use New Technologies to Cross-Link Our Channels Together as Needed
   i) Communicate via Dispatch Centers Only
   j) Other
   k) Not Sure

49) Have you experienced a situation in which the ability to interoperate with ADOT was or could have been particularly helpful? (please describe)

50) Please provide any additional comments you may have. If the comments relate to a particular question, please provide the question number.

RESPONSES TO SELECTED SURVEY QUESTIONS

Note: Some respondents understood "Agency" to mean their group of a department. Those responses need to be taken in the proper context, i.e. they may not represent the situation of the entire agency. In some cases, it appears that responses might have been guesses, i.e. the question might not have been clear or as equally relevant to the statewide manager as it was for the local supervisor. Additionally, not everyone provided a response to every question, i.e. the totals or averages represent trends and not exact definitions of resources or practices. Finally, Some of the averages may add up to more than 100%, possibly due to erroneous / unintended entries or question interpretation.

TABLE G.1
NUMBER OF SURVEY RESPONDENTS PER AGENCY

RESPONDING AGENCY	TOTAL	RESPONDING AGENCY	TOTAL
Apache County (Roads)	2	New Mexico DOT (NMDOT)	1
Arizona Department of Public Safety (DPS)	2	New Mexico State Police	3
Arizona DOT (including Phoenix TOC, TSG ITG, Holbrook District, MVES, and Org 8853)	22	Peoria, City of	1
Avondale, City of	1	Phoenix, City of (including Public Transit Department)	2
Bullhead City, City of	1	Pima County (Fleet Services and Sheriff's Department)	2
California DOT	1	Pinal County	1
California Highway Patrol	1	Pinetop-Lakeside, Town of (Police Department)	1
Chandler, City of	2	Puerco Valley, Locality of (Fire District)	2
Cochise County Information Technology	1	Red Mountain Machinery Co.	1
Coconino County Public Works Department	1	Safford, City of (Police Department)	1
Federal Highway Administration (FHWA)	1	Santa Cruz County Public Works	1
Flagstaff, City of (including Public Works and Fire Departments)	3	Scottsdale, City of (Police Department)	1
Ganado, City of (Fire District)	2	Sedona, City of	1
Gilbert, Town of	1	Snowflake - Taylor, Cities of	1
Glendale, City of	1	Springerville, Town of	1
Globe, City of (Police Department)	1	St. John's, City of (Police Department)	1
Graham County	1	Taylor, City of (Fire Department)	1
Hayden, City of (Police Department)	1	Tempe, City of (Police Department)	1
Holbrook, City of (Police Department)	1	Tuba City, City of (Police Department)	1
Kingman, City of (Public Works)	1	Tucson, City of (including Streets/Traffic Maintenance, Fire and Police Departments)	4
Lake Havasu City, City of (Fire and Public Works Departments)	2	U.S. Fish and Wildlife Service	1
Las Vegas, City of (Metro Police – Laughlin Station)	1	USDA Forest Service	3
Maricopa Association of Governments	1	Winslow, City of (Fire Department)	1
Maricopa County DOT (MCDOT)	3	Yavapai County (Public Works Department, Sheriff's Office, and Office of Emergency Management)	3
Miami, Town of (Police Department)	1	**TOTAL**	**96**
Navajo County (including Public Works Department and Sheriff's Office)	3		
Navajo Nation Department of Public Safety	1		
Nevada DOT (NDOT)	1		

TABLE G.2 – QUESTION 4: Which types of communications equipment are used by your agency? (select all that apply): a) Vehicle Mounted Land Mobile Radio; b) Hand Held Land Mobile Radio; c) Cellular Telephones; d) Satellite Telephones; e) Nextel; f) Pagers; g) Mobile Data Terminal; h) Mobile Laptop Computer Terminals; i) Other; j) Not Sure									
AGENCY	**SUM OF RESPONSES**								
	4a	**4b**	**4c**	**4d**	**4e**	**4f**	**4g**	**4h**	**4i**
ADOT	21	17	22	1	3	17		4	1
Apache County	2	2	2						
Bullhead City, City of	1	1	1						
Caltrans	1	1	1		1				
Chandler, City of	1	1	1			1			
Cochise County	1	1	1			1			
Coconino County	1	1	1			1			
DPS	2	2	2			1	1		
FHWA			1	1					
Flagstaff, City of	3	3	1			1	1		
Ganado, City of	2	2	2			2			
Gilbert, Town of	1	1	1		1	1			
Glendale, City of	1	1	1						
Globe, City of	1	1	1						
Graham County	1	1	1			1		1	
Hayden, City of	1	1	1						
Holbrook, City of	1	1				1			
Kingman, City of	1	1	1			1			
Lake Havasu City, City of	2	2	2			1		1	
Las Vegas, City of	1		1	1		1	1		
MCDOT	3	2	3		2	3	1	2	
Miami, Town of	1	1	1						
Navajo County	3	2	3			1			
Navajo Nation	1	1					1		
NDOT	1	1	1		1				
NMDOT	1	1	1						
Peoria, City of	1		1		1	1	1	1	
Phoenix, City of	2	2	2		1	2	2	2	1
Pima County	2	2	2	1	1	2		1	
Pinal County	1	1	1	1	1	1	1	1	
Puerco Valley, Locality of	2	1	2						
Red Mountain Machinery Co.					1				
Safford, City of	1	1	1			1			
Santa Cruz County	1	1	1			1			
Scottsdale, City of	1	1	1			1		1	
Sedona, City of	1	1	1			1			
Snowflake - Taylor, Cities of	1	1	1						
Springerville, Town of	1	1	1			1			
State of California	1								
State of New Mexico	3	2	3	1		3	2	2	
Taylor, City of	1	1	1			1			
Tuba City, City of	1	1							
Tucson, City of	3	3	3	1	1	2	3	1	
U.S. Fish and Wildlife Service	1	1	1	1		1		1	
USDA Forest Service	3	3	3	2		3			
Winslow, City of	1	1	1			1			
Yavapai County	3	3	3	1		2			
TOTAL	86	75	82	11	14	58	14	18	2

TABLE G.3 – QUESTION 5: Is your land mobile radio system capable of narrow band operation?			
AGENCY	**No**	**Not Sure**	**Yes**
ADOT	2	17	2
Apache County			2
Bullhead City, City of		1	
Caltrans			1
Chandler, City of		2	
Cochise County			1
Coconino County			1
DPS		1	
Flagstaff, City of			3
Ganado, City of	1	1	
Gilbert, Town of		1	
Glendale, City of		1	
Globe, City of	1		
Graham County		1	
Hayden, City of		1	
Holbrook, City of	1		
Kingman, City of	1		
Lake Havasu City, City of		2	
Las Vegas, City of		1	
MCDOT		3	
Miami, Town of		1	
Navajo County		2	1
Navajo Nation			1
NDOT			1
NMDOT			1
Peoria, City of		1	
Phoenix, City of			2
Pima County	2		
Pinal County			1
Puerco Valley, Locality of	1	1	
Red Mountain Machinery Co.		1	
Safford, City of		1	
Santa Cruz County		1	
Scottsdale, City of	1		
Sedona, City of		1	
Snowflake - Taylor, Cities of	1		
Springerville, Town of	1		
State of California		1	
State of New Mexico	2	1	
Taylor, City of		1	
Tuba City, City of	1		
Tucson, City of	3	1	
U.S. Fish and Wildlife Service			1
USDA Forest Service			3
Winslow, City of		1	
Yavapai County		1	2
TOTAL	18	47	23

TABLE G.4 – QUESTION 6: Was the majority of your land mobile radio system equipment procured after January 1, 1998?			
AGENCY	**No**	**Not Sure**	**Yes**
ADOT	3	7	6
Chandler, City of		2	
DPS	1		
Ganado, City of		1	
Gilbert, Town of			1
Glendale, City of			1
Graham County		1	
Lake Havasu City, City of		1	
MCDOT		1	2
Navajo County	1		1
Peoria, City of		1	
Puerco Valley, Locality of	1		
Red Mountain Machinery Co.	1		
Santa Cruz County			1
State of New Mexico	1		
Taylor, City of	1		
Yavapai County	1		
TOTAL	10	14	12

TABLE G.5 – QUESTION 7: Identify the relative percentage of traffic on your agency's land mobile radio system:			
AGENCY	**AVERAGED RESPONSE ***		
	Field Unit to Field Unit	**Dispatcher to Field Unit**	**Other**
ADOT	57%	38%	28%
Apache County	70%	30%	0%
Bullhead City, City of	70%	30%	0%
Caltrans	50%	40%	10%
Chandler, City of	90%	10%	0%
Cochise County	10%	80%	10%
Coconino County	90%	10%	10%
DPS	20%	75%	10%
Flagstaff, City of	57%	30%	0
Ganado, City of	45%	55%	0%
Gilbert, Town of	60%	20%	20%
Glendale, City of	70%	70%	70%
Globe, City of	10%	90%	0%
Graham County	40%	40%	20%
Hayden, City of	50%	50%	0%
Holbrook, City of	30%	70%	0%
Kingman, City of	70%	30%	0%
Lake Havasu City, City of	65%	30%	10%
Las Vegas, City of	0%	100%	0%
MCDOT	57%	53%	23%
Miami, Town of	10%	80%	10%
Navajo County	50%	40%	40%
Navajo Nation	50%	50%	0%
NDOT	80%	20%	0%
NMDOT	60%	40%	0%
Peoria, City of	20%	80%	0%
Phoenix, City of	10%	85%	10%
Pima County	55%	40%	10%
Pinal County	30%	70%	0%
Puerco Valley, Locality of	50%	40%	10%
Red Mountain Machinery Co.	100%	0%	0%
Safford, City of	50%	50%	0%
Santa Cruz County	90%	0%	10%
Scottsdale, City of	30%	70%	0%
Sedona, City of	90%	10%	0%
Snowflake - Taylor, Cities of	10%	90%	0%
Springerville, Town of	90%	10%	0%
State of New Mexico	20%	73%	10%
Taylor, City of	40%	50%	10%
Tuba City, City of	50%	50%	0%
Tucson, City of	43%	53%	10%
U.S. Fish and Wildlife Service	60%	30%	10%
USDA Forest Service	50%	50%	0%
Winslow, City of	50%	50%	0%
Yavapai County	45%	55%	100% *
OVERALL AVERAGE	48%	49%	13%

* For each agency shown, the percentage represents an average of all responses obtained from the agency (typical for many questions shown). Some of the averages may add up to more than 100% possibly due to erroneous / unintended entries or question interpretation.

