MARICOPA ASSOCIATION of GOVERNMENTS

MAG ITS Strategic Plan Update

Technical Memorandum #7

- ITS Telecommunications Plan

Prepared by:

Kimley-Horn and Associates, Inc.

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091452000

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1. INTRODUCTION

1.1 ITS Telecommunications Plan

Technical Memorandum Number 7 summarizes the efforts of Task 11, Develop ITS Telecommunications Plan. The purpose of this task is to develop a telecommunications plan for the MAG region to support both the continuation of existing systems as well as future systems that will be identified in the ITS Implementation Plan. (The ITS Implementation Plan is included in Technical Memorandum Number 6B.)

Key activities in the ITS Telecommunications Plan include:

- *Review of telecommunications technologies and standards* – This activity includes a description of the ITS communications framework and terminology, a review of communications technology, and a description of network standards. The impact of the Telecommunications Act of 1996 also is included.
- *Review of ITS telecommunications needs* – Agencies in the MAG region were reviewed to determine their existing and future ITS telecommunications needs.
- *Telecommunications infrastructure* – This activity included a review of the existing and planned components of the ITS telecommunications infrastructure for the MAG agencies.
- *Near-term telecommunications plan* – A near-term (years 2001-2006) telecommunications plan was developed that recommends the projects that must be completed in order for MAG agencies to transition to a regional fiber network by the year 2006.
- *Medium and long-term strategies* – Medium and long-term strategies to address the time-frame beyond 2006 were developed to recommend the steps that the MAG agencies which were not addressed in the near-term telecommunications plan should complete to transition to a regional fiber network.
- *Collaboration with the private sector* – This activity provides recommendations for possible collaboration with the private sector to implement portions of the MAG ITS Telecommunications Plan.

1.2 Telecommunications Background in the MAG Region

In 1997, the Maricopa County Department of Transportation (MCDOT) entered into a public/private partnership agreement with U.S. West in support of the AZTech™ ITS Model Deployment Initiative in the Phoenix metropolitan area. This agreement aided in establishing an asynchronous transfer mode (ATM) data communications network between the jurisdictional Traffic Management Centers (TMCs), the Emergency Operations Center (EOC) identified at that time, and the ADOT Traffic Operations Center (TOC) for the exchange of computer data and closed-circuit television (CCTV) video.

The MCDOT/U.S. West Agreement expires in 2003; therefore, a new telecommunications plan is needed to provide direction for preparations that need to be in place by 2003 and a course to follow that will support the MAG ITS communication needs for the next two decades. The goal of the MAG ITS Telecommunications Plan is to lay the framework that is required to transition from an existing infrastructure that is highly dependent on leased services to a regional wide area network (WAN) comprised of fiber owned by MAG.

This regional ITS Telecommunications Plan focuses strictly on center-to-center communications and assumes that all agencies and departments that will be interconnected by the regional WAN will make some optical fibers within their existing and planned infrastructure available to support this initiative. A map showing existing infrastructure in the metro area is included in the **Appendix**. This map also shows requirements for 2003 and 2006 communication infrastructure build-out.

1.3 Communications Acronyms

The following is a list of frequently used acronyms in the ITS Telecommunications Plan:

ADSL	Asymmetric Digital Subscriber Line
ATM	Asynchronous Transfer Mode
BISDN	Broadband ISDN
bps	Bits per Second
BRI	Basic Rate Interface
CCTV	Closed-circuit Television
CODECS	Coder/Decoder
DWS	Dialable Wideband Service
EOC	Emergency Operations Center
FCC	Federal Communications Commission
FDN	Field Device Network
HAR	Highway Advisory Radio
ISDN	Integrated Services Digital Network
kbps	Kilobits per Second
LAN	Local Area Network
LMDS	Local Multipoint Distribution Service
Mbps	Megabits per Second
NTCIP	National Transportation Communications for ITS Protocol
NTSC	National Television Standards Committee
PBX	Private Branch Exchange
POTS	Plain Old Telephone Service
PRI	Primary Rate ISDN
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
TCP/IP	Transmission Control Protocol/Internet Protocol
TMC	Transportation (or Traffic) Management Center
TOC	Traffic Operations Center
TWP	Twisted-wire Pair (copper)
VLAN	Virtual LAN
VMS	Variable Message Sign
WAN	Wide Area Network

2. TECHNOLOGIES AND STANDARDS

The ITS practitioner has many choices available for providing a communication system. Each technology has strengths and weaknesses, and systems generally employ a mixture of several technologies based on bandwidth needs, cost, operation and maintenance, and agency familiarity or preference. This section defines the framework and terminology used within the ITS Telecommunications Plan and introduces the most widely used ITS communication methods available today.

2.1 ITS Communication Framework and Terminology

A number of different communication components make up the basic framework of a regional ITS communication infrastructure.

2.1.1 Regional WAN

The regional WAN is the primary component that is used to provide communications among the various agencies within the regional network. Typically, the symbol used to depict the regional WAN is a cloud as shown in **Figure 2.1**. The lines stemming from the cloud depict the various agencies that are interconnected by the regional WAN.

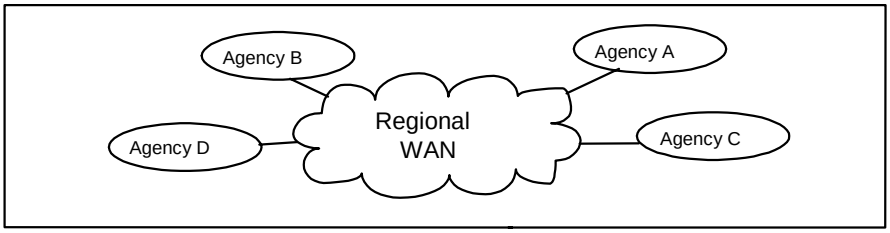


Figure 2.1 – Regional WAN

2.1.2 Regional Node

The term "node" is used to identify the network equipment used to provide an agency connectivity into the regional WAN. Because there will be other types of nodes within the framework, the node equipment at the agency used to connect to the regional WAN is identified as a regional node (**Figure 2.2**).

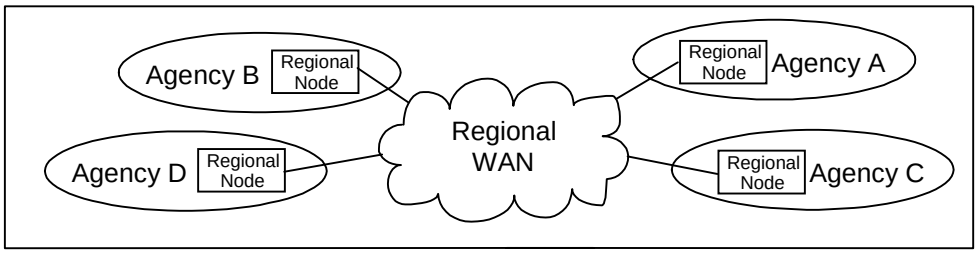


Figure 2.2 – Regional WAN Nodes

2.1.3 Local Area Network

Each agency typically has a local area network (LAN) that is used to interconnect the computer devices within the agency (i.e., servers, workstations, computers, printers, etc.). In **Figure 2.3** below, Agency A uses its LAN for communication between its computer devices. By connecting this LAN to the regional node, computers within Agency A can communicate to computers within the LAN at Agency B. The regional WAN provides the physical connection needed between the two agencies.

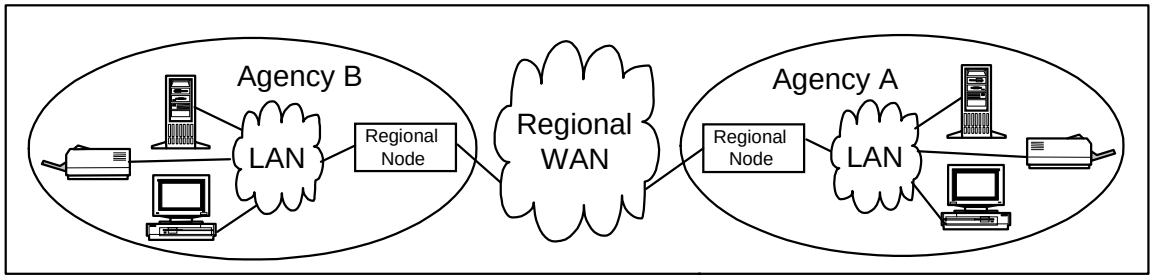


Figure 2.3 – LAN/Regional WAN Connectivity

2.1.4 Regional WAN Extension

An extension of the regional WAN is a link between an agency or department that has a regional node with one that does not have regional node equipment. Through a regional WAN extension, the agency that does not have a regional node can gain access to the regional WAN without the use of the expensive node equipment. Less expensive LAN equipment is used to connect to the LAN of the agency that has the regional WAN node, thus creating a regional WAN extension by connecting the LANs of the two agencies together. This is depicted in **Figure 2.4**. In this figure, computers at Agency C can communicate to the computers at Agency A through the use of the regional WAN extension via Agency B.