TABLE G.6 – QUESTION 8: Rank each communications technology in order of importance for Interoperability with the Arizona Department of Transportation: (use 1 to indicate The most important technology and 9 to indicate the least important technology). (a) Vehicle Mounted Land Mobile Radio; (b) Hand Held Land Mobile Radio; (c) Cellular Telephone; (d) Satellite Telephone; (e) Nextel; (f) Pagers; (g) Mobile Data Terminal; (h) Mobile Laptop Computer Terminals; (i) Other

AGENCY	8a		8b		8c		8d		8e		8f		8g		8h		8i	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A
ADOT	22.0	2.8	29.0	4.8	34.0	3.8	11.0	5.5	12.0	4.0	32.0	4.0	12.0	6.0	13.0	6.5	3.0	3.0
Bullhead City, City of	2.0	2.0	3.0	3.0	1.0	1.0	5.0	5.0	4.0	4.0	4.0	4.0	6.0	6.0	7.0	7.0		
Caltrans	2.0	2.0	3.0	3.0	1.0	1.0	8.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0		
Chandler, City of	3.0	3.0	1.0	1.0	2.0	2.0					2.0	2.0	3.0	3.0	3.0	3.0		
Cochise County	1.0	1.0	3.0	3.0	2.0	2.0	4.0	4.0										
Coconino County	1.0	1.0	1.0	1.0	2.0	2.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
DPS	1.0	1.0	2.0	2.0	3.0	3.0												
FHWA					8.0	8.0	5.0	5.0			8.0	8.0						
Flagstaff, City of	12.0	4.0	16.0	5.3	5.0	2.5	17.0	8.5	17.0	8.5	17.0	8.5	17.0	8.5	13.0	6.5	8.0	8.0
Ganado, City of	5.0	2.5	4.0	2.0	3.0	1.5	10.0	5.0	2.0	1.0	5.0	2.5	3.0	1.5	2.0	1.0	1.0	1.0
Globe, City of	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	1.0	1.0
Graham County																		
Hayden, City of	1.0	1.0	1.0	1.0	2.0	2.0												
Holbrook, City of	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	9.0	9.0	9.0	9.0	4.0	4.0	4.0	4.0		
Kingman, City of	2.0	2.0	2.0	2.0	1.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0		
Lake Havasu City, City of	3.0	3.0	2.0	2.0	1.0	1.0	4.0	4.0	5.0	5.0	5.0	5.0	7.0	7.0	6.0	6.0		
Las Vegas, City of	1.0	1.0	1.0	1.0	3.0	3.0	5.0	5.0	9.0	9.0	9.0	9.0	2.0	2.0	6.0	6.0		
MCDOT	2.0	2.0	2.0	2.0	1.0	1.0			2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0		
Miami, Town of	2.0	2.0	5.0	5.0	2.0	2.0	1.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	5.0	5.0
Navajo County	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0
Navajo Nation	1.0	1.0	2.0	2.0	4.0	4.0	3.0	3.0	6.0	6.0	6.0	6.0	5.0	5.0	7.0	7.0		
NDOT	2.0	2.0	3.0	3.0	1.0	1.0			4.0	4.0	4.0	4.0						
Pima County	2.0	2.0	5.0	5.0	2.0	1.0	7.0	7.0	4.0	4.0	4.0	4.0	6.0	6.0	3.0	3.0		
Pinal County	1.0	1.0	2.0	2.0	5.0	5.0	7.0	7.0			6.0	6.0	4.0	4.0	3.0	3.0		
Puerco Valley, Locality of	1.0	1.0	1.0	1.0	4.0	4.0												
Safford, City of	1.0	1.0	2.0	2.0	3.0	3.0												
Santa Cruz County	2.0	2.0	3.0	3.0	1.0	1.0					4.0	4.0	5.0	5.0	6.0	6.0		
Scottsdale, City of	5.0	5.0	5.0	5.0	2.0	2.0					2.0	2.0			1.0	1.0		
Sedona, City of					1.0	1.0												
State of California	1.0	1.0	2.0	2.0	3.0	3.0												
State of New Mexico	3.0	3.0	6.0	6.0	5.0	5.0	5.0	5.0	9.0	9.0	9.0	9.0	5.0	5.0	9.0	9.0	9.0	9.0
Taylor, City of	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	7.0	7.0	4.0	4.0	2.0	2.0	2.0	2.0		
Tuba City, City of	1.0	1.0	2.0	2.0														
Tucson, City of	9.0	3.0	5.0	1.7	5.0	1.3	8.0	8.0	14.0	4.7	15.0	5.0	11.0	5.5	16.0	5.3		
U.S. Fish and Wildlife Service	1.0	1.0	2.0	2.0	3.0	3.0	4.0	4.0	7.0	7.0	7.0	7.0	6.0	6.0	5.0	5.0		
USDA Forest Service	2.0	1.0	2.0	1.0	7.0	3.5	12.0	6.0	9.0	9.0	10.0	5.0	9.0	9.0	9.0	9.0	9.0	9.0
Winslow, City of	1.0	1.0	1.0	1.0	1.0	1.0	9.0	9.0	9.0	9.0	9.0	9.0	6.0	6.0	6.0	6.0		
Yavapai County	1.0	1.0	1.0	1.0														
TOTAL	107.0	2.0	132.0	2.6	131.0	2.5	157.0	5.5	175.0	6.4	219.0	5.9	161.0	5.8	170.0	5.6	46.0	5.1

Note: S – Sum; A – Average

TABLE G.7 – QUESTION 9: What commercial services (if any) does your agency use to supplement its land mobile radio system?	
AGENCY	**RESPONSES**
ADOT	None; Several paging system providers; Cell Phones and Pagers; Several wireless companies; not sure
Apache County	N/A
Caltrans	Some Nextel
Cochise County	Sprint Cell Phone; Valley Telecom Cell Phone; Arch Pagers
Coconino County	N/A
DPS	DNA; None
Flagstaff, City of	N/A; Verizon Cellular
Ganado, City of	None; Motorola
Gilbert, Town of	Nextel w way
Globe, City of	None
Graham County	N/A
Holbrook, City of	Pager
Lake Havasu City, City of	Self owned; None
Las Vegas, City of	None
MCDOT	None; Nextel; Cellular phones, pagers
Miami, Town of	None
Navajo County	Cell Phone - Cell One of Northeast Arizona; None; Navajo County owns the system
Navajo Nation	Frontier Communications Co.
NDOT	AT&T Cell; Verizon Cell; Nextel ; Land Line Sprint
NMDOT	none
Peoria, City of	Cellular Phones
Phoenix, City of	None; Cellular; CDPD; leased circuits
Pima County	None
Pinal County	Nextel/Verizon?
Puerco Valley, Locality of	Cell Phones
Red Mountain Machinery Co.	CELL PHONES
Safford, City of	Cell Phones & Pagers
Scottsdale, City of	none
Snowflake - Taylor, Cities of	N/A
Springerville, Town of	Verizon
State of California	None
State of New Mexico	Motorola Phone System; Qwest Phone System; Local Motorola Repair - Four State Communications; Alltel Communications; None
Tuba City, City of	NCC
Tucson, City of	Verizon Wireless; None
U.S. Fish and Wildlife Service	N/A
USDA Forest Service	None
Winslow, City of	N/A
Yavapai County	cell phone; Pager; None

TABLE G.8 – QUESTION 10: If you use a commercial service provider to supplement your land mobile radio service provider, please identify the service provider by brand name:	
AGENCY	**RESPONSES**
ADOT	Verizon; Alltell; Cellular One; Qwest; Mohave Wireless; Motorola; Other
Bullhead City, City of	Motorola
Caltrans	Nextel
Flagstaff, City of	Verizon; N/A
Ganado, City of	N/A
Gilbert, Town of	NEXTEL
Globe, City of	Agency provided
Graham County	N/A
Kingman, City of	N/A
Las Vegas, City of	N/A
MCDOT	N/A; Nextel; Unknown
Miami, Town of	N/A
Navajo Nation	Frontier Communications Co.
NDOT	AT&T Cellular, Nextel (limited use)
NMDOT	N/A
Peoria, City of	Nextel
Phoenix, City of	NEXTEL; ALLTEL; QWEST
Pima County	None; Alltel Communications
Pinal County	Nextel; Verizon
Red Mountain Machinery Co.	Nextel
Safford, City of	Valley Telecom; Montel
Sedona, City of	None
Snowflake - Taylor, Cities of	N/A
Springerville, Town of	Verizon cell service
State of California	N/A
State of New Mexico	MOTOROLA AND QWEST; None; Alltel; Motorola
Tuba City, City of	Frontier
Tucson, City of	Verizon; N/A
U.S. Fish and Wildlife Service	N/A
USDA Forest Service	Agency Provided; N/A
Yavapai County	Verizon wireless; N/A

TABLE G.9 – QUESTION 11: If you use a commercial service provider to supplement your land mobile radio system, does your commercial service provider offer a push-to-talk feature?			
AGENCY	**No**	**Not Sure**	**Yes**
ADOT	9	4	
Bullhead City, City of			1
Caltrans			1
Chandler, City of		1	
Cochise County	1		
Flagstaff, City of			1
Ganado, City of	1		
Gilbert, Town of			1
Glendale, City of		1	
Globe, City of	1		
Graham County	1		
Lake Havasu City, City of	1		
MCDOT		1	1
Miami, Town of	1		
Navajo County	2		
Navajo Nation			1
NDOT			1
Peoria, City of			1
Phoenix, City of			1
Pima County	1		
Pinal County			1
Puerco Valley, Locality of	1		
Red Mountain Machinery Co.			1
Safford, City of	1		
Santa Cruz County		1	
Sedona, City of	1		
Springerville, Town of		1	
State of California	1		
State of New Mexico	1	1	
Tuba City, City of		1	
Tucson, City of			1
USDA Forest Service	1		
Yavapai County	1		1

TABLE G.10 – QUESTION 12: At how many sites does your agency operate two-way radio base stations today?	
AGENCY	**NO. OF SITES REPORTED**
ADOT	From 1 to 200
Apache County	8
Bullhead City, City of	1
Caltrans	45
Cochise County	10
Coconino County	2
DPS	1
Flagstaff, City of	5 to 6
Ganado, City of	3
Gilbert, Town of	8 with Police Department
Globe, City of	1
Graham County	2
Hayden, City of	1
Holbrook, City of	1
Kingman, City of	2
Lake Havasu City, City of	1 to 3
Las Vegas, City of	2
MCDOT	3 to 7
Miami, Town of	1
Navajo County	1 to 3
Navajo Nation	8
NDOT	50+
NMDOT	1
Peoria, City of	unknown
Phoenix, City of	3 to 60
Pima County	7 to 8
Pinal County	7
Puerco Valley, Locality of	2
Red Mountain Machinery Co.	0
Safford, City of	1
Santa Cruz County	2
Scottsdale, City of	0
Sedona, City of	2
Snowflake - Taylor, Cities of	1
Springerville, Town of	1
St. John's, City of	2
State of California	2
State of New Mexico	3 to 19
Taylor, City of	2
Tuba City, City of	4
Tucson, City of	1 to 12
U.S. Fish and Wildlife Service	20
USDA Forest Service	3 to 18
Winslow, City of	2
Yavapai County	2 to 7
Note: The range of responses represents different perceptions (as to "your agency") and may not correspond to the actual number of sites.	