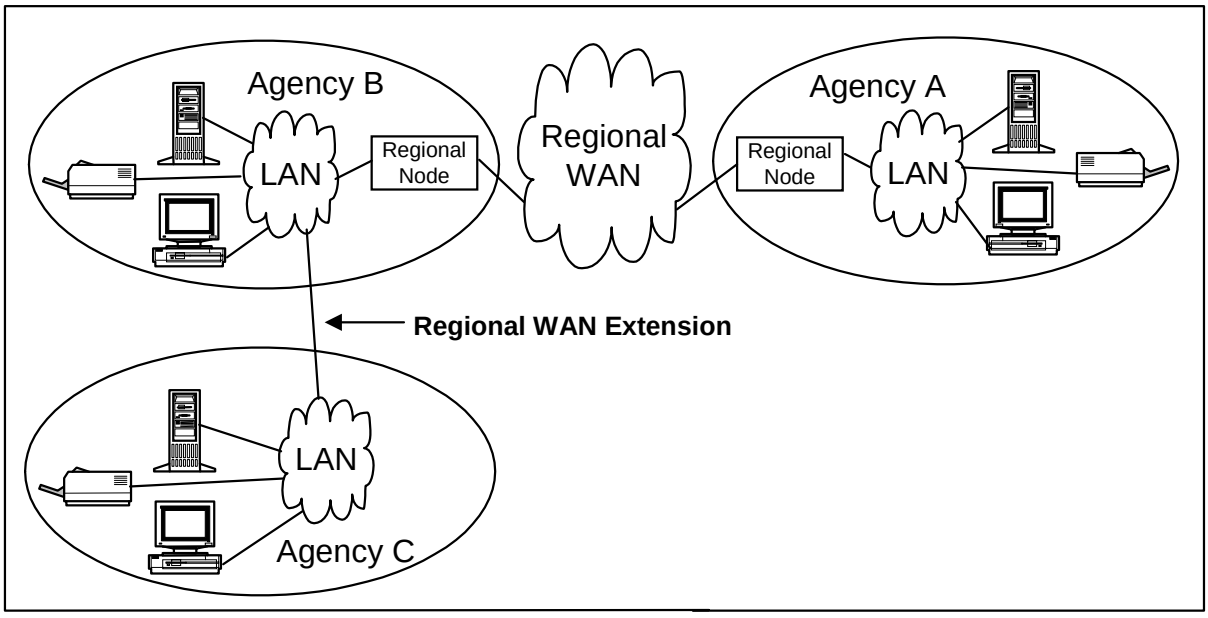


Figure 2.4 – Regional WAN Extension

2.1.5 Field Distribution Network

An agency uses a field distribution network (FDN) to communicate to the ITS field devices owned by that agency (i.e., CCTV cameras, variable message signs [VMS], highway advisory radio [HAR], traffic signal controllers, etc.) Because the communication links needed to communicate to field devices are typically at a lower data rate than the LAN, field node equipment is needed to provide connectivity between the field distribution network and the LAN. This is depicted in **Figure 2.5**.

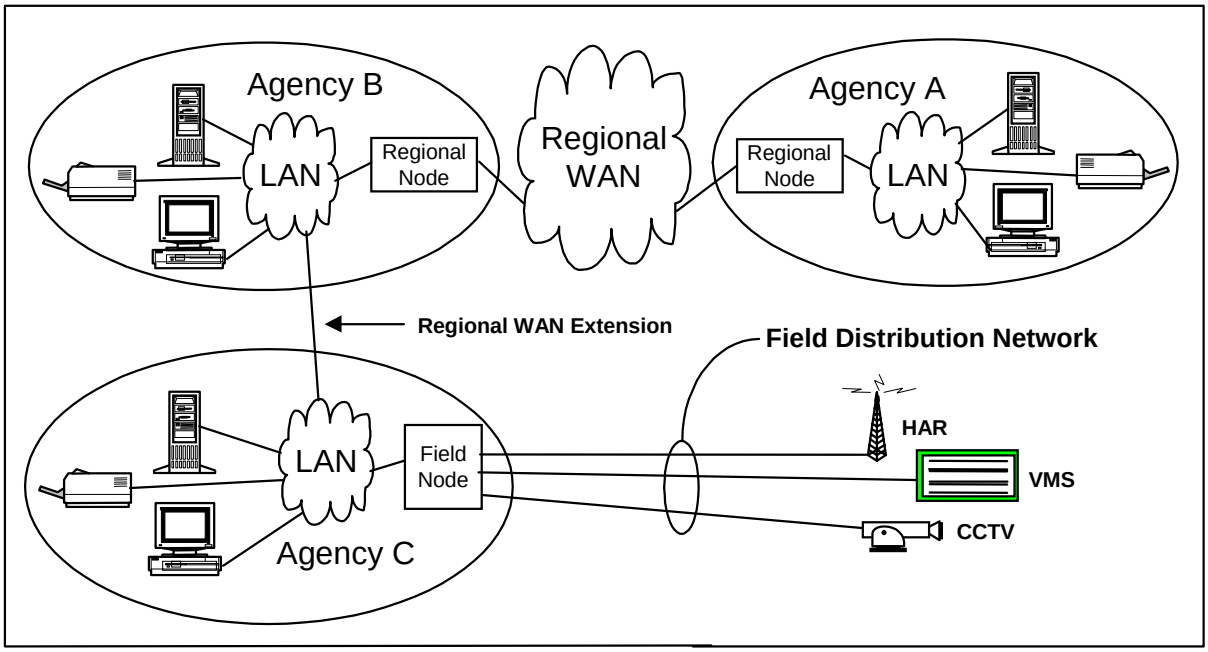


Figure 2.5 – Field Distribution Network

2.1.6 Agency WAN

Some agencies that need to cover a larger geographical area for deployment of field devices and/or desire to utilize their infrastructure more efficiently can deploy an agency WAN. There are two approaches to deploying an agency WAN. The first is to extend the LAN out to the field through the agency WAN, and deploy the field node equipment needed to interface with the LAN in field cabinets or node buildings. This approach is depicted in **Figure 2.6**. The second approach is to keep the field node equipment at a central hub and just extend the field distribution network through the agency WAN, as depicted in **Figure 2.7**.

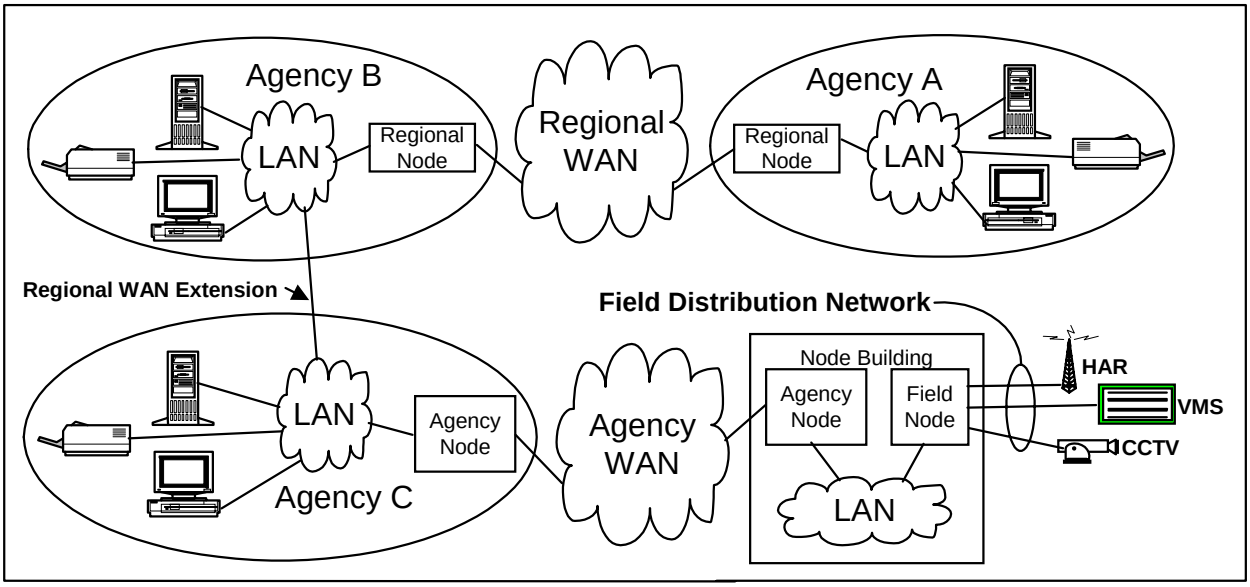


Figure 2.6 – Field Node/LAN Interface

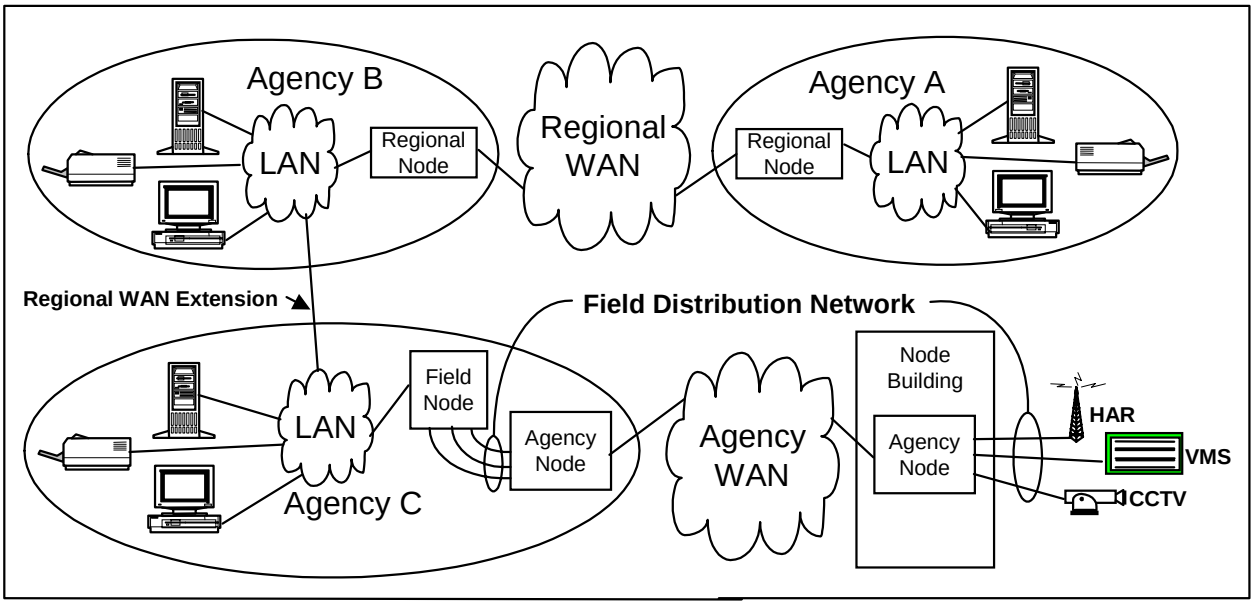


Figure 2.7 – FDN Extension through Agency WAN

2.2 Transmission Mediums

2.2.1 Copper Twisted-Wire Pairs

Twisted-wire pairs (TWP) are the most common method used to establish communication for ITS field distribution networks. The cost for these components is reasonable, and their universal application makes this method the standard by which other communication methods are judged. Bandwidth is generally 1200 to 2400 bits per second (bps) for copper-based signal system and ITS infrastructures, but the trend is moving toward 19.2 kilobits per second (kbps) in support of new National Transportation Communications for ITS Protocol (NTCIP) requirements, although higher data rates (up to 38.4 kbps) are possible and are in use.