TABLE G.11 – QUESTIONS 13 – 15: Question 13: How many mobile vehicle mounted two-way radios does your agency operate today? Question 14: How many portable hand-held two-way radios does your agency operate today? Question 15: How many mobile data terminals does your agency operate today?			
AGENCY	**NO. OF REPORTED UNITS**		
	2-Way Radios	**Hand-Held Radios**	**MDTs**
ADOT	Up to 3500+	Up to 1000	2
Apache County	240	20	0
Bullhead City, City of	30	15	
Caltrans	600	200	
Cochise County	300	300	0
Coconino County	150	50	0
DPS	78	65	0
Flagstaff, City of	35 to 107	50 to 75	0
Ganado, City of	16	12	0
Gilbert, Town of	315w/P.D.	160w/P.D	3?
Globe, City of	16	26	0
Graham County	40+	25+	N/A
Hayden, City of	7	7	0
Holbrook, City of	20	25	0
Kingman, City of	15	15	0
Lake Havasu City, City of	35 to 54	14 to 60	0 to 8
Las Vegas, City of	35	35	35
MCDOT	100 to 200	150+	0 to 5
Miami, Town of	6	8	0
Navajo County	50 to 180	20 to 50	0
Navajo Nation	24	24	2
NDOT	1,000+	1000+	None
NMDOT	200	100	0
Phoenix, City of	3450 (includes 450 Transit radios)	4050 (includes 50 Transit radios)	1950 (includes 750 Transit MDTs)
Pima County	210 to 384	90 to 1376	0 to 275
Pinal County	400	150	20
Puerco Valley, Locality of	11	30	0
Red Mountain Machinery Co.	0	100	0
Safford, City of	21	21	0
Santa Cruz County	3	10	
Scottsdale, City of	350	550	100
Sedona, City of	4	15	0
Snowflake - Taylor, Cities of	13	13	0
Springerville, Town of	9	11	0
St. John's, City of	8	8	0
State of California	20	25	0
State of New Mexico	29	24 to 34	0
Taylor, City of	9	35	0
Tuba City, City of	35	33	0
Tucson, City of	30 to 1521	100 to 3296	2 to 1500
U.S. Fish and Wildlife Service	200	300	0
USDA Forest Service	50 to 240	100 to 500	N/A or 0
Winslow, City of	5	10	N/A
Yavapai County	2 to 150	2 to 150	N/A or 0

TABLE G.12 – QUESTION 17: What are the other organizations with whom your agency shares its land mobile radio infrastructure	
AGENCY	**OTHER ORGANIZATIONS**
ADOT	Internally; DPS; Infrastructure sites are shared with other state agencies.
Flagstaff, City of	Northern Arizona University owns the system
Gilbert, Town of	Chandler; Mesa; Possibly others
Graham County	Graham County Sheriff; Graham County Highway; Safford PD; Thatcher PD; Pima PD; Safford FD; Thatcher FD; Pima FD; Ft. Thomas FD
MCDOT	All Maricopa County including the sheriff's office; Flood Control District; Equipment Services; Sheriff's Department; Emergency Management; Animal Services; Several others
Navajo County	Development Services department Navajo County Contract with Joseph City Fire, Sun Valley Fire, White Mtn. Lake Fire, Linden Fire, Claysprings/Pinedale Fire.
Phoenix, City of	Mesa, Maricopa County, Valley Transit, Fire Departments of Glendale, Peoria, Tolleson, Buckeye, Tempe, Avondale, Chandler, Sun City, Sun City West, Luke AFB, Litchfield, Laveen, Gilbert, Surprise, Goodyear, Youngtown, El Mirage
Puerco Valley, Locality of	Apache County Sheriffs Office, BIA, Mutual Aid
Scottsdale, City of	Maricopa County Wireless Systems
State of New Mexico	Socorro County Sheriffs Office, Catron County Sheriffs Office, Game And Fish, Sierra County Sheriffs Office, Magdalena Village Marshalls Office
Taylor, City of	Snowflake Taylor Police Dept. Snowflake Fire Department
Yavapai County	All Yavapai County police agencies except the Dept. of Public Safety; Yavapai County Adult Probation; Yavapai County Emergency Management; Yavapai Prescott Tribal Police
Yavapai County	Yavapai County Health Dept.; Yavapai County Facilities Dept.

TABLE G.13 – QUESTION 18: In which band does your agency operate land mobile radio systems? (select all that apply) (a) None; (b) Low Band VHF (25 - 50 MHz); (c) High Band VHF (150 - 174 MHz); (d) Federal UHF (406 - 420 MHz); (e) UHF (450 - 470 MHz); (f) 700 MHz; (g) 800 MHz; (h) Other; (i) Not Sure									
AGENCY	**SUM OF RESPONSES PER CATEGORY**								
	18a	**18b**	**18c**	**18d**	**18e**	**18f**	**18g**	**18h**	**18i**
ADOT	1		6		1		3		9
Apache County			2						
Bullhead City, City of									1
Caltrans							1		
Cochise County			1		1				
Coconino County					1				
DPS					1				1
Flagstaff, City of			1		1		2	1	
Ganado, City of			1						
Gilbert, Town of									1
Glendale, City of							1		
Globe, City of			1						
Graham County			1		1				
Hayden, City of									1
Holbrook, City of		1							
Kingman, City of			1		1				
Lake Havasu City, City of			1				2		
MCDOT			1		1		2		1
Miami, Town of									1
Navajo County			3						
Navajo Nation			1						
NDOT							1		
Peoria, City of									1
Phoenix, City of			1		2		1		
Pima County							2		
Pinal County			1						
Pinetop-Lakeside, Town of									
Puerco Valley, Locality of			2		2				
Red Mountain Machinery Co.									1
Safford, City of			1						
Santa Cruz County									1
Scottsdale, City of							1		
Sedona, City of									1
Snowflake - Taylor, Cities of			1						
Springerville, Town of			1						
St. John's, City of									1
State of California		1							
State of New Mexico			2						
Taylor, City of			1						
Tempe, City of									
Tuba City, City of			1						
Tucson, City of			2		2		1		1
U.S. Fish and Wildlife Service			1						
USDA Forest Service			3						
Winslow, City of			1						
Yavapai County			3		1				
Sum	1	2	41	0	15	0	17	1	21

TABLE G.14 – QUESTION 19: Which type of land mobile radio systems does your agency currently operate? (a) Conventional Analog (non-trunked); (b) Conventional Digital (non-trunked); (c) Trunked Analog; (d) Trunked Digital (Vendor Specific); (e) Trunked Digital (APCO 25 Compliant); (f) Other; (g) Not Sure							
AGENCY	**SUM OF RESPONSES BY CATEGORY**						
	19a	**19b**	**19c**	**19d**	**19e**	**19f**	**19g**
ADOT	2		3	1			12
Apache County	2						
Bullhead City, City of							1
Caltrans	1		1				
Chandler, City of							
Cochise County	1						
Coconino County		1					
DPS							1
FHWA							
Flagstaff, City of	3		1				
Ganado, City of	1						
Gilbert, Town of					1		1
Glendale, City of				1			
Globe, City of	1						
Graham County		1					
Hayden, City of							1
Holbrook, City of	1						
Kingman, City of							1
Lake Havasu City, City of	1		2	1			
Las Vegas, City of							1
MCDOT		1		1			1
Miami, Town of		1					
Navajo County	3						
Navajo Nation	1		1				
NDOT			1				
Peoria, City of							1
Phoenix, City of	2	1	1	1	1		
Pima County			2				
Pinal County	1						
Pinetop-Lakeside, Town of							
Puerco Valley, Locality of	2	1		1			
Red Mountain Machinery Co.							1
Safford, City of	1						
Santa Cruz County							1
Scottsdale, City of			1	1			
Sedona, City of							1
Snowflake - Taylor, Cities of			1				
Springerville, Town of	1						
St. John's, City of			1				
State of California							1
State of New Mexico	1						1
Taylor, City of	1						
Tuba City, City of							1
Tucson, City of	3	1					1
U.S. Fish and Wildlife Service	1	1			1		
USDA Forest Service	2		1	1			
Winslow, City of	1						1
Yavapai County	2						1
Sum	35	8	16	8	3	0	29

TABLE G.15 - QUESTION 21: Does your agency plan to upgrade its land mobile radio system within the next five years?			
AGENCY	**SUM OF RESPONSES**		
	No	**Not Sure**	**Yes**
ADOT	1	13	2
Apache County	2		
Bullhead City, City of		1	
Cochise County			1
Coconino County	1		
DPS		2	
Flagstaff, City of		3	
Ganado, City of	1		
Gilbert, Town of		1	
Glendale, City of			1
Globe, City of			1
Graham County			1
Hayden, City of	1		
Holbrook, City of		1	
Kingman, City of	1		
Lake Havasu City, City of	1	1	
Las Vegas, City of		1	
MAG			
MCDOT		2	1
Miami, Town of		1	
Navajo County	2		1
Navajo Nation			1
NDOT	1		
Peoria, City of			1
Phoenix, City of			2
Pima County	1		1
Pinal County			1
Puerco Valley, Locality of		1	1
Red Mountain Machinery Co.	1		
Safford, City of			1
Santa Cruz County			1
Scottsdale, City of			1
Sedona, City of	1		
Snowflake - Taylor, Cities of	1		
Springerville, Town of	1		
St. John's, City of	1		
State of California		1	
State of New Mexico		1	1
Taylor, City of		1	
Tuba City, City of		1	
Tucson, City of		1	3
U.S. Fish and Wildlife Service			1
USDA Forest Service	1		2
Winslow, City of		1	
Yavapai County		1	2
SUM TOTAL	18	34	27

TABLE G.16 - QUESTION 22: What radio technology is your agency likely to choose for its radio upgrade program?	
AGENCY	**TECHNOLOGY**
ADOT	u/n
Graham County	VHF Narrowband
MCDOT	The radio dispatch console will be updated to the Motorola Gold Elite model soon
Navajo County	"Standard VHF - Maycom Orion VHF radios, Pyramid in car repeater system, W/UHF Kenwood portables (crossband setup)"
Peoria, City of	800 MHz
Phoenix, City of	Project 25 Multizone Trunked Simulcast; Transit trunked analog Motorola 450
Scottsdale, City of	APCO 25
State of New Mexico	VHF Trunking
Tucson, City of	APCO 25
Yavapai County	Not sure; Additional repeaters

TABLE G.17 – QUESTION 23: Is it likely that your agency will adopt the APCO 25 digital radio standard, as part of its next radio system upgrade?			
AGENCY	**SUM OF RESPONSES**		
	No	**Not Sure**	**Yes**
ADOT	1		1
Graham County		1	
MCDOT	1		
Navajo County		1	
Peoria, City of		1	
Phoenix, City of	1		1
Puerco Valley, Locality of		1	
Santa Cruz County		1	
Scottsdale, City of			1
State of New Mexico			1
Tucson, City of			1
Yavapai County		2	

TABLE G.18 – QUESTION 24: Does your agency's land mobile radio system use wireless voice security? (select one)				
AGENCY	SUM OF RESPONSES			
	NONE	DIGITAL ENCRYPTION	SCRAMBLING DEVICE	NOT SURE
ADOT	4			10
Apache County	2			
Bullhead City, City of				1
Caltrans	1			
Cochise County	1			
Coconino County	1			
DPS	1			1
Flagstaff, City of	3			
Ganado, City of	1			
Gilbert, Town of				1
Globe, City of	1			
Graham County	1			
Hayden, City of	1			
Holbrook, City of	1			
Kingman, City of				1
Lake Havasu City, City of	2			
Las Vegas, City of				1
MCDOT	1			2
Miami, Town of	1			
Navajo County	3			
Navajo Nation	1			
NDOT		1		
Peoria, City of				1
Phoenix, City of	1	1		
Pinal County	3			
Puerco Valley, Locality of	1			1
Red Mountain Machinery Co.	1			
Safford, City of	1			
Santa Cruz County	1			
Scottsdale, City of		1		
Sedona, City of	1			
Snowflake - Taylor, Cities of	1			
Springerville, Town of	1			
St. John's, City of	1			
State of California	1			
State of New Mexico	2			
Taylor, City of	1			
Tuba City, City of		1		
Tucson, City of	2	1		1
U.S. Fish and Wildlife Service		1		
USDA Forest Service	3			
Winslow, City of				1
Yavapai County	3			

TABLE G.19 – QUESTION 25: Which of the following best describes your agency's arrangements for dispatching? (a) Agency performs its own dispatching 24 hrs/day; (b) Agency performs its own dispatching 9 AM to 5 PM; (c) Agency uses a combined dispatch center; (d) Agency uses a contracted dispatching service				
AGENCY	**SUM OF RESPONSES**			
	a	**b**	**c**	**d**
ADOT	9	3	3	
Apache County		2		
Bullhead City, City of		1		
Caltrans	1			
Cochise County	1			
Coconino County		1		
DPS	2			
FHWA			1	
Flagstaff, City of		2	1	
Ganado, City of	1			
Gilbert, Town of	1			
Globe, City of	1			
Graham County	1			
Hayden, City of				1
Holbrook, City of	1			
Kingman, City of		1		
Lake Havasu City, City of		1	1	
Las Vegas, City of	1			
MCDOT		3		
Miami, Town of	1			
Navajo County	2	1		
Navajo Nation	1			
NDOT		1		
Peoria, City of	1			
Phoenix, City of	2			
Pima County	1		1	
Pinal County	1			
Puerco Valley, Locality of	1		1	
Red Mountain Machinery Co.	1			
Safford, City of				1
Scottsdale, City of	1			
Sedona, City of		1		
Snowflake - Taylor, Cities of	1			
Springerville, Town of			1	
St. John's, City of			1	
State of California	1			
State of New Mexico	1		1	
Taylor, City of			1	
Tuba City, City of	1			
Tucson, City of	2		1	
U.S. Fish and Wildlife Service			1	
USDA Forest Service	1	2		
Winslow, City of			1	
Yavapai County	1	1		
TOTAL	39	20	14	2

TABLE G.20 – QUESTION 26: Describe after-hours dispatch arrangements (if answered Yes to Question 25b)	
AGENCY	**ANSWER**
ADOT	24/7 during winter storm events at the District level; On-call areas/individuals utilize pagers and/or Nextel phones with alphanumeric paging and radio capabilities; Use local agencies like county and DPS
Apache County	after hours will be by phone call and then dispatched out.
Lake Havasu City, City of	On previous question: Agency performs its own dispatching 7 AM to 5 PM.
MCDOT	Actual dispatch hours are from 0600 to 1700, Monday through Friday, After hours calls are referred to the Sheriffs Department who then, depending on the call, will contact our stand-by personnel; goes to sheriff's office for normal emergencies, REACT is paged directly by police agencies
Navajo County	Only when needed which is very rare.
USDA Forest Service	Agency performs its own dispatching 9 AM to 5 PM - then goes to answering service.
Yavapai County	Yavapai County Sheriff's dispatch takes calls

TABLE G.21 – QUESTION 27: Identify combined dispatch center: (if answered "Yes" to Question 25c)	
AGENCY	**COMBINED DISPATCH CENTER**
ADOT	ADOT operations/TOC; The district office dispatches during working hours 7 am to 5 PM, TOC has a 24 hour there after
FHWA	USDOT Crisis Management Center, |Washington D.C.
Puerco Valley, Locality of	Apache County Sheriffs Office, Puerco Valley Fire Dist.
Springerville, Town of	Apache County Sheriffs Dispatch
State of New Mexico	San Juan County Communications Authority
Taylor, City of	Snowflake Taylor Police Department

TABLE G.22 – QUESTION 28: Do you currently have the ability to communicate with any of the following ADOT groups using radio communications?

COMMUNICATE W/ ADOT MAINTENANCE				COMMUNICATE W/ ADOT CONSTRUCTION			
AGENCY	No	Not Sure	Yes	AGENCY	No	Not Sure	Yes
ADOT	2		14	ADOT	2		14
Apache County			2	Apache County			2
Bullhead City, City of			1	Bullhead City, City of			1
Caltrans		1		Caltrans		1	
Cochise County	1			Cochise County	1		
Coconino County	1			Coconino County	1		
DPS	1	1		DPS	1	1	
FHWA	1			FHWA	1		
Flagstaff, City of	3			Flagstaff, City of	3		
Ganado, City of			1	Ganado, City of	1		
Gilbert, Town of		1		Gilbert, Town of		1	
Globe, City of	1			Globe, City of	1		
Graham County	1			Graham County	1		
Hayden, City of	1			Hayden, City of	1		
Kingman, City of	1			Kingman, City of	1		
Lake Havasu City, City of	1	1		Lake Havasu City, City of	1	1	
Las Vegas, City of	1			Las Vegas, City of	1		
MCDOT	2	1		MCDOT	2	1	
Miami, Town of	1			Miami, Town of	1		
Navajo County	1	1	1	Navajo County	1	1	1
Navajo Nation	1			Navajo Nation	1		
NDOT	1			NDOT	1		
Peoria, City of		1		Peoria, City of		1	
Phoenix, City of	2			Phoenix, City of	2		
Pima County	2			Pima County	2		
Pinal County		1		Pinal County		1	
Puerco Valley, Locality of	1		1	Puerco Valley, Locality of	1		
Red Mt. Machinery Co.	1			Red Mt. Machinery Co.			1
Safford, City of	1			Safford, City of	1		
Santa Cruz County	1			Santa Cruz County	1		
Scottsdale, City of	1			Scottsdale, City of	1		
Sedona, City of	1			Sedona, City of	1		
Snowflake-Taylor, Cities of	1			Snowflake-Taylor, Cities of	1		
Springerville, Town of	1			Springerville, Town of	1		
St. John's, City of	1			St. John's, City of	1		
State of California	1			State of California	1		
State of New Mexico	2			State of New Mexico	2		
Taylor, City of	1			Taylor, City of	1		
Tuba City, City of	1			Tuba City, City of	1		
Tucson, City of	2	1		Tucson, City of	2	1	
U.S. Fish and Wildlife Svc		1		U.S. Fish and Wildlife Svc		1	
USDA Forest Service	1	1	1	USDA Forest Service	1	2	
Winslow, City of			1	Winslow, City of	1		
Yavapai County	3			Yavapai County	3		
TOTAL	45	11	22	TOTAL	46	12	19

TABLE G.22 – QUESTION 28: Do you currently have the ability to communicate with any of the following ADOT groups using radio communications?

COMMUNICATE WITH ADOT HAZMAT				COMMUNICATE WITH ADOT MVD			
AGENCY	No	Not Sure	Yes	AGENCY	No	Not Sure	Yes
ADOT	4	2	9	ADOT	7	2	6
Apache County			2	Apache County			2
Bullhead City, City of			1	Bullhead City, City of			1
Caltrans		1		Caltrans		1	
Cochise County	1			Cochise County	1		
Coconino County	1			Coconino County	1		
DPS	1	1		DPS	1	1	
FHWA	1			FHWA	1		
Flagstaff, City of	3			Flagstaff, City of	3		
Ganado, City of	1			Ganado, City of	1		
Gilbert, Town of		1		Gilbert, Town of		1	
Globe, City of	1			Globe, City of	1		
Graham County	1			Graham County	1		
Hayden, City of	1			Hayden, City of	1		
Kingman, City of	1			Kingman, City of	1		
Lake Havasu City, City of	1	1		Lake Havasu City, City of	1	1	
Las Vegas, City of	1			Las Vegas, City of	1		
MCDOT	2	1		MCDOT	2	1	
Miami, Town of	1			Miami, Town of	1		
Navajo County	1	1	1	Navajo County	1	1	1
Navajo Nation	1			Navajo Nation	1		
NDOT	1			NDOT	1		
Peoria, City of		1		Peoria, City of		1	
Phoenix, City of	2			Phoenix, City of	2		
Pima County	2			Pima County	2		
Pinal County		1		Pinal County		1	
Puerco Valley, Locality of	1		1	Puerco Valley, Locality of	1		1
Red Mt. Machinery Co.	1			Red Mt. Machinery Co.	1		
Safford, City of	1			Safford, City of	1		
Santa Cruz County	1			Santa Cruz County	1		
Scottsdale, City of	1			Scottsdale, City of	1		
Sedona, City of	1			Sedona, City of	1		
Snowflake-Taylor, Cities of	1			Snowflake-Taylor, Cities of	1		
Springerville, Town of	1			Springerville, Town of	1		
St. John's, City of	1			St. John's, City of	1		
State of California	1			State of California	1		
State of New Mexico	2			State of New Mexico	1		1
Taylor, City of	1			Taylor, City of	1		
Tuba City, City of	1			Tuba City, City of	1		
Tucson, City of	2	1	1	Tucson, City of	2	1	
U.S. Fish and Wildlife Svc		1		U.S. Fish and Wildlife Svc		1	
USDA Forest Service	1	2		USDA Forest Service	1	1	1
Winslow, City of	1			Winslow, City of	1		
Yavapai County	3			Yavapai County	3		
TOTAL	49	14	15	TOTAL	51	13	13

TABLE G.23 – QUESTION 29: Under which circumstances does your agency have a need to communicate with the Arizona Department of Transportation? (select all that apply). (a) None; (b) Routine Daily Operations; (c) For Road Construction; (d) For Task Forces & Unusual; (e) Planned Events Only (permit closures, major spectator events, etc).; (f) For Emergency Conditions Only (forest fires, floods, etc).						
AGENCY	SUM OF RESPONSES					
	29a	29b	29c	29d	29e	29f
ADOT	1	14	1	1	9	9
Apache County				2	2	2
Bullhead City, City of				1	1	1
Caltrans			1	1	1	1
Chandler, City of						
Cochise County				1	1	1
Coconino County					1	
DPS		2	2	2	2	2
FHWA					1	1
Flagstaff, City of			2		3	3
Ganado, City of					1	
Gilbert, Town of			1	1	1	1
Globe, City of	1					
Graham County			1	1	1	1
Hayden, City of					1	1
Holbrook, City of				1	1	1
Kingman, City of			1		1	1
Lake Havasu City, City of			1	1	1	2
Las Vegas, City of					1	1
MCDOT		2	1	3	3	3
Miami, Town of			1	1	1	1
Navajo County					2	1
Navajo Nation		1	1	1	1	1
NDOT					1	1
Peoria, City of		1	1	1	1	1
Phoenix, City of		1	2	2	1	1
Pima County				1	2	2
Pinal County					1	1
Pinetop-Lakeside, Town of						
Puerco Valley, Locality of		1		2	2	1
Red Mountain Machinery Co.			1			
Safford, City of			1		1	1
Santa Cruz County					1	
Scottsdale, City of						
Sedona, City of			1		1	
Snowflake - Taylor, Cities of				1	1	
Springerville, Town of			1	1	1	1
St. John's, City of				1	1	1
State of California		1		1	1	1
State of New Mexico			1	2	2	1
Taylor, City of				1	1	1
Tuba City, City of					1	
Tucson, City of		1	1	3	3	4
U.S. Fish and Wildlife Service					1	1
USDA Forest Service				1	3	1
Winslow, City of				1	1	1
Yavapai County		1	1		3	3
TOTAL	2	25	32	44	66	57