The universality of TWP, combined with the large number of cable plants in use throughout the United States and the constant quest to maximize bandwidth, means that new technologies are constantly being developed for copper. The newest and most promising technology for traffic engineering applications is xDSL. xDSL was developed for the telephone industry to deliver high-bandwidth digital communication to homes and businesses over the phone companies' existing copper networks. It is capable of speeds in excess of 1Mbps, which is a suitable rate for transmitting of full-motion video. Mitretek, a nonprofit agency that evaluates technologies on the behalf of the Federal Highway Administration (FHWA) for use in the transportation field, has been testing the use of xDSL for transportation-related video delivery. Reports so far are favorable and are available from the FHWA. This technology promises to extract much more out of legacy copper systems than is possible today.

2.2.2 Telecommunication Service Providers

Many telecommunication service providers in the area, including cable TV companies that entered the telecommunications arena, can provide a broad range of communication links from which MAG can choose. The desired connectivity level and bandwidth needed will depend on the specific application of the communication link. The use of telecommunication service providers translates to lower up-front costs, but there is typically a substantial per-month charge for each service point, and this cost needs to be factored in to the operating budget for the network. The following are some of the most common types of services that can be found in the ITS arena:

- Plain Old Telephone Service (POTS): POTS has capabilities similar to direct-wire TWP connections, except that the connections are provided by the telephone company instead of by the operating agency. In most cases, the type of modem that is deployed to interface the POTS is not directly compatible with private copper networks. POTS links are dial-up connections; the communication channel is normally off ("on hook," as with an in-home telephone) and requires time to dial and make a connection. Low-capacity leased lines that are always connected also are available, but cost considerably more because dedicated bandwidth for point-to-point connection must be continually maintained by the telephone company.
- Integrated Services Digital Network (ISDN): ISDN lines provide relatively low-cost voice and moderate-speed data pathways to the ITS market. ISDN combines phone service with some basic equipment to create three separate digital channels (two B channels at 56/64 kbps and one D channel at 16 kbps). Basic Rate Interface (BRI) ISDN outperforms today's POTS technology by enabling simultaneous voice, data, video, and fax communications with data transmission speeds up to 128 kbps, and

throughput exceeding 500 kbps using compression techniques. With primary rate ISDN (PRI), speeds of 1.54 megabits per second (Mbps) can be achieved and are selectable in increments of 64 kbps with the dialable wideband service (DWS) feature. ISDN is available in most metropolitan areas across North America, and is deployed in over 30 different countries. ISDN forms the foundation for an array of low-cost solutions, such as video conferencing, image processing, network-to-network connectivity, and private branch exchange (PBX) connectivity to the public network.

- xDSL: As mentioned previously, communication service providers can offer xDSL links to deliver high-bandwidth digital communication to homes and businesses over the phone companies' existing copper networks. xDSL technology is a transport technology like SONET. Since xDSL is a transport technology, a variety of different network standards (such as Ethernet & ATM) can be transported between two or more points using xDSL links from a communication service provider.

  It is important to note that xDSL technologies are not fully standardized. By not being fully standardized it is possible that xDSL equipment purchased for use with one telecommunications service provider may not work with an xDSL link being provided by another telecommunications service provider. This may also be the case within the same telecommunications service provider's coverage area, but at different locations within that area.

  The following are just a few of many different types of xDSL technologies that are available from telecommunication service providers today:

  - Asymmetric DSL (ADSL): The asymmetric naming convention stems from the fact that the bandwidth provided on an ADSL link differs between the upstream (transmit) path and the downstream (receive) path. This type of xDSL line could be more cost effective in point-to-point CCTV applications where the bandwidth intensive CCTV video goes in one direction and the non-intensive CCTV control data goes in the other direction. The amount of bandwidth provided for each direction is dependent on how far the service drop is away from the telecommunication provider's node/hub and the available capacity of the switching system at the node/hub.
  - Symmetric DSL (SDSL): SDSL provided symmetric (the same) bandwidth availability on both the upstream (transmit) and downstream (receive) paths. Most xDSL technologies are symmetric between upstream and downstream paths, but differ in the maximum amount of bandwidth provided, the transmission medium used and the transmission distances that can be obtained.
  - High Bit Rate DSL (HDSL): HDSL is one of the most common xDSL technologies deployed within a telecommunication service providers infrastructure; since it provides a fixed bandwidth of 1.544 Mbps (T1 bandwidth equivalent) at distances greater then the standard T1 service.

- Frame Relay: Frame relay is a high-speed communications service that is used in many networks throughout the world. Frame relay is a way of sending information over the telephone network and it divides the information into frames or packets. The frames travel through a series of switches within the telephone network to reach their destination. It offers high bandwidth and reliability that is typically needed in WAN applications. Frame relay service is not a single physical connection between two endpoints. Instead, a logical path (called a virtual circuit) is defined within the network. Bandwidth is allocated to the path until actual data needs to be transmitted, and then the bandwidth within the network is allocated on a packet-by-packet basis.

Frame Relay/ATM Interworking has been ratified by both the ATM and Frame Relay Forums (see section 2.3.2). The Frame Relay/ATM PVC Interworking Implementation Agreements (IAs) provide a standards-based solution for interworking between existing or new frame relay networks and ATM networks without any changes to end user or network devices. ITS applications that deploy ATM networking node equipment can interwork leased frame relay circuits and ATM node equipment to protect the capital investment in existing ATM equipment, and to support planned transitions from leased frame relay circuits to ATM over a private fiber optic network.

- DS-3: The North American Digital Signal Hierarchy is comprised of a series of circuits that are commonly referred to by the number of voice channels that they can support and the total bandwidth of the circuit. The circuit naming convention used is the Digital Signal Level (DS-#), where DS stands for Digital Signal and the value of the number identifies the type of circuit. DS-3 circuits over fiber are currently being leased for connecting some of the existing ATM nodes within the regional network. Each DS-3 circuits can provide 44.7 Mbps of data communication bandwidth, 672 voice channels, or a predefined combination of both data and voice channels depending on the edge equipment connected to the DS-3 circuit.
- Ethernet: Ethernet is a data network standard that is described in the following section, but since some telecommunication providers are offering Ethernet communication links as a service it is germane to discuss a few points to watch out for when evaluating a leased Ethernet circuit option.

  There are a number of way that Ethernet can be transported to service locations. Many of the above transport channels can be used to deliver Ethernet; therefore, it is not safe to assume that there is access to 10Mbps (or 100 Mbps) of bandwidth just because a 10Base-T (or 100Base-T) Ethernet link is used as the interface. The bandwidth may be limited by the transport circuit being used. If the communications service provider guarantees a throughput capacity or a maximum capacity and it is less than typical Ethernet standards, then the transport could be determined by this value being provided. If the communications service provider is reluctant to guarantee a throughput capacity/bandwidth and only offers a maximum value, then there is a good chance that the Ethernet link is not "dedicated" and the available bandwidth is dependent how much and when circuit is being accessed by others.

2.2.3 Microwave

Using microwave frequencies to establish point-to-point communication without installing wires is common in the traffic industry. Microwave frequencies for traffic generally range from 950 MHz to 33 GHz, and many of the frequencies in use must be licensed by the Federal Communications Commission (FCC). Microwave transmission requires a direct line of sight between transceivers and is limited in range by atmospheric absorption. Microwave range is dependent on frequency and signal strength and typically varies from approximately one to 25 miles. Typical bandwidth can be up to 155 Mbps, although higher bandwidth transceivers are available at a much greater cost. Spread-spectrum is a common modulation technique used with microwave data transmission to reduce interference during communication.

2.2.4 Fiber optics

Fiber optics are historically more expensive than TWP, but current cost evaluations have shown a decrease in the cost of fiber optic infrastructures. With the competitive prices in the fiber industry, the need for greater bandwidth that is available with fiber, and the added reliability typically inherent with fiber optic infrastructures, the use of fiber optics is commonplace in today's ITS arena. Fiber optic communication relies on the propagation of light through glass strands. Although fiber is more difficult to work with than copper during initial installation, the maintenance required with fiber is less during the life of the system.

Many agencies utilize a hybrid copper/fiber system. In such a system, fiber optics are extended to communication hubs in the field, then copper is used to make the connection between the hubs and the field equipment (signal controllers and ITS elements). This kind of hybrid system can provide the high bandwidth of a fiber system along communication trunks where it is needed, while utilizing existing copper TWP infrastructure (or other form of communication) for links with lower bandwidth requirements.

2.2.5 Internet

There are other communications technologies available such as the use of the burgeoning Internet system. At this time, the Internet is not considered appropriate for video and data center-to-center communications due to factors such as bandwidth requirements of the data link, and the recurring operational expenses of the data link. Although the use of the Internet is not economical at this time, there may be some opportunities in the future to add center-to-center communications to the list of functions that are incorporated within an agency or department Internet link.

2.3 Communication Network Standards

Implementers of communication systems have many choices at their disposal, and the state-of-the-art is constantly improving. This section presents and defines the current preferred standards and technologies for communication.