TABLE G.24 – QUESTION 30: How often does your agency have the need for direct radio communications with the Arizona Department of Transportation? (select all that apply). (a) Daily; (b) Weekly; (c) Monthly; (d) Yearly; (e) During Recurring Mutual Aid Situations; (f) During Infrequent Mutual Aid Situations; (g) Never; (h) Not Sure								
AGENCY	**30a**	**30b**	**30c**	**30d**	**30e**	**30f**	**30g**	**30h**
ADOT	14	3	3	3	3	3		
Apache County					2	2		
Bullhead City, City of						1		
Caltrans						1		
Cochise County						1		
Coconino County						1		
DPS	2							
FHWA			1					
Flagstaff, City of					2	1		
Ganado, City of						1		
Gilbert, Town of								1
Globe, City of						1		
Graham County						1		
Hayden, City of					1			
Holbrook, City of						1		
Kingman, City of							1	
Lake Havasu City, City of						2		
Las Vegas, City of						1		
MCDOT	1	1			1	1		1
Miami, Town of					1			
Navajo County						3		1
Navajo Nation			1		1			
NDOT						1		
Peoria, City of					1	1		
Phoenix, City of		1			1	1		
Pima County	1					1		
Pinal County					1			
Puerco Valley, Locality of			2		2			
Red Mountain Machinery Co.	1							
Safford, City of			1		1	1		
Santa Cruz County						1		
Scottsdale, City of								1
Sedona, City of					1			
Snowflake - Taylor, Cities of						1		
Springerville, Town of		1			1			
St. John's, City of				1		1		
State of California						1		
State of New Mexico						2		
Tuba City, City of			1					
Tucson, City of	1					3		
U.S. Fish and Wildlife Service					1	1		
USDA Forest Service					1	3		
Winslow, City of					1			
Yavapai County			1			3		
TOTAL	2	6	1	4	22	42	1	4

TABLE G.25 – QUESTION 31: Does your agency currently have land mobile radio interoperability with any other agencies?			
AGENCY	**No**	**Not Sure**	**Yes**
ADOT	9	4	1
Apache County			2
Bullhead City, City of		1	
Caltrans			1
Cochise County			1
Coconino County	1		
DPS	2		
FHWA	1		
Flagstaff, City of			2
Ganado, City of			1
Gilbert, Town of		1	
Globe, City of			1
Graham County		1	
Hayden, City of			1
Holbrook, City of			1
Kingman, City of	1		
Lake Havasu City, City of	1		1
Las Vegas, City of			1
MCDOT		1	2
Miami, Town of			1
Navajo County			3
Navajo Nation			1
Peoria, City of		1	
Phoenix, City of	1		1
Pima County	1		1
Pinal County			1
Puerco Valley, Locality of			2
Red Mountain Machinery Co.	1		
Safford, City of			1
Santa Cruz County		1	
Scottsdale, City of			1
Sedona, City of	1		
Snowflake - Taylor, Cities of			1
Springerville, Town of			1
St. John's, City of			1
State of California		1	
State of New Mexico			2
Taylor, City of			1
Tuba City, City of			1
Tucson, City of	1		3
U.S. Fish and Wildlife Service			1
USDA Forest Service	1		2
Winslow, City of			1
Yavapai County	1		2
TOTAL	22	11	43

TABLE G.26 – QUESTION 32: With which agencies does your agency currently share land mobile radio system interoperability? (If answered "Yes" to Question 31)	
AGENCY	**ANSWER**
ADOT	DPS Highway Patrol
Apache County	ADOT, ACSO, local public works, local EMS, local FD, local PD, other county agencies.
Flagstaff, City of	Police and Fire
MCDOT	ADOT; any agencies from municipalities to include fire, and police
Navajo County	All fire Departments and most law enforcement agencies within Navajo County, as well as some law enforcement agencies in adjoining counties.
Phoenix, City of	Most Valley Fire Departments, Mesa
Puerco Valley, Locality of	Apache County Sheriffs Office, Ganado FD, Mutual Aid,
Red Mountain Machinery Co.	Any with Nextel radio service
Scottsdale, City of	Tempe, Paradise Valley, Chandler, MCSO
Snowflake - Taylor, Cities of	Local Fire, EMS, Navajo County Sheriff's Office
Springerville, Town of	Eagar P.D., Apache County Sheriffs, Town of Eagar, Town of Springerville
State of New Mexico	Interoperability for all brands
Taylor, City of	Navajo County Sheriff's Office, Show Low FD. Lakeside FD / Show Low FD. White Mtn Lake FD. Pinetop FD. Snowflake Taylor Pd. Snowflake FD. Heber FD. Linden FD. Pinedale Clay Springs FD. USFS. Eager FD. Springerville FD. St Johns FD.
Tucson, City of	Department of Public Safety; Pima S.O.
Yavapai County	All Yavapai County Law Enforcement and Fire Agencies; All adjoining County Law Enforcement Agencies

TABLE G.28 – QUESTION 34: List Agencies with whom you need land mobile radio interoperability: (If answered "Yes" to Question 33)	
AGENCY	**ANSWER**
ADOT	Cities, counties, law enforcement, fire, emergency services, etc
	DPS, Local Police Agency, Fire and Rescue, Forest Service, Tribal PD, Prison
	All law enforcement agencies state, federal, and Indian, Emergency services agencies, fire agencies
	law enforcement, fire, tow, MVD/ITD, trunked/non-trunked, Forest Service (state and federal), BLM, other federal agencies , state land
	DPS, USFS, City of Flagstaff, Coconino Cty., Navajo PD
	Law Enforcement, Emergency Services, MVD, Other Public Highway Agencies
	DPS, County, Phoenix PD
Apache County	We have the capability of all VHF agencies, (ADOT etc) but do NOT have permission to program agencies to their freq's.
DPS	ADOT; Pinal County S.O..; Eloy P.D.; Casa Grande P.D.; Coolidge P.D.; Apache Junction P.D.; Gila River P.D. & Fire; Casa Grande Fire; A.J. Fire; Kearney P.D.; Mammoth P.D.; Ak-Chin P.D. & Fire Florence P.D. & Fire
Gilbert, Town of	neighboring municipalities and other related agencies
MCDOT	ADOT, police, fire and local transportation departments; MCSO & most Valley police agencies
Navajo County	Law enforcement and Fire; Any agency with whom we could provide public safety
Peoria, City of	ADOT, MCDOT, bordering West Valley Cities
Phoenix, City of	ADOT, MVD, Valley Police Departments, additional Fire Departments; City police and fire
Puerco Valley, Locality of	ADOT. DPS
Red Mountain Machinery Co.	ADOT, MCDOT
Santa Cruz County	DPS, ADOT, Emergency Services
Scottsdale, City of	Phoenix, DPS, Salt River Indian Police
Springerville, Town of	ADOT, Fire, DPS
State of New Mexico	We have to ability to communicate with all agencies
Taylor, City of	ADOT, AZ DPS
Tucson, City of	Department of Public Safety, Pima S.O.
Yavapai County	Arizona Dept. of Public Safety

TABLE G.29 – QUESTION 35: Does your agency have at least one radio channel designated for communicating with other agencies?			
AGENCY	**No**	**Not Sure**	**Yes**
ADOT	8	4	4
Apache County			2
Bullhead City, City of		1	
Caltrans	1		
Cochise County			1
Coconino County	1		
DPS	1	1	
Flagstaff, City of			2
Ganado, City of			1
Gilbert, Town of		1	
Globe, City of			1
Graham County	1		
Hayden, City of	1		
Holbrook, City of	1		
Kingman, City of			1
Lake Havasu City, City of	1		1
Las Vegas, City of			1
MCDOT	2	1	
Miami, Town of			1
Navajo County	3		
Navajo Nation			1
NDOT			1
Peoria, City of	1		
Phoenix, City of	1		1
Pima County	1		1
Pinal County		1	
Puerco Valley, Locality of	1		1
Red Mountain Machinery Co.	1		
Safford, City of			1
Santa Cruz County		1	
Scottsdale, City of			1
Sedona, City of	1		
Snowflake - Taylor, Cities of			1
Springerville, Town of	1		
St. John's, City of			1
State of California			1
State of New Mexico			2
Taylor, City of			1
Tuba City, City of			1
Tucson, City of			4
U.S. Fish and Wildlife Service			1
USDA Forest Service	1		2
Winslow, City of			1
Yavapai County	2		1
TOTAL	30	10	38

TABLE G.30 – QUESTION 36: Describe your agency policies for use of any channels designated for interoperability: (If answered Yes to Question 35)	
AGENCY	**POLICIES**
ADOT	u/n; DPS
Apache County	We can program all VHF agencies in our radios, just need the permission and the freq's.
Phoenix, City of	Mutual Aid, Automatic Aid, other policies being developed
Scottsdale, City of	Call the agency and ask their officers in affected area to come up on the channel.
Snowflake - Taylor, Cities of	Mutual Aid
State of New Mexico	During an emergency, we will and have the ability to use all channels.
State of New Mexico	UNKNOWN
Taylor, City of	State's that is used as needed.
Tucson, City of	Has in place a VHF, UHF, 800 MHz analog repeater for Public Safety use.