2.3.1 Ethernet

Ethernet (IEEE 802.3) is the most widely used packet-based Local Area Network standard. Ethernet has been in existence since 1973 and the IEEE 802.3 standard of 1982 has been adopted by numerous national and international standards bodies. Ethernet started its climb of Local Area Network dominance in 1990 when IEEE adopted 10Base-T which provided 10 Mb/s of Ethernet bandwidth over Unshielded Twisted-wire Pair (UTP). In 1995, 100Base-T (FAST Ethernet) became an official standard offering 100 Mb/s of bandwidth. In order to protect the investment of the existing 10Base-T infrastructures and to provide a migration path for 100Base-T, 10/100 auto-sensing Ethernet products were developed. These products provided the ability to deploy new computers and network equipment with the 100 Mb/s Ethernet while still being able to communicate with existing equipment at 10 Mb/s Ethernet. Most of the LANs in existence today are predominantly using 100Base-T devices with some non-bandwidth intensive applications running on older PCs that are still equipped with 10Base-T network cards.

Although 100Base-T has captured the market for servers and PCs within the LANs, it does not provide enough bandwidth for today's typical backbone/WAN needs. In order to rectify this problem, the 1000Base-T (Gigabit Ethernet) standard (802.3z) was ratified by the IEEE 802.3 Committee in 1998. This latest 1000 Mb/s Ethernet standard is gaining momentum as the backbone technology of choice due to the typical lower cost that is historically associated with Ethernet and the availability products that support distances up to 50 km via single-mode fiber optic cable. As 1000/100/10 auto-sensing products become widely available, it is anticipated that Gigabit Ethernet will move down to the server and PC side of the LAN in the same manner as the 100Base-T (FAST Ethernet) migration path of existing 10Base-T LANs.

Currently 10 Gigabit Ethernet (10,000 Mb/s) is being standardized in the IEEE 802.3ae supplement to the Ethernet standard. This new standard is not expected to be formally ratified until March 2002; however, vendors are already announcing the availability of 10 Gbps Ethernet equipment.

Broadcom Corporation, a leading developer of integrated circuits, announced it is entering the optical networking market, and is sampling the world's first single-chip 10-gigabit per second Ethernet transceiver that supports the proposed IEEE 802.3ae standard interface. The new transceiver is capable of simultaneously transmitting and receiving Ethernet data at 10 gigabits per second over 50 kilometers on single mode fiber. Samples of this chip are available today.

2.3.2 Asynchronous Transfer Mode

ATM is a fixed-length, 53-byte, packet-based transmission technology that is used to transmit data, voice, and video traffic at speeds up to 2.4 Gbps. The small, constant ATM packet size allows ATM equipment to transmit video, audio, and computer data over the same network, and assures that no single type of data monopolizes the line.

ATM works with very short, fixed-length cells of 44.7 Mbps to 2.4 Gbps and more, which allows for time-efficient and cost-effective hardware (switches, etc.). ATM uses 53-byte cells, consisting of a five-byte header and a 48-byte payload. Because ATM is connection-oriented, the cells can have a short address space and are not used to establish and maintain the circuit. Once a circuit is set up, the bandwidth can be used entirely for data transport. After the circuit is set up, ATM associates each cell with the virtual connection between origin and destination, which can be a virtual channel or path. The 40-bit header holds eight bits for the virtual path (256 max), and 16 bits for the virtual channel (65,536 max). Having both virtual paths and channels makes it easy for the switch to handle many connections with the same origin and destination.

Some schools of thought support ATM as the answer to the Internet bandwidth problem, but others are skeptical. ATM creates a fixed channel (or route) between two points whenever data transfer begins. This differs from Transmission Control Protocol/Internet Protocol (TCP/IP), in which messages are divided into packets and each packet can take a different route from source to destination. This difference makes it easier to track and bill data usage across an ATM network, but it makes it less adaptable to sudden surges in network traffic.

The ATM Forum is a multivendor consortium developing ATM standards for data networking. The ATM Forum is a worldwide organization aimed at promoting ATM within the industry and the end user communities. Formed in October 1991 with four members, the ATM Forum membership currently includes more than 700 companies representing all sectors of the communications and computer industries, as well as a number of government agencies, research organizations and users.

2.3.3 SONET

SONET is an open standard for communicating digitally over fiber optics. It was developed in the 1980s and enhanced in the 1990s by the telephone industry so that fiber optic telephony communication equipment could be purchased from multiple vendors without compatibility issues. Proprietary fiber optic digital information delivery systems (such as MuxLAN and other trademarked products) can be purchased for less initial capital outlay, but in the long run, it is more cost-effective to utilize equipment conforming to open standards such as SONET.

SONET is the U.S. standard for synchronous data transmission on a fiber optic medium. The international equivalent of SONET is synchronous digital hierarchy (SDH). Together, they ensure standards so that digital networks can interconnect and that existing conventional transmission systems can take advantage of fiber optic communication mediums through tributary attachments. Unlike other networking standards that are moderately changing over time, the comprehensive SONET standard is expected to provide the transport infrastructure for worldwide telecommunications for at least the next two or three decades.

SONET currently provides standards for a number of line rates up to the maximum data rate of 9.953 Gbps. Actual line rates approaching 20 Gbps are possible. SONET is considered to be the foundation for the physical layer of the broadband ISDN (BISDN).

ATM runs as a layer on top of the SONET transport for communicating over a fiber optic medium, so some of the SONET bandwidth can be used for interconnecting ATM nodes together and the remaining SONET bandwidth can be used for high quality video node equipment.

The increased configuration flexibility and bandwidth availability of SONET provides significant advantages over older telecommunication systems. These advantages include the following:

- Reduction in equipment requirements and an increase in network reliability;
- Provision of overhead and payload bytes—the overhead bytes permit managing the payload bytes on an individual basis which facilitates centralized fault sectionalization;
- Definition of a synchronous multiplexing format for carrying lower level digital signals (such as DS-1, DS-3) and a synchronous structure that greatly simplifies the interface to digital switches, digital cross-connect switches, and add-drop multiplexers;
- Availability of a set of generic standards that enable products from different vendors to be connected; and
- A flexible architecture capable of accommodating future applications with a variety of transmission rates.

2.4 Telecommunication Act of 1996

The Federal Telecommunications Act, passed February 1, 1996, was a complete overhaul of the then-current Communications Act of 1934. The act accomplished the following major changes:

- *Additional telephone competition.* Long-distance carriers and telephone companies were allowed to enter the local telephone business. Also, local telephone companies were allowed to enter the long-distance telephone business, provided certain market conditions were met, to ensure a competitive environment. This has fostered additional competition in the telephone industry.

- *Cable and video competition.* Telephone companies were allowed to enter the cable television business, but were not allowed to purchase cable companies (although they could purchase up to a 10% stake in such). This, together with development of DirecTV and other satellite-based television services, has increased competition in delivery of television signals.
- *Other changes.* More concentrated ownership of television and radio stations were allowed, which quickly resulted in mergers and acquisitions in the broadcast business.

Other changes in the telecommunications industry were occurring at about the same time. For instance, the FCC re-allocated microwave frequencies in the mid-1990s, auctioning several bands to private operators for LMDS (local multipoint distribution service), a high-bandwidth, wireless Internet access/network provisioning technology. Because some of these bands were previously reserved for ITS-related communication (such as the 31 GHz band), not all were to the benefit of ITS operators; however, the general legislative and technological trend has been toward more options for communication. More telecommunications providers and increased competition within the telecommunications industry promotes enhancements to overall service and delivery, which ultimately benefits the end users.

3. ITS TELECOMMUNICATION NEEDS

In order to support the regional transportation needs identified in Technical Memorandum #3, the number of agencies interconnected using the AZTech™ regional WAN will need to grow, and in some cases, the level of connectivity that agencies currently have also will need to increase. The existing AZTech™ WAN consists of an AZTech™ Server at the ADOT TOC, and uses primarily leased telecommunications lines. Currently there are 13 agencies or departments interconnected by the existing network, and this number is expected to grow over 30 within the next 20 years. Of the 13 existing connections, there are nine agencies or departments that can share both video and data. The remaining four existing connections only support the exchange of data. The following table (**Table 3.1)** summarizes some of the agencies or departments that will eventually be connected to a regional WAN and their current connectivity level. It is important to note that other departments/agencies/cities, not listed in the following table, may also be interconnected into the regional fiber network as their ITS program grows and staff to support this endeavor is identified:

Table 3.1 – Existing Regional Connectivity

Agency	Address		Level of Connectivity
1. ADOT TOC	2302 W Durango	Phoenix	Hub Facility
2. Arizona Department of Public Safety	2102 W Encanto Boulevard	Phoenix	None
3. Chandler Police Department	250 E Chicago Street	Chandler	None
4. Chandler TMC	215 E Buffalo Street	Chandler	Leased Circuit (T-1)
5. Glendale Police Department	6835 N 57th Drive	Glendale	None
6. Glendale TMC	6210 W Myrtle Avenue	Glendale	Leased Circuit (DS-3)
7. Gilbert Police Department	1025 S Gilbert Road	Gilbert	None
8. Gilbert TMC	1025 S Gilbert Road	Gilbert	Leased Circuit (T-1)
9. MCDOT TMC	2901 W Durango	Phoenix	Leased Circuit (DS-3)
10. Maricopa County Sheriff's Office	102 W Madison	Phoenix	None
11. Mesa Police and Fire Dispatch Center	161 E. 6th Place	Mesa	None
12. Mesa TMC	320 E 6th Street	Mesa	Leased Circuit (DS-3)
13. Mesa Transit	Greenfield and Virginia	Mesa	None
14. Paradise Valley Police	6443 E Lincoln Drive	Paradise Valley	Leased Circuit (T-1)

Table 3.1 – Existing Regional Connectivity

Agency	Address		Level of Connectivity
15. Peoria Police Department	8343 W Monroe	Peoria	None
16. Peoria TMC	8850 N 79th Avenue	Peoria	Leased Circuit (T-1)
17. Phoenix Fire	150 S 12th Street	Phoenix	Leased Circuit (DS-3)
18. Phoenix Police Department	620 W Washington Street	Phoenix	None
19. Phoenix TMC	200 W Washington Street	Phoenix	Regional Fiber Network (DS-3)
20. Phoenix Transit	2225 W Lower Buckeye	Phoenix	Leased Circuit (DS-3)
21. Rural Metro	8401 E Indian School	Scottsdale	None
22. Scottsdale Police Department (1)	9065 E Via Linda	Scottsdale	None
23. Scottsdale Police Department (2)	3700 N 75th Street	Scottsdale	None
24. Scottsdale TMC	7447 E Indian School Road	Scottsdale	Leased Circuit (DS-3)
25. Scottsdale Transit	7800 Pierce Street	Scottsdale	None
26. Sky Harbor Airport	3400 Sky Harbor Boulevard	Phoenix	None
27. Tempe Police Department	120 E 5th Street	Tempe	None
28. Tempe TMC	945 W Rio Salado	Tempe	Leased Circuit (DS-3)
29. Tempe Transit	1031 W 1st Street	Tempe	None

The level of connection required for each of the agencies is dependent on the parameters of that specific agency. For example, the level of connectivity required for a specific TMC is fundamentally dependent on the number of adjacent cities with which it needs to communicate and whether or not there is a freeway running through its boundaries. Agencies needed for incident clearance, such as police and fire, will need a connectivity level that facilitates interconnections with multiple key agencies within their response areas.