TABLE G.31 – QUESTION 37: Identify the type of voice channel available for interoperability. (select all that apply) (If answered "Yes" to Question 35). (a) Low Band VHF (25 -50 MHz); (b) High Band VHF (150 -174 MHz); (c) Federal UHF (406 - 420 MHz); (d) UHF (450 - 470 MHz); (e) 700 MHz; (f) 800 MHz; (g) Other Band; (h) Conventional Analog (non-trunked); (i) Conventional Digital (non-trunked); (j) Trunked Analog; (k) Trunked Digital (vendor specific); (l) Trunked Digital (APCO 25); (m) Other System; (n) Not Sure

AGENCY	SUM OF RESPONSES													
	37a	**37b**	**37c**	**37d**	**37e**	**37f**	**37g**	**37h**	**37i**	**37j**	**37k**	**37l**	**37m**	**37n**
ADOT		1				1				1				3
Apache County		1												
Flagstaff, City of						1			1					
Phoenix, City of		1		1		1			1			1		
Scottsdale, City of		1		1		1				1	1			
State of New Mexico	1	1	1	1	1	1	1	1	1	1	1		1	1
Taylor, City of														1
Tucson, City of		1		1		1		1	1					
TOTAL	1	6	1	4	1	6	1	2	4	3	2	1	1	5

TABLE G.32 – QUESTION 38: Is your agency willing to issue a letter of authorization to incorporate agency designated frequencies into ADOT's land mobile radio system?			
AGENCY	**No**	**No, but we are willing to consider other interoperability solutions**	**Yes**
ADOT	3	3	3
Apache County			2
Cochise County			1
Coconino County			1
DPS			1
Flagstaff, City of		1	
Ganado, City of			1
Globe, City of			1
Graham County		1	
Hayden, City of			1
Holbrook, City of			1
Kingman, City of		1	
Lake Havasu City, City of	1		
MCDOT		1	2
Miami, Town of		1	
Navajo County		1	2
Navajo Nation			1
Phoenix, City of		1	
Pima County		2	
Puerco Valley, Locality of			2
Red Mountain Machinery Co.		1	
Safford, City of			1
Scottsdale, City of		1	
Springerville, Town of			1
State of California		1	
State of New Mexico		1	1
Taylor, City of			1
Tuba City, City of			1
Tucson, City of		3	
U.S. Fish and Wildlife Service			1
USDA Forest Service		1	1
Winslow, City of			1
Yavapai County		1	1
TOTAL	4	21	28

TABLE G.34 – QUESTION 40: What is the primary job description of the individuals who would be likely to use a land mobile radio system that inter-operates with the ADOT (e.g. Roadway Maintenance Superintendent, Traffic Signal Technician, Law Enforcement Officer, Firefighter, Incident Commander, etc).	
AGENCY	**ANSWER**
ADOT	Shift supervisor during snowstorms; Construction Inspectors; Designated Incident Commander; ALL THE ABOVE; Roadway Maintenance; Maintenance Tech, Maint. Supervisor; Law Enforcement Officer; Maintenance, Construction, Administrative
Apache County	All
Bullhead City, City of	Roadway Maintenance Superintendent
Caltrans	Highway Mtce Superintendent or Supervisor
Cochise County	Law Enforcement, Roadway Maintenance, Haz-Mat, IC
Coconino County	Roadway Maintenance
DPS	ADOT maintenance; signing; ADOT emergency rapid response; fire; police
Flagstaff, City of	Road Maint. Super., Traffic Signal Tech.; Street Supervisor
Ganado, City of	Incident commander
Gilbert, Town of	all of the above and more?
Graham County	Highway Foreman, Law Enforcement, Incident Commanders
Hayden, City of	Law Enforcement Officer, Firefighter
Holbrook, City of	Law Enforcement Officer, Firefighter, Incident Commander
Lake Havasu City, City of	Street Supervisor, Transportation Manager. Firefighter, Incident Commander
Las Vegas, City of	Law Enforcement Officers
MCDOT	All listed above; Incident Commander and responders
Miami, Town of	Law Enforcement Officer
Navajo County	Roadway Supervisors ~ Department Head ~ Lead Men over crews; Deputies
Navajo Nation	All police sergeants, police officers, criminal investigators
NDOT	Roadway Maintenance Superintendent
Peoria, City of	All the above
Phoenix, City of	Streets, Police, Fire, Water, other Public Works, Transit dispatchers and operators
Pima County	Roadway Maint. Super., Traffic Signal Technician, Law Enforcement Officer, Dispatch & Incident Commander & Aircraft
Pinal County	Roadway Maintenance Supt., Law Enforcement Officer, Incident Commander
Pinetop-Lakeside, Town of	Law Enforcement Officer
Puerco Valley, Locality of	Firefighting, EMS, Incident Commanders
Red Mountain Machinery Co.	Field Traffic control Supervisors
Scottsdale, City of	Traffic Signal Technicians
Springerville, Town of	law enforcement, Fire, EMS
St. John's, City of	Law Enforcement, Animal Control, Incident Commander
State of New Mexico	Law Enforcement, Firefighter, Emergency Management, Incident Commander
Taylor, City of	Incident Commander, Fire Officer
Tuba City, City of	All of the above
Tucson, City of	Incident Commander, Transportation Supts., Division Admin., Office Staff, Area Supervisors, Law and Fire Commander; Fire Incident Command
U.S. Fish and Wildlife Service	Law Enforcement Officer, Firefighter, Incident Commander, in future situations where Homeland Security and incidents that require use of national resources (Type I or Type II teams).
USDA Forest Service	Law Enforcement Officer, Firefighter, Incident Commander
Winslow, City of	Fire Department - Firefighter/EMS Personnel
Yavapai County	Emergency Operating Center Radio Operator, Law Enforcement Officer, Law Enforcement Dispatcher, Public Works Director; Area Road Superintendents

TABLE G.35 – QUESTION 41: What level of interoperability planning with ADOT would best serve your agency? (select one)						
AGENCY	**TOTAL RESPONSES PER CATEGORY**					
	County-wide	**Local Area**	**Not Sure**	**Other**	**State-wide**	**State-wide including surrounding states**
ADOT		4			5	5
Apache County	2					
Bullhead City, City of		1				
Caltrans		1				
Cochise County	1					
Coconino County	1					
DPS			1		1	
FHWA					1	
Flagstaff, City of	1	2				
Ganado, City of				1		
Gilbert, Town of	1					
Globe, City of			1			
Graham County	1					
Hayden, City of		1				
Holbrook, City of	1					
Kingman, City of	1					
Lake Havasu City, City of	1	1				
Las Vegas, City of		1				
MCDOT	3					
Miami, Town of	1					
Navajo County	2	1				
Navajo Nation		1				
NDOT		1				
Peoria, City of					1	
Phoenix, City of	1	1				
Pima County	2					
Pinal County	1					
Pinetop-Lakeside, Town of	1					
Puerco Valley, Locality of	1	1				
Red Mountain Machinery Co.					1	
Safford, City of	1					
Scottsdale, City of	1					
Sedona, City of		1				
Snowflake - Taylor, Cities of	1					
Springerville, Town of						1
St. John's, City of	1					
State of California			1			
State of New Mexico		1				1
Taylor, City of					1	
Tuba City, City of	1					
Tucson, City of	2	1			1	
U.S. Fish and Wildlife Service						1
USDA Forest Service	1	2				
Winslow, City of						1
Yavapai County	3					
TOTAL	33	21	3	1	11	9

TABLE G.36 – QUESTION 42: How important do you consider land mobile radio interoperability with ADOT Maintenance (1 – Not Important; 5 – Very Important, typical for all rating questions)					
AGENCY	**NO. OF RESPONSES BY CATEGORY**				
	1	**2**	**3**	**4**	**5**
ADOT	1			3	10
Apache County					2
Bullhead City, City of				1	
Caltrans				1	
Cochise County				1	
Coconino County			1		
DPS					2
FHWA			1		
Flagstaff, City of	1		2		
Ganado, City of				1	
Gilbert, Town of			1		
Globe, City of	1				
Graham County				1	
Hayden, City of		1			
Holbrook, City of				1	
Kingman, City of			1		
Lake Havasu City, City of				1	
Las Vegas, City of		1			
MCDOT			1	1	1
Miami, Town of			1		
Navajo County			1	1	1
Navajo Nation					1
NDOT		1			
Peoria, City of			1		
Phoenix, City of			1		1
Pima County	1	1			
Pinal County				1	
Pinetop-Lakeside, Town of				1	
Puerco Valley, Locality of			1		1
Red Mountain Machinery Co.			1		
Safford, City of			1		
Scottsdale, City of		1			
Sedona, City of			1		
Snowflake - Taylor, Cities of				1	
Springerville, Town of					1
St. John's, City of			1		
State of California			1		
State of New Mexico	1		1		
Taylor, City of					1
Tuba City, City of				1	
Tucson, City of		1	1	2	
U.S. Fish and Wildlife Service	1				
USDA Forest Service	1	1		1	
Winslow, City of					1
Yavapai County		1	1		
TOTAL	7	8	20	19	22

TABLE G.37 – QUESTION 43: How important do you consider land mobile radio interoperability with ADOT Construction?				
AGENCY	**NO OF RESPONSES PER CATEGORY**			
	1	**2**	**3**	**4**
ADOT	2	1	2	2
Bullhead City, City of			1	
Caltrans			1	
Cochise County			1	
Coconino County	1			
FHWA	1			
Flagstaff, City of	1		2	
Ganado, City of		1		
Gilbert, Town of			1	
Globe, City of	1			
Graham County			1	
Hayden, City of		1		
Holbrook, City of			1	
Kingman, City of			1	
Lake Havasu City, City of				1
Las Vegas, City of	1			
MCDOT			1	1
Miami, Town of			1	
Navajo County			1	1
Navajo Nation				
NDOT		1		
Peoria, City of			1	
Phoenix, City of			1	
Pima County	1		1	
Pinal County			1	
Pinetop-Lakeside, Town of			1	
Puerco Valley, Locality of		1		1
Red Mountain Machinery Co.			1	
Safford, City of			1	
Scottsdale, City of		1		
Sedona, City of		1		
Snowflake - Taylor, Cities of			1	
Springerville, Town of				1
St. John's, City of		1		
State of California			1	
State of New Mexico	1		1	
Taylor, City of				1
Tuba City, City of		1		
Tucson, City of		2	1	1
U.S. Fish and Wildlife Service	1			
USDA Forest Service	1			1
Winslow, City of			1	
Yavapai County	1	1	1	
TOTAL	12	12	27	10

TABLE G.38 – QUESTION 44: How important do you consider land mobile radio interoperability with the ADOT Motor Vehicle Division?					
AGENCY	**NO OF RESPONSES BY CATEGORY**				
	1	**2**	**3**	**4**	**5**
ADOT	5	3	1	1	5
Apache County		2			
Bullhead City, City of		1			
Caltrans	1				
Cochise County		1			
Coconino County	1				
DPS			2		
FHWA	1				
Flagstaff, City of	1		1		
Ganado, City of	1				
Gilbert, Town of			1		
Globe, City of	1				
Graham County			1		
Hayden, City of				1	
Holbrook, City of			1		
Kingman, City of	1				
Lake Havasu City, City of	1				1
Las Vegas, City of			1		
MCDOT	1	1	1		
Miami, Town of					1
Navajo County			1	2	
Navajo Nation					1
NDOT		1			
Peoria, City of		1			
Phoenix, City of	1				1
Pima County	1			1	
Pinal County		1			
Pinetop-Lakeside, Town of				1	
Puerco Valley, Locality of					2
Red Mountain Machinery Co.	1				
Safford, City of		1			
Scottsdale, City of		1			
Sedona, City of	1				
Snowflake - Taylor, Cities of			1		
Springerville, Town of					1
St. John's, City of			1		
State of California		1			
State of New Mexico	1		1		
Taylor, City of				1	
Tuba City, City of					1
Tucson, City of		3		1	
U.S. Fish and Wildlife Service	1				
USDA Forest Service	2			1	
Winslow, City of		1			
Yavapai County	3				
TOTAL	25	18	13	9	13