The majority of the existing communication links are dependent on leased lines from a communication provider. Because these links are not part of the regional fiber optic network, there is a substantial monthly operating expense to maintain these leased services. In turn, one of the main objectives of the ITS Telecommunications Plan is to provide a migration path from many of the leased communication links to the regional fiber optic network by 2003 when the current lease agreement expires. This will significantly reduce the operations funding that is needed to support the proposed regional WAN.

As shown in **Table 3.1**, there are a number of agencies that currently use a leased communication link into the existing regional WAN. In order to connect these additional agencies into the system and maintain a reasonable operating budget during the transition period, some existing leased links will need to transition over to the regional fiber optic network. The ultimate goal of the communication infrastructure is to have all agencies interconnected via the regional fiber optic network with both data and multiple video communication channels.

4. TELECOMMUNICATIONS INFRASTRUCTURE

4.1 Current Telecommunications Infrastructure

The current regional WAN is arranged in a star topology that is centered around the ADOT TOC as the hub facility. Through the use of a telecommunication service provider, point-to-point digital connections have been established between the agencies and departments and the hub facility. Although the bandwidth is leased, the departments and agencies own their own end communication equipment (i.e., ATM switches). As shown previously in **Table 3.1**, seven of the agencies are currently using leased point-to-point DS-3 (44.7 Mbps) full duplex circuits, and four are connected via lower speed T-1 (1.54 Mbps) point-to-point full duplex leased circuits.

Currently there is only one agency (City of Phoenix TMC) that is connected to the hub facility via the region's private fiber optic network.

A partial map of the MAG region that shows the locations of the agencies and departments that are currently connected into the regional WAN and those that have been identified for future connectivity is in the **Appendix**. As shown on this map, there is a substantial amount of existing fiber optic infrastructure owned by various agencies and departments within the MAG region. In addition to the existing fiber optic infrastructure, future infrastructure already slated for construction also is shown. The dashed lines indicate recommended future fiber infrastructure in key areas that need to be programmed for construction.

Within some of the existing fiber infrastructure shown on the map, ADOT is deploying a SONET OC-12 WAN (Optical Carrier, level 12, 622 Mbps). By 2003, ADOT will have deployed three SONET node locations.

4.2 Other Government Networks

As with all public funded networks within Maricopa County, the citizens benefit from the increased service availability and reduced cost when public conduit and fiber infrastructure is shared to serve multiple government networks. As the regional fiber network grows and new fiber cables are installed, additional fiber capacity will be required for other networks to use. Typically these other networks do not have the bandwidth-intensive demands such as real time 30/60 frames per second video applications associated with the transportation CCTV coverage; therefore, providing these agencies with access to bandwidth within the regional network of data switches also could be another way of helping these networks reduce reoccurring monthly expenses associated with leasing lines from a telecommunications service provider. Current network switching technology offers virtual LAN (VLAN) capabilities that can logically separate multiple networks within the same network switching platform. Logically separating networks controls the links that an incoming data path can have access to. This will provide a level of security between the various networks and a means of controlling/prioritizing the bandwidth consumed. As time goes on, more and more bandwidth is needed to support data applications and voice/video conferencing on existing data networks. Providing bandwidth into the regional network should be viewed as a secondary or temporary choice if direct access to spare fibers is not currently available for these networks.

4.2.1 MAG Regional Video Conferencing System

MAG Telecommunications Advisory Group (MAG TAG) is currently implementing a Videoconferencing System. The MAG Videoconferencing System will allow member agencies to videoconference to meetings thereby reducing travel and congestion and enhancing air quality. It also will allow for greater participation by member agencies in regional decision-making, provide additional public outreach opportunities, and help to foster more multi-jurisdictional collaboration.

Initial implementation of the video conferencing network will be comprised of predominantly leased ISDN circuits. As the network expands, it will need to migrate over to a fiber based network to elevate the monthly operating expenses incurred from its leased circuit dependency. For this reason, it is strongly recommended that additional fibers be installed and reserved within the regional fiber network to support this innovative endeavor that MAG TAG is undertaking.

4.2.2 Transit Wide Area Network

The various transit agencies and transit service providers have developed a network that is based on leased T1 and lower speed circuits. The Transit network is currently setup as follows:

- The Security Building (PTS Admin) is connected to both Phoenix Transit North and South Divisions with leased T1 lines allowing data to be shared between the three sites.
- PTS Admin is then connected to PTD/Regional Public Transportation Authority (RPTA) by a leased T1 line.
- PTD/RPTA is connected to the City of Phoenix Frame Relay by a T1 frame relay.
- PTD/RPTA is connected to Maricopa County for internet access by a LADA circuit.
- Arnett (City of Phoenix Dial-A-Ride) is connected to PTD/RPTA by an ISDN line for e-mail.

When the new scheduling system is implemented with a regional dispatch module there will be a need for at least a T1 type of connection to Laidlaw, Forsythe (Mesa), Forsythe (Tempe), Forsythe (Scottsdale), South Division, North Division, and PTD/RPTA. PTD/RPTA will be where the servers are located. This will allow for all the dispatch locations to access and use the same scheduling system.

With the new regional scheduling system it also will be necessary to connect all Dial-A-Ride locations for both data and voice. This will allow the Dial-A-Ride agencies to use a regional phone number, a regional Automatic Call Distribution system and a future Interactive Voice Response (IVR) system.

The Transit locations that will need to be on the Transit WAN with at least a T1 bandwidth capacity are identified on the partial map of the MAG region in the **Appendix** and in the following table:

Table 4.1 – Transit WAN Connectivity

Agency	Address		Number of Vehicles
01. Arnett Transportation Services (Phoenix Dial-A-Ride and DASH)	830 E. Sherman	Phoenix	90 Vehicles (9-DASH)
02. ATC/Vancom (RPTA Division Fixed Route Scottsdale/Phoenix)	3255 S. 44th Street	Phoenix	46 Vehicles
03. Atlantic ParaTran Inc. Tempe, and East Valley Dial-A-Ride	45 N. Sunway Drive	Gilbert	68 Vehicles Serves Chandler, Gilbert, Mesa, Scottsdale
04. Central Station Customer Services	300 N. Central Avenue	Phoenix	Issues fare media, LED sign
05. City of El Mirage Dial-A-Ride	PO Box 26	El Mirage	2 Vehicles
06. Forsythe & Associates, Inc. Mesa Fixed Route	4811 E. Julep #116	Mesa	47 Vehicles
07. Forsythe & Associates, Inc. Scottsdale Fixed Route	4800 E. Pierce, #A	Scottsdale	26 Vehicles

Table 4.1 – Transit WAN Connectivity

Agency	Address		Number of Vehicles
08. Forsythe & Associates, Inc. Tempe Fixed Route	2031 W. 1st Street	Tempe	78 Vehicles 18 Vehicles (RPTA fixed route Rt. 81)
09. City of Glendale Dial-A-Ride	6322 W. Myrtle	Glendale	14 Vehicles
10. Town of Guadalupe Dial-A-Ride	8401 W. Monroe	Peoria	1 Vehicles
11. Laidlaw Transit Service Phoenix Fixed Route, Westside	5150 N. Tom Murray	Glendale	55 Vehicles
12. Mesa Transit	At Greenfield Road & Virginia Street	Mesa	50 Vehicles
13. City of Peoria Dial-A-Ride	8401 W. Monroe	Peoria	6 Vehicles
14. City of Phoenix Human Resources Reserve-A-Ride	3045 S. 22nd Avenue	Phoenix	42 Vehicles
15. Phoenix Public Transit Department, RPTA Customer Services (Call Center)	302 N. 1st Avenue	Phoenix	
16. Phoenix Transit System Phoenix Fixed Route (North Division)	2010 W. Desert Cove	Phoenix	North Dispatch Location
17. Phoenix Transit System Phoenix Fixed Route (South Division)	2225 W. Lower Buckeye	Phoenix	390 Vehicles
18. Phoenix Transit System Security Building	234 N. Central Avenue	Phoenix	Administrative Offices
19. Red Cross Maricopa County Dial-A-Ride	3335 W. Durango Street	Phoenix	
20. Scottsdale Transit	7800 Pierce Street	Scottsdale	
21. Sun City Area Transit System Dial-A-Ride	PO Box 1972	Sun City	14 Vehicles
22. City of Surprise Dial-A-Ride	15818 N. Hollyhock	Surprise	2 Vehicles
23. Tempe Transit	1031 W.1st Street	Tempe	

4.3 Proposed Telecommunication Infrastructure

The proposed regional WAN is a single-mode fiber optic based infrastructure that is not dependent on leased links for center-to-center communications. The basic interface standards between systems are Ethernet for data and the National Television Standards Committee (NTSC) for video. How the Ethernet and NTSC are transported from center to center is fully open to any type of telecommunications equipment that makes sense at the time based on available budget, quantity and length of available fibers, quality of service deemed acceptable, and the ability to use existing equipment. Although ATM technology is currently being used, there is no reason to dictate the need for additional ATM equipment when another technology might better fit the requirements of a particular agency or department.

In order to keep the regional WAN as open as possible for many different types of telecommunication technologies, the WAN will continue to use the ADOT TOC as its primary hub facility. The equipment at the ADOT TOC hub that provides connectivity between the data networks and the video networks is a high-speed ATM/Ethernet network switch and an NTSC video switch. Each agency or department can decide the best way to utilize the available fibers between its location and the hub.

The following are just a few of the options available to choose from:

- Connect Ethernet optical transceivers and video multiplexing optical transceivers to the available single-mode fibers between the two locations.
- Use video CODECs (coder/decoder) to convert analog NTSC video to a compressed digital signal. The digital video signal is then routed along with the digital Ethernet signal into an ATM link that is connected to the available fibers between the two locations.
- Deploy broadband multiplexing technology that can combine multiple video channels and an Ethernet channel into a single optical signal that is transmitted over available fiber between the two locations.
- Have a "WAN Extension" agreement with a neighboring agency or department that is to be connected to the ADOT TOC hub. Within this agreement, the neighboring agencies and departments will deploy enough channels for both facilities, which means less expensive equipment and shorter fiber links can be used to connect them.
- Use the ADOT SONET system for connecting to the ADOT TOC hub and deploy a WAN extension from the nearest ADOT SONET node.

Although the majority of fiber needed for the proposed regional WAN infrastructure is already existing or programmed, there is still a substantial amount needed before the region can fully transition from the leased center-to-center links previously identified in **Table 3.1**. **Table 4.2** shows the target dates established for various agencies and departments in the MAG region to be operational utilizing the regional fiber infrastructure. The target dates have been set based on the locations of existing or programmed fiber infrastructure, the anticipated time new fiber links can be established, and the priority level of the particular agency/department.

The new fiber links, identified within this document, are "best guess" at this time, but must remain flexible in order to take advantage of future projects along different routes as they arise. In turn, the established target dates must also remain flexible with respect to future cost saving opportunities.

As previously mentioned, other departments/agencies/cities not listed in the following table may also be interconnected into the regional fiber network as their ITS program grows and staff to support this endeavor is identified.

Table 4.2 – Transition Target Dates for Regional Fiber Optic Network Connections

Currently Connected	Connected by 2003	Connected by 2006	Connected by 2020
ADOT TOC	Chandler TMC	Glendale TMC	Chandler PD
Phoenix TMC	Department of Public Safety	Gilbert TMC	Emergency Operation Centers
	MCDOT TMC	MC Sheriff	Glendale PD
	Phoenix Fire	Mesa TMC	Gilbert PD
	Phoenix Transit	Paradise Valley PD	Mesa PD & Fire Dispatch
	Rural Metro	Peoria TMC	Mesa Transit
	Scottsdale TMC		Peoria PD
	Tempe TMC		Phoenix PD
			Scottsdale PD (1)
			Scottsdale PD (2)
			Scottsdale Transit
			Sky Harbor Airport
			Tempe PD
			Tempe Transit
			New ITS Cities

The future telecommunications connections are also referenced systematically in **Figure 4.1**.

5. NEAR-TERM TELECOMMUNICATIONS PLAN

The near-term telecommunications plan covers those agencies and departments that are to transition to the regional fiber network by year 2003 and 2006. This section focuses on the recommended steps that need to take place before these entities can transition to the regional fiber network. A preliminary estimate of probable cost for the additional infrastructure and communications equipment required for the transition can be found in each subsequent section, with a summary included in the **Appendix**.

As previously mentioned, the fiber routes identified in this section are preliminary at this time. The exact path taken between two points is not germane, but having available fibers to provide the connection between the locations is critical. Taking advantage of potential resource sharing opportunities with other agency/department projects along a different path is encouraged.

The preliminary estimate of probable cost provided is based on the assumption that spare single-mode fiber is available within existing and programmed infrastructure and that the existing ATM equipment will be available in the future.

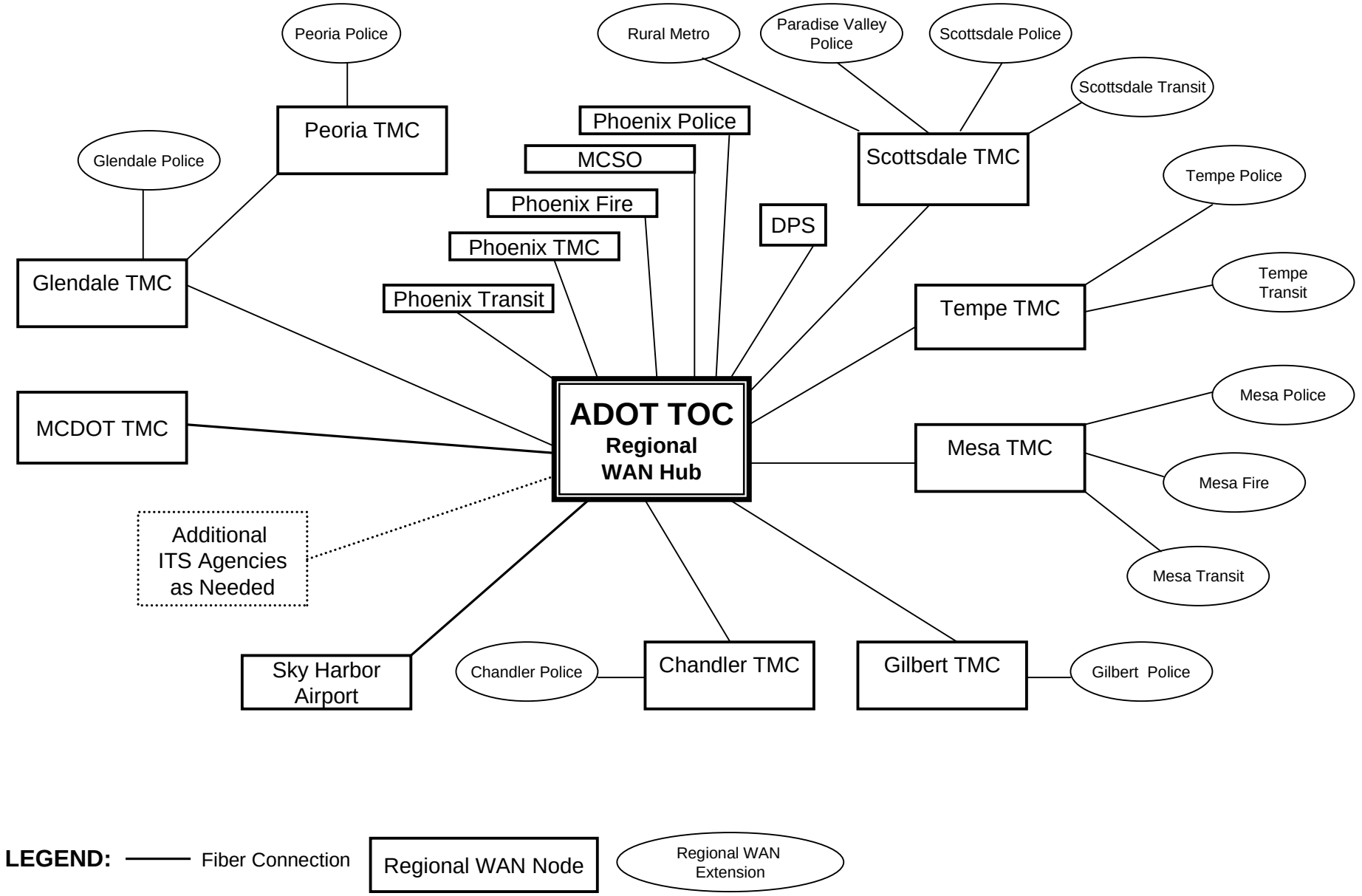


Figure 4.1 – Future ITS Telecommunications Connections

5.1 ADOT

Because the ADOT TOC is to remain the hub facility for the regional WAN, a significant amount of existing spare fiber infrastructure needs to be identified and reserved for agencies and departments in the MAG region to create the regional fiber network. It is recommended that ADOT perform an evaluation of its existing fiber optic infrastructure to identify where and how much spare capacity is available. It is then recommended that ADOT develop a plan for interconnecting these spare fiber segments for each of the WAN links identified within this ITS Telecommunications Plan. It is important to note that not all of the WAN fiber links need to be brought back to the ADOT TOC. ADOT may decide to add DS-3 channels and other types of interfaces within their existing SONET. If this is the case, then some fiber paths only need to go to the nearest SONET node.

It is recommended that ADOT identify or add and reserve a minimum of 12 single-mode fibers within its current programmed infrastructure along U.S. 60 between SR-143 and Dobson Road. It is further recommended that ADOT install a continuation of this fiber within the programmed conduit infrastructure along U.S. 60 beyond Dobson Road to Gilbert Road.

The current ADOT video switch has ample video inputs and outputs to support this expanded operation; however, ADOT's older equipment might have some limitations as to how many control interfaces can be utilized without compromising the performance of the system. ADOT might want to consider upgrading the central video switching equipment to operate more efficiently. ADOT has recently upgraded its current ATM/Ethernet switching equipment capacity; however, added functionality and bandwidth demands on this equipment will most likely require another upgrade within the next six years.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
ADOT	1.	Evaluate existing infrastructure, develop a plan for interconnecting spare fiber segments, and perform the fiber connections needed to for each of the WAN links identified.	2003	$75,000
	2.	Configure SONET equipment to support the various WAN links.	2006	$125,000
	3.	Program the installation of fiber within the conduit infrastructure along U.S. HWY 60 beyond Dobson Road to Gilbert Road (fiber design and installation).	2006	$125,000
	4.	Upgrade the existing video switching system.	2003	$250,000
	5.	Upgrade WAN hub data equipment (ATM/Ethernet switches).	2006	$100,000

5.2 Arizona Department of Public Safety

The Arizona Department of Public Safety (DPS) has a transition target date of 2003. The fiber design between the DPS and the ADOT TOC has already been completed and installation is recommended by the year 2003. Existing (spare ADOT equipment) Frequency Division Multiplexing (FDM) equipment is planned for use to connect CCTV video and the data network equipment is yet to be defined. It is recommended that the DPS follow through with the current plan for tying into the regional fiber network. It is also recommended that the DPS perform a communication technology evaluation to determine what best suits the DPS for interconnection its data network into the regional WAN (See 4.3, Proposed Telecommunications Infrastructure).