TABLE G.39 – QUESTION 45: How important do you consider land mobile radio interoperability with ADOT HAZMAT?					
AGENCY	**NO OF RESPONSES BY CATEGORY**				
	1	**2**	**3**	**4**	**5**
ADOT	2	1	2	1	9
Apache County					2
Bullhead City, City of				1	
Caltrans				1	
Cochise County					1
Coconino County	1				
DPS					2
FHWA	1				
Flagstaff, City of			2		1
Ganado, City of					1
Gilbert, Town of			1		
Globe, City of	1				
Graham County					1
Hayden, City of					1
Holbrook, City of					1
Kingman, City of			1		
Lake Havasu City, City of				1	1
Las Vegas, City of				1	
MCDOT				1	2
Miami, Town of					1
Navajo County			1	1	1
Navajo Nation					1
NDOT				1	
Peoria, City of				1	
Phoenix, City of		1			1
Pima County		1		1	
Pinal County					1
Pinetop-Lakeside, Town of					1
Puerco Valley, Locality of					2
Red Mountain Machinery Co.			1		
Safford, City of				1	
Scottsdale, City of			1		
Sedona, City of		1			
Snowflake - Taylor, Cities of				1	
Springerville, Town of					1
St. John's, City of				1	
State of California					1
State of New Mexico			2		
Taylor, City of					1
Tuba City, City of					1
Tucson, City of		1			3
U.S. Fish and Wildlife Service					1
USDA Forest Service		1			2
Winslow, City of					1
Yavapai County		1		1	1
TOTAL	5	7	11	14	42

TABLE G.40(a) – QUESTION 46: Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.				
46A - LACK OF FREQUENT NEED FOR INTEROPERABILITY				
AGENCY	**Major Obstacle**	**Minor Obstacle**	**Not an Obstacle**	**Not Sure**
ADOT	2	6	4	2
Apache County	2			
Bullhead City, City of		1		
Caltrans		1		
Cochise County			1	
Coconino County				1
DPS			1	1
FHWA	1			
Flagstaff, City of	1	2		
Ganado, City of	1			
Gilbert, Town of	1			
Globe, City of	1			
Graham County	1			
Hayden, City of				1
Holbrook, City of		1		
Kingman, City of				1
Lake Havasu City, City of		1		1
Las Vegas, City of				1
MCDOT		1	1	1
Miami, Town of				1
Navajo County		2		1
Navajo Nation			1	
NDOT		1		
Peoria, City of		1		
Phoenix, City of		1	1	
Pima County		1	1	
Pinal County		1		
Pinetop-Lakeside, Town of		1		
Puerco Valley, Locality of	1	1		
Red Mountain Machinery Co.		1		
Safford, City of		1		
Scottsdale, City of				1
Sedona, City of				1
Snowflake - Taylor, Cities of		1		
Springerville, Town of		1		
St. John's, City of	1			
State of California			1	
State of New Mexico			2	
Taylor, City of	1			
Tuba City, City of	1			
Tucson, City of	2		1	1
U.S. Fish and Wildlife Service			1	
USDA Forest Service		2		1
Winslow, City of		1		
Yavapai County	1	1	1	
TOTAL	17	30	16	15

TABLE G.40(b) – QUESTION 46: Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.				
46B - TECHNICAL ISSUES (DIFFERENT BANDS AND RADIO SYSTEMS)				
AGENCY	Major Obstacle	Minor Obstacle	Not an Obstacle	Not Sure
ADOT	6	6	2	
Apache County	2			
Bullhead City, City of	1			
Caltrans	1			
Cochise County			1	
Coconino County				1
DPS	2			
FHWA			1	
Flagstaff, City of		2	1	
Ganado, City of	1			
Gilbert, Town of	1			
Globe, City of				1
Graham County	1			
Hayden, City of	1			
Holbrook, City of	1			
Kingman, City of				1
Lake Havasu City, City of	1			1
Las Vegas, City of				1
MCDOT	2			1
Miami, Town of				1
Navajo County	1	1	1	
Navajo Nation			1	
NDOT	1			
Peoria, City of	1			
Phoenix, City of	2			
Pima County	2			
Pinal County	1			
Pinetop-Lakeside, Town of	1			
Puerco Valley, Locality of	2			
Red Mountain Machinery Co.				1
Safford, City of		1		
Scottsdale, City of	1			
Sedona, City of				1
Snowflake - Taylor, Cities of	1			
Springerville, Town of	1			
St. John's, City of		1		
State of California				1
State of New Mexico			2	
Taylor, City of	1			
Tuba City, City of	1			
Tucson, City of	2	1		
U.S. Fish and Wildlife Service	1			
USDA Forest Service		2		1
Winslow, City of	1			
Yavapai County	2	1		
TOTAL	42	15	9	11

TABLE G.40(c) – QUESTION 46: Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.				
46C - DIFFERENT COVERAGE AREA				
AGENCY	Major Obstacle	Minor Obstacle	Not an Obstacle	Not Sure
ADOT	10	4		
Apache County	2			
Bullhead City, City of		1		
Caltrans		1		
Cochise County		1		
Coconino County				1
DPS			1	1
FHWA			1	
Flagstaff, City of	1	2		
Ganado, City of		1		
Gilbert, Town of				1
Globe, City of		1		
Graham County	1			
Hayden, City of	1			
Holbrook, City of	1			
Kingman, City of				1
Lake Havasu City, City of		1		1
Las Vegas, City of				1
MCDOT			2	1
Miami, Town of				1
Navajo County		2	1	
Navajo Nation			1	
NDOT			1	
Peoria, City of	1			
Phoenix, City of	1	1		
Pima County	1	1		
Pinal County		1		
Pinetop-Lakeside, Town of				1
Puerco Valley, Locality of	1	1		
Red Mountain Machinery			1	
Safford, City of			1	
Scottsdale, City of	1			
Sedona, City of				1
Snowflake - Taylor, Cities of		1		
Springerville, Town of		1		
St. John's, City of	1			
State of California				1
State of New Mexico			2	
Taylor, City of		1		
Tuba City, City of	1			
Tucson, City of	2	1		
U.S. Fish and Wildlife Service	1			
USDA Forest Service	1	1	1	
Winslow, City of	1			
Yavapai County	2		1	
TOTAL	30	23	13	11

TABLE G.40(d) – QUESTION 46: Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.				
46D - REGULATORY OR LICENSING ISSUES				
AGENCY	**Major Obstacle**	**Minor Obstacle**	**Not an Obstacle**	**Not Sure**
ADOT	3	4	2	5
Apache County			2	
Bullhead City, City of		1		
Caltrans		1		
Cochise County			1	
Coconino County				1
DPS			1	1
FHWA			1	
Flagstaff, City of		1	2	
Ganado, City of		1		
Gilbert, Town of				1
Globe, City of		1		
Graham County	1			
Hayden, City of		1		
Holbrook, City of		1		
Kingman, City of				1
Lake Havasu City, City of		1		1
Las Vegas, City of				1
MCDOT			1	2
Miami, Town of				1
Navajo County		2	1	
Navajo Nation			1	
NDOT			1	
Peoria, City of		1		
Phoenix, City of	1	1		
Pima County			1	1
Pinal County	1			
Pinetop-Lakeside, Town of				1
Puerco Valley, Locality of		2		
Red Mountain Machinery				1
Safford, City of		1		
Scottsdale, City of				1
Sedona, City of				1
Snowflake - Taylor, Cities of	1			
Springerville, Town of		1		
St. John’s, City of				1
State of California				1
State of New Mexico			2	
Taylor, City of		1		
Tuba City, City of	1			
Tucson, City of		2		1
U.S. Fish and Wildlife Service		1		
USDA Forest Service			1	2
Winslow, City of				1
Yavapai County	1	1	1	
TOTAL	9	25	18	25

TABLE G.40(e) – QUESTION 46: Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.				
46E - SECURITY CONCERNS				
AGENCY	Major Obstacle	Minor Obstacle	Not an Obstacle	Not Sure
ADOT	7	1	2	4
Apache County			2	
Bullhead City, City of		1		
Caltrans		1		
Cochise County			1	
Coconino County				1
DPS			1	1
FHWA		1		
Flagstaff, City of		1	2	
Ganado, City of		1		
Gilbert, Town of	1			
Globe, City of	1			
Graham County				1
Hayden, City of		1		
Holbrook, City of		1		
Kingman, City of				1
Lake Havasu City, City of			1	1
Las Vegas, City of				1
MCDOT		2		1
Miami, Town of	1			
Navajo County		3		
Navajo Nation			1	
NDOT		1		
Peoria, City of		1		
Phoenix, City of		2		
Pima County			2	
Pinal County		1		
Pinetop-Lakeside, Town of	1			
Puerco Valley, Locality of		2		
Red Mountain Machinery				1
Safford, City of			1	
Scottsdale, City of				1
Sedona, City of				1
Snowflake - Taylor, Cities of	1			
Springerville, Town of	1			
St. John's, City of			1	
State of California				1
State of New Mexico			2	
Taylor, City of		1		
Tuba City, City of	1			
Tucson, City of	2	2		
U.S. Fish and Wildlife Service	1			
USDA Forest Service				3
Winslow, City of		1		
Yavapai County	1	1	1	
TOTAL	18	25	17	18

TABLE G.40(f) – QUESTION 46: Based on your agency's experience, indicate the severity of the following obstacles to interoperability with ADOT.				
46F - LACK OF TRAINING AND PLANNING				
AGENCY	Major Obstacle	Minor Obstacle	Not an Obstacle	Not Sure
ADOT	8	5	1	
Apache County			2	
Bullhead City, City of	1			
Caltrans			1	
Cochise County	1			
Coconino County				1
DPS			1	1
FHWA			1	
Flagstaff, City of	1	2		
Ganado, City of		1		
Gilbert, Town of				1
Globe, City of		1		
Graham County	1			
Hayden, City of		1		
Holbrook, City of		1		
Kingman, City of				1
Lake Havasu City, City of		1		1
Las Vegas, City of				1
MCDOT		2		1
Miami, Town of		1		
Navajo County	2	1		
Navajo Nation			1	
NDOT		1		
Peoria, City of	1			
Phoenix, City of	1	1		
Pima County		2		
Pinal County		1		
Pinetop-Lakeside, Town of	1			
Puerco Valley, Locality of	1	1		
Red Mountain Machinery		1		
Safford, City of		1		
Scottsdale, City of				1
Sedona, City of				1
Snowflake - Taylor, Cities of	1			
Springerville, Town of	1			
St. John’s, City of	1			
State of California			1	
State of New Mexico			2	
Taylor, City of	1			
Tuba City, City of	1			
Tucson, City of	3	1		
U.S. Fish and Wildlife Service		1		
USDA Forest Service	1		1	1
Winslow, City of	1			
Yavapai County	2		1	
TOTAL	30	26	12	10