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Arizona Department of Public Safety	1.	Provide WAN connection on the regional fiber network that supports DPS (Evaluation and Installation).	2003	$30,000
	2.	Install new fiber connection between the DPS and I-17.	2003	$400,000

5.3 Chandler TMC

The Chandler TMC has a transition target date of 2003. In order for this to occur, it is recommended that the City of Chandler identify and reserve a minimum of four single-mode fibers within its programmed infrastructure along Chandler Boulevard between the Chandler TMC and Loop 101.

It is recommended that Chandler coordinate with ADOT and have a SMFO cable installed, and reserve a minimum of four fibers for the Chandler TMC, within the programmed conduit infrastructure along Loop 101 between Chandler Boulevard and Guadalupe Road. These fibers are intended for connection to the programmed fiber infrastructure of FMS Phase 6A along Loop 101 at Guadalupe Road.

Due to the proximity of the ADOT SONET node 9/10, ADOT and the City of Chandler might choose to use this node for interconnection into the regional WAN.

Once coordination has taken place to identify the communications path, the City of Chandler will need to perform a communication technology evaluation to determine what equipment best suits the City's needs to connect to the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path at ADOT TOC and Chandler TMC or ADOT SONET node and Chandler TMC. It is recommended that when the City of Chandler performs the technology evaluation, it includes enough video and data capacity to support a future regional WAN extension to the Chandler Police Department.

PRELIMINARY ESTIMATE OF PROBABLE COST YEARS 2000 TO 2006				
Agency/Department	**Task Description**		**Target Date**	**Estimated Cost**
Chandler TMC	1.	Design and install the fiber connections between the ADOT and Chandler infrastructure.	2003	$50,000
	2.	Provide WAN connection on the regional fiber network that supports both Chandler TMC and PD (evaluation and installation).	2003	$170,000
ADOT	3.	Installation of fiber optic cable within programmed conduit infrastructure along SR-101 between Chandler Boulevard and Guadalupe Road (fiber installation).	2003	$100,000

5.4 Glendale TMC

The Glendale TMC has a transition target date of 2006. In order for this to occur, a substantial amount of new fiber infrastructure needs to be installed within the ADOT and Glendale limits. The following steps are needed to connect the Glendale TMC to the fiber network:

- It is recommended that new conduit and a minimum of eight single-mode fibers be installed within the City of Glendale along Glendale Avenue between 59th Avenue and 75th Avenue.
- It is recommended that a minimum of eight single mode fibers be installed within existing City of Glendale conduit along Glendale Avenue between 75th Avenue and Loop 101.
- It is recommended that the City of Glendale enter an intergovernmental agreement with ADOT and have a minimum of eight fibers installed within existing ADOT conduit infrastructure along Loop 101 between Glendale Avenue and I-10.
- It is recommended that ADOT program in the additional conduit infrastructure needed along I-10 between Loop 101 and 83rd Avenue.

These recommendations are based on the assumption that the City of Glendale has eight available fibers in its existing infrastructure between the Glendale TMC and the intersection of 59th Avenue and Glendale, and that ADOT has eight available fibers in its existing infrastructure between the I-10/83rd Avenue interchange and the ADOT TOC. If only four fibers can be made available within any part of this existing infrastructure, then the City of Glendale could function as a regional WAN extension point for the City of Peoria. The City of Glendale will need to coordinate with ADOT to determine WAN connectivity.

Once coordination has taken place to identify the communications path, the City of Glendale needs to perform a communication technology evaluation to determine what equipment best suits the City for interconnection into the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Glendale TMC). It is recommended that when the City of Glendale performs the technology evaluation that it includes enough video and data capacity to support a future regional WAN extension to the Glendale Police Department. It is also recommended that the City of Glendale coordinate their efforts with the City of Peoria and consider a potential WAN extension to the Peoria TMC that supports the Peoria TMC and Police Department.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Glendale TMC	1.	Design and install new fiber and conduit infrastructure along Glendale Ave between 59th Avenue and 75th Avenue.	2006	$370,000
	2.	Design and install new fiber within existing City of Glendale conduit infrastructure along Glendale Avenue between 75th Avenue and Loop 101.	2006	$75,000
	3.	Provide WAN connection on the regional fiber network that supports Peoria TMC and PD, the Glendale TMC and PD (Evaluation and Installation).	2006	$150,000
ADOT	4.	Install new fiber within existing conduit infrastructure along Loop 101 between Glendale Avenue and I-10.	2006	$137,500
	5.	Design and install new conduit and fiber infrastructure along I-10 between Loop 101 and 83rd Avenue.	2006	$370,000

5.5 Gilbert TMC

The Gilbert TMC has a transition target date of 2006. In order for this to occur, a substantial amount of new fiber infrastructure needs to be installed within the Town of Gilbert's limits and within the ADOT right-of-way. It is recommended that Gilbert install new conduit and a minimum of four single-mode fibers along Gilbert Road between the Gilbert TMC and the Gilbert Town limit at Baseline Road. It is then recommended that the Town of Gilbert coordinate with the City of Mesa and continue this fiber path along Gilbert Road between Baseline and U.S. 60. In order to complete this fiber path for the Town of Gilbert (as well as Mesa's fiber path), it is recommended that ADOT program an extension of its fiber optic infrastructure along U.S. 60 between Gilbert Road and Dobson Road. Due to the proximity of the ADOT SONET nodes located at the Broadway curve on I-10 and the Loop 202/Loop 101 interchange, ADOT and the Town of Gilbert could choose one of these nodes for interconnection into the regional WAN.

Once coordination has taken place to identify the communications path, the Town of Gilbert needs to perform a communications technology evaluation to determine what equipment best suits the Town for interconnection into the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Gilbert TMC or ADOT SONET node and Gilbert TMC). It is recommended that when Gilbert performs the technology evaluation it includes enough video and data capacity to support a future regional WAN extension to the Gilbert Police Department.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Gilbert TMC	1.	Design and install new conduit and fiber infrastructure within Gilbert Town Limits for the fiber path along Gilbert Road between Baseline and the Gilbert TMC.	2006	$647,500
	2.	Provide WAN connection on the regional fiber network that supports Gilbert TMC and PD.	2006	$170,000
Mesa TMC	3.	Design and install new conduit and fiber infrastructure within Mesa Limits for the fiber path along Gilbert Road between Baseline and U.S. 60.	2006	$185,000

5.6 MCDOT TMC

The MCDOT TMC has a transition target date of 2003. There is existing conduit and fiber installed between the MCDOT TMC and the ADOT TOC, and plans are in the works to provide the necessary communications equipment within a few months.

5.7 Maricopa County Sheriff's Office

The Maricopa County Sheriff's Office (MCSO) has a transition target date of 2006. It is recommended that the MCSO have a direct fiber connection to the ADOT TOC. Currently there are some resource sharing agreements for dark fibers between the City of Phoenix Information Technology Department (ITD) and communication service providers in the downtown area. It is recommended that MCSO coordinate with ITD to identify and reserve four single-mode fibers along Washington to the existing ADOT infrastructure at I-17. MCSO will need to design and install any missing pieces of the conduit and/or fiber infrastructure needed to connect to ADOT. The MCSO also will need to coordinate its efforts with ADOT to reserve four fibers within the existing ADOT conduit/fiber infrastructure.

Once coordination has taken place to identify the communications path, the MCSO needs to perform a communications technology evaluation to determine what equipment best suits its needs for interconnection into the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and MCSO).

Note: If MCSO desires a temporary connection into the regional WAN, they can use the Counties existing leased OC-3 connection between the MCSO building and the MCDOT TMC building. Based on the available bandwidth that currently exist within this connection, it is possible for MCSO to have a regional WAN extension off MCDOT TOC that supports both data and video.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Maricopa County Sheriff's Office	1.	Design and install new conduit and fiber infrastructure within Phoenix City Limits for the fiber path between MCSO and ADOT TOC.	2006	$92,500
	2.	Provide WAN connection on the regional fiber network that supports MCSO (evaluation and installation).	2006	$30,000

5.8 Mesa TMC

The Mesa TMC has a transition target date of 2006. In order for this to occur, a fair amount of new fiber infrastructure needs to be installed within the City of Mesa limits and within the ADOT right-of-way. It is recommended that the City of Mesa identify and reserve four single-mode fibers in its current program as follows:

- Along 6th Street between the Mesa TMC and Center Street;
- Along Center Street between 6th Street and McKellips Drive;
- Along McKellips Drive between Center Street and Stapley Drive;
- Along Stapley Drive between McKellips Drive and University Drive;
- Along University Drive between Stapley Drive and Gilbert; and
- Along Gilbert Road between University Drive and U.S. 60.

In order to complete this fiber path for the City of Mesa (and Gilbert's fiber path), it is recommended that ADOT program an extension of its fiber optic infrastructure along U.S. 60 between Gilbert Road and Dobson Road. Due to the proximity of the ADOT SONET node located at the Broadway curve on I-10, ADOT and the City of Mesa could use this node for interconnection into the regional WAN.