TABLE G.41 – QUESTION 47: What is your agency's overall opinion on land mobile radio interoperability? (select all that apply). (a) It is not needed; (b) It would be nice but, must be affordable; (c) It must be funded outside our agency's normal budget; (d) It would be nice but, could pose too many security risks; (e) It must be easy to use; (f) It must be available during emergencies; (g) It must be available 24/7; (h) Not sure.								
AGENCY	**SUM OF RESPONSES**							
	47a	**47b**	**47c**	**47d**	**47e**	**47f**	**47g**	**47h**
ADOT	1	2	6		12	12	13	
Apache County						2		
Bullhead City, City of		1	1		1			
Caltrans		1						
Cochise County		1	1		1	1		
Coconino County								1
DPS			1		1	2	2	
FHWA						1		
Flagstaff, City of			2		2	2	3	
Ganado, City of		1		1		1	1	
Gilbert, Town of			1		1	1		
Globe, City of	1							
Graham County			1		1	1	1	
Hayden, City of		1						
Holbrook, City of			1		1	1	1	
Kingman, City of		1	1			1		
Lake Havasu City, City of	1		1		1	1	1	
Las Vegas, City of								1
MCDOT		2			3	3	2	
Miami, Town of			1		1		1	
Navajo County	1	1	3		3	3	1	
Navajo Nation							1	
NDOT	1					1		
Peoria, City of						1	1	
Phoenix, City of		1	1		2	2	2	
Pima County	1	1	2		2	2	1	
Pinal County					1	1	1	
Pinetop-Lakeside, Town of		1	1		1	1	1	
Puerco Valley, Locality of					2	2	2	
Red Mountain Machinery Co.		1			1	1	1	
Safford, City of		1				1		
Scottsdale, City of					1	1	1	
Sedona, City of								1
Snowflake - Taylor, Cities of			1		1	1		
Springerville, Town of			1		1	1	1	
St. John's, City of						1		
State of California								1
State of New Mexico		1				2		
Taylor, City of			1		1	1	1	
Tempe, City of								
Tuba City, City of		1			1	1	1	
Tucson, City of		1	3	1	4	3	4	
U.S. Fish and Wildlife Service				1	1	1	1	
USDA Forest Service	1				1	2	2	
Winslow, City of			1		1	1	1	
Yavapai County		1	2		2	2	1	
TOTAL	7	20	33	3	51	61	49	4

TABLE G.42 – QUESTION 48: What does your agency consider to be the optimal solution for interoperability with the Arizona Department of Transportation. (a) No Solution is Required; (b) Current Solution is Adequate; (c) Swap Handheld/Mobile Radios with ADOT as Needed; (d) Use a Radio Scanner to Scan Each Other's Radio Channels; (e) Program Our Agency's Frequencies in ADOT's Radios; (f) Program ADOT Frequencies in Our Radios; (g) Use Commercial Wireless Services (e.g. cell phones or Nextel); (h) Use New Technologies to Cross-Link Our Channels Together as Needed; (i) Communicate via Dispatch Centers Only; (j) Other; (k) Not Sure

AGENCY	SUM OF RESPONSES										
	48a	48b	48c	48d	48e	48f	48g	48h	48i	48j	48k
ADOT		1	3	6	4	2	4	4	2		4
Apache County					2	2					
Bullhead City, City of		1	1				1				
Caltrans							1				
Cochise County								1			
Coconino County					1	1					
DPS					1	1		1			1
FHWA	1										
Flagstaff, City of								3			
Ganado, City of					1	1	1	1			
Glendale, City of											
Globe, City of				1					1		
Graham County									1		
Hayden, City of											
Holbrook, City of									1		
Kingman, City of							1				
Lake Havasu City, City of		1						1			
Las Vegas, City of					1	1			1		
MCDOT					2	2	1	1			1
Miami, Town of									1		1
Navajo County					2	2	2	2	1		
Navajo Nation					1	1					
NDOT			1				1				
Peoria, City of								1			
Phoenix, City of								2			
Pima County		1					2	1	1	1	
Pinal County											1
Pinetop-Lakeside, Town of								1			
Puerco Valley, Locality of					2	2					
Red Mountain Machinery Co.			1			1	1				
Safford, City of					1						
Scottsdale, City of								1			
Sedona, City of											1
Snowflake - Taylor, Cities of					1	1					
Springerville, Town of					1	1	1	1			
St. John’s, City of								1			
State of California											1
State of New Mexico		1					1	1			
Taylor, City of					1			1			
Tempe, City of											
Tuba City, City of					1	1		1			
Tucson, City of				1			2	3			
U.S. Fish and Wildlife Service					1	1	1	1			
USDA Forest Service			1		1	1	1		2		
Winslow, City of					1						
Yavapai County						1	1	1			
TOTAL	1	5	7	8	25	22	22	30	11	1	10

TABLE G.43 – QUESTION 49: Have you experienced a situation in which the ability to inter-operate with ADOT was or could have been particularly helpful? (please describe)	
AGENCY	**ANSWER**
ADOT	▪ Forest fires, heavy winter storms, accidents and emergencies ▪ When snow plowing on I40, HAZMAT situations, accidents and incidents, first responders at scene to give better details. ▪ Accidents every day ▪ Emergencies, weather, special events, ▪ Yes on a regular basis in responding to accident / incidents and setting up detours.
Apache County	▪ Icy roads, wrecks on roads, etc. etc. etc.
Bullhead City, City Of	▪ N/A
Caltrans	▪ No
Cochise County	▪ Unknown
DPS	▪ Severe snow storms every year, construction sites ▪ Regularly with collisions, detours, construction, weather incidents
Flagstaff, City Of	▪ Yes, HAZMAT incidents that are on a highway.
Ganado, City Of	▪ Majority Of ADOT Maintenance crew would be traffic control. It helps with the man power.
Globe, City Of	▪ None
Las Vegas, City Of	▪ River Run 2002 April 27, 2002 - Outlaw Motorcycle Gangfight
McDOT	▪ Working the same incident, cannot communicate except for cell phone. During emergencies most cells are taken by the media.
Miami, Town Of	▪ Accidents on U.S. Hwy. 60 just outside Miami P.D. jurisdiction, construction and disabled vehicles
Navajo County	▪ Yes during forest fires it may have been helpful, but could do so through DPS or our dispatch, if not by radio. ▪ The Rodeo Chediski Fire, The Fire Of 2003 On White Mtn Apache Res., During Snow Storms, Floods
Navajo Nation	▪ All vehicle accidents on state roads within the reservation.
Peoria, City Of	▪ During scheduled events (i.e. baseball events) causing back ups on the freeway. To report incidents on the Loop 101.
Phoenix, City Of	▪ Fire emergencies, police emergencies, hazmat emergencies, road closures due to water emergencies, traffic control during special events, VIP visits
Pima County	▪ Multiple vehicle collision on the interstate with HAZMAT and damage to roadway, etc.
Pinal County	▪ Various HAZMAT situations on highways/railways, flooding issues/bridge-road washouts.
Puerco Valley, Locality Of	▪ Motor Vehicle Accidents. ▪ Accident On I 40
Red Mountain Machinery Co.	▪ During intense situations where traffic restrictions are being set and maintained
Scottsdale, City Of	▪ No, and have not heard of any issues from other city departments where this was an issue.
Sedona, City Of	▪ No
Snowflake - Taylor, Cities Of	▪ Poor road conditions, flooding, snow, severe accidents
State Of New Mexico	▪ Forest fires and vehicle pursuits from Arizona to New Mexico
Taylor, City Of	▪ On traffic accidents
Tuba City, City Of	▪ Hazard spill on 89, traffic accident, washout, floods, major incidents
Tucson, City Of	▪ MVAs On I-10 And I-19, during construction especially, would be helpful - coordinate lane closure.
USDA Forest Service	▪ Most issues handled by phone between authorized people.
Yavapai County	▪ Homicide investigations on or near a state highway. ▪ Roadway obstruction on a state highway ▪ Snow removal efforts.
Yavapai County	▪ No

TABLE G.44 – QUESTION 50: Please provide any additional comments you may have. If the comments relate to a particular question, please provide the question number.	
AGENCY	**ANSWER**
ADOT	▪ Many of the questions asked in this survey didn't relate to an ADOT organization. ▪ ITG utilizes pagers, blackberries, and Nextel phones with radio and alpha paging capabilities. ITG does not use a separate mobile radio communication system. ▪ This is for a small area, Winslow; i can not speak for entire state.
Apache County	▪ it would be a great help if we had permission to use the ADOT freq.'s in emergencies, we have the capability of programming the freq.'s in our radios.
DPS	▪ Many of these answers relate only to my district which encompasses all of Pinal County. For the bigger picture you need to contact our DPS radio engineers.
FHWA	▪ In general, FHWA does not need radio interoperability with ADOT. We do however have a need to get information as quick as possible for certain major incidents. This can be done by phone but a pager solution might be worth exploring.
Las Vegas, City of	▪ We are very close to AZ and we all need to communicate during emergencies.
MCDOT	▪ Presently only the TMC's communicate through the land lines
Scottsdale, City of	▪ The City of Scottsdale is a user of the Maricopa County System, any decisions regarding interoperability sharing of frequencies, etc, would be decisions made by the County.
Tucson, City of	▪ We have a tremendous need for interoperability but the first priority is to establish this among law enforcement first responders and other public safety responders (fire and medical).
Winslow, City of	▪ We have an excellent work relationship with the local ADOT Personnel
Yavapai County	▪ Our need for interoperability with ADOT would only be when the county Emergency Operating Center is activated (fire, flood, HAZMAT, etc).

APPENDIX H – PROJECT PARTICIPANTS

In addition to ADOT, interoperability stakeholders that participated in project included representatives from various departments of the following agencies or entities:

- Ames Construction Co.
- Apache County
- Arizona Department of Public Safety
- California Department of Transportation (Caltrans)
- California Highway Patrol
- Cities of Snowflake - Taylor
- City of Avondale
- City of Bullhead City
- City of Chandler
- City of Flagstaff / Northern Arizona University
- City of Ganado
- City of Glendale
- City of Globe
- City of Hayden
- City of Holbrook
- City of Kingman
- City of Lake Havasu City
- City of Las Vegas
- City of Mesa
- City of Peoria
- City of Phoenix
- City of Safford
- City of Scottsdale
- City of Sedona
- City of St. John's
- City of Tempe
- City of Tuba City
- City of Tucson
- City of Winslow
- Cochise County
- Federal Highway Administration
- Graham County
- Lifeline Ambulance
- Maricopa Association of Governments
- Maricopa County Department of Transportation
- Mojave County
- Navajo County
- Navajo Nation

- Nevada Department of Transportation
- New Mexico Department of Transportation
- New Mexico State Police
- Pima Association of Governments
- Pima County
- Pinal County
- Puerco Valley
- Red Mountain Machinery Co.
- Santa Cruz County
- Town of Miami
- Town of Pinetop-Lakeside
- Town of Prescott Valley
- Town of Springerville
- U.S. Fish and Wildlife Service
- USDA Forest Service
- Yavapai County

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