Once coordination has taken place to identify the communications path, the City of Mesa needs to perform a communications technology evaluation to determine what equipment best suits the City for interconnection into the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Mesa TMC or ADOT SONET node and Mesa TMC). It is recommended that when the City of Mesa performs the technology evaluation it includes enough video and data capacity to support a future regional WAN extension to the Mesa Police and Fire Departments as well as Transit.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Mesa TMC	1.	Design and make fiber connections within programmed fiber infrastructure for fiber optic path between the Mesa TMC and U.S. 60.	2006	$50,000
	2.	Provide WAN connection on the regional fiber network that supports Mesa TMC, Fire, Transit and Police.	2006	$120,000

5.9 Paradise Valley Police Department

The Paradise Valley Police Department (PVPD) has a transition target date of 2006. A fair amount of new fiber infrastructure needs to be installed within the limits of Paradise Valley, Phoenix, and Scottsdale before the PVPD can be connected into the regional fiber network. This recommended infrastructure route for new conduit and a minimum of four single-mode fibers is along Invergordon Road between the PVPD and the intersection of Invergordon Road and Indian School Road. Once at Indian School Road, it is recommended that the PVPD coordinate with Scottsdale to identify four available fibers within Scottsdale's existing infrastructure to complete the fiber to the Scottsdale TMC.

Once coordination has taken place to identify the communications path, the PVPD needs to perform a communications technology evaluation to determine what equipment best suits the PVPD for interconnection to the regional WAN extension to the Scottsdale TMC (See 4.3, Proposed Telecommunications Infrastructure). It is further recommended that the PVPD coordinate its technology evaluation efforts with Scottsdale to ensure that the equipment selected fully utilizes the connectivity level into the regional WAN being provided at the Scottsdale TMC.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Paradise Valley PD	1.	Design and install new conduit and fiber infrastructure within Paradise Valley town limits for the fiber path between PVPD and Scottsdale TMC.	2006	$92,500
	2.	Design and install new conduit and fiber infrastructure within Phoenix city limits for the fiber path between PVPD and Scottsdale TMC.	2006	$92,500
	3.	Design and install new conduit and fiber infrastructure within Scottsdale city limits for the fiber path between PVPD and Scottsdale TMC.	2006	$92,500
	4.	Provide WAN connection on the regional fiber network that supports PVPD (evaluation and installation).	2006	$30,000

5.10 Peoria TMC

The Peoria TMC has a transition target date of 2006. There are two approaches that the Peoria TMC can follow for tying into the regional fiber network: the first approach is to have a regional WAN extension off the Glendale TMC, and the second is to have a direct fiber path to the ADOT TOC. Both approaches would require a fiber path between the Peoria TMC and the Glendale TMC. To achieve a fiber path between the Peoria TMC and the Glendale TMC, it is recommended that the following occur:

- The City of Peoria and the City of Glendale coordinate their efforts install new conduit and fiber infrastructure along Olive Avenue between the Peoria TMC and 59th Avenue; and
- The City of Peoria and the City of Glendale coordinate their efforts to identify and reserve four single-mode fibers, within the City of Glendale's existing infrastructure, along 59th Avenue between Olive Avenue and the Glendale TMC.

Once the communications path between the Peoria TMC and the Glendale TMC has been determined, it is recommended that the Cities of Peoria and Glendale determine if the Peoria TMC will have a regional WAN extension off the Glendale TMC, or if the Peoria TMC will have a direct fiber connection to the ADOT TOC. In order for the City of Peoria to have a direct fiber connection between the Peoria TMC and the ADOT TOC, the Peoria fiber path will parallel the Glendale TMC fiber path along Glendale Avenue, Loop 101, and I-10 to existing ADOT infrastructure.

Once the fiber optic communications path has been identified, the City of Peoria needs to perform a communications technology evaluation to determine what equipment best suits the City for interconnection to the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Peoria TMC or Peoria TMC and Glendale TMC). This technology evaluation should include enough video and data capacity to support a future regional WAN extension to the Peoria PD.

If it is decided that the Peoria TMC should have a regional WAN extension from the Glendale TMC, it is further recommended that the City of Peoria coordinate with the City of Glendale when designing Glendale's regional WAN connection. This WAN connection will need to be sufficient enough to support the Peoria TMC and PD and the Glendale TMC and PD.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Peoria TMC	1.	Design and install new conduit and fiber infrastructure within Peoria city limits for the fiber path between Peoria TMC and Glendale TMC.	2006	$277,500
	2.	Provide WAN connection on the regional fiber network that supports Peoria TMC and Police Department (evaluation and installation).	2006	$60,000
Glendale TMC	3.	Design and install new conduit and fiber infrastructure within Glendale city limits for the fiber path between Peoria TMC and Glendale TMC.	2006	$277,500

5.11 Phoenix Fire

Phoenix Fire has a transition target date of 2003. Currently there is conduit infrastructure programmed in, by COP Information Technology Department, along 12th Street and Washington between Phoenix Fire and the existing ADOT conduit/fiber infrastructure at SR 51. It is recommended that Phoenix Fire have a single mode fiber optic cable installed within this conduit infrastructure and reserve a minimum of four fibers for interconnection to the ADOT TOC via ADOT existing infrastructure along SR 51 and I-17. It is recommended that Phoenix Fire coordinate with ADOT to identify and reserve four fibers within ADOT's existing infrastructure.

Once the fiber optic communications path has been identified, Phoenix Fire needs to perform a communications technology evaluation to determine what equipment best suits Phoenix Fire for interconnection to the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Phoenix Fire).

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Phoenix Fire	1.	Design and install new fiber within the programmed conduit infrastructure along 12th Street and Washington between Phoenix Fire and the existing ADOT conduit/fiber infrastructure at SR 51.	2003	$50,000
	2.	Provide WAN connection on the regional fiber network that supports Phoenix Fire (evaluation and installation).	2003	$30,000

5.12 Phoenix TMC

The Phoenix TMC is currently connected to the regional fiber network. The same ATM technology provided through the current U.S. West contract is being used as the interface to the fibers owned by the City. MAG understands that the existing ATM equipment is the property of each agency/department, and no additional telecommunications work is necessary for the City of Phoenix TMC.

5.13 Phoenix Transit

Phoenix Transit has a transition target date of 2003. It is recommended that Phoenix Transit have new fiber infrastructure installed between Phoenix Transit and the ADOT TOC, and it is also recommended that Phoenix Transit perform a communications technology evaluation to determine what equipment best suits Phoenix Transit for interconnection into the regional WAN (See 4.3, Proposed Telecommunications Infrastructure).

PRELIMINARY ESTIMATE OF PROBABLE COST YEARS 2000 TO 2006				
Agency/Department	**Task Description**		**Target Date**	**Estimated Cost**
Phoenix Transit	1.	Design and install new conduit and fiber infrastructure between the Phoenix Transit and the ADOT TOC.	2003	$92,500
	2.	Provide WAN connection on the regional fiber network that supports Phoenix Transit (evaluation and installation).	2003	$30,000

5.14 Rural Metro

Rural Metro has a transition target date of 2003. It is recommended that Rural Metro coordinate with Scottsdale and identify four available fibers within Scottsdale's existing infrastructure between the Scottsdale TMC and Rural Metro. Some new infrastructure will be needed between the existing Scottsdale infrastructure and the Rural Metro building.

Once the fiber optic communications path has been identified, Rural Metro needs to perform a communications technology evaluation to determine what equipment best suits Rural Metro for interconnection for the regional WAN extension to the Scottsdale TMC (See 4.3, Proposed Telecommunications Infrastructure). It is further recommended that Rural Metro coordinate its technology evaluation efforts with Scottsdale to ensure that the equipment selected fully utilizes the connectivity level into the regional WAN being provided at the Scottsdale TMC.

PRELIMINARY ESTIMATE OF PROBABLE COST YEARS 2000 TO 2006				
Agency/Department	**Task Description**		**Target Date**	**Estimated Cost**
Rural Metro Fire	1.	Design and install new conduit and fiber infrastructure between the Scottsdale existing infrastructure and the Rural Metro building.	2003	$92,500
	2.	Provide WAN connection on the regional fiber network that supports Rural Metro (Evaluation and Installation).	2003	$30,000

5.15 Scottsdale TMC

The Scottsdale TMC has a transition target date of 2003. Currently the City of Scottsdale and ADOT have a Inter-Governmental Agreement (IGA) to install new fiber in its existing ADOT conduit infrastructure on Loop 101 between Indian School Road and the Loop 101/Loop 202 interchange. In order to complete this fiber path, it is recommended that the City of Scottsdale identify and reserve a minimum of four single-mode fibers within its existing infrastructure along Indian School Road between the Scottsdale TMC and the intersection of Indian School Road and Loop 101.

Once the fiber optic communications path has been identified, the City of Scottsdale needs to perform a communications technology evaluation to determine what equipment best suits the City for interconnection to the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Scottsdale TMC or ADOT SONET node and Scottsdale TMC). It is recommended that when the City of Scottsdale performs its technology evaluation, it includes enough video and data capacity to support a future regional WAN extension to Scottsdale PD, PVPD, Scottsdale Transit, and Rural Metro.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Scottsdale TMC	1.	Program the installation of 12 single-mode fibers into existing conduit infrastructure along Loop 101 between Indian School Road and Loop 202 and provide fiber connection within existing fiber infrastructures (fiber installation).	2003	$112,500
	2.	Provide WAN connection on the regional fiber network that supports Scottsdale TMC, transit, PDs (1 and 2) and Rural Metro (evaluation and installation).	2003	$150,000

5.16 Tempe TMC

The Tempe TMC has a transition target date of 2003. The City of Tempe and ADOT have already coordinated their efforts and identified fibers within existing infrastructures for the connection between the Tempe TMC and the ADOT TOC. It is anticipated that this fiber path will be interconnected within a year. The City of Tempe needs to perform a communications technology evaluation to determine what equipment best suits the City for interconnection to the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Tempe TMC). It is recommended that when the City of Tempe performs its technology evaluation that it includes enough video and data capacity to support a future regional WAN extension to the Tempe PD and Tempe Transit.

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department		Task Description	Target Date	Estimated Cost
Tempe TMC	1.	Design and install the fiber connections between the ADOT and Tempe infrastructure.	2003	$30,000
	2.	Provide WAN connection on the regional fiber network that supports Tempe TMC, Transit, and PD (Evaluation and Installation).	2003	$90,000

6. MEDIUM AND LONG-TERM STRATEGIES

The medium and long-term plans cover those agencies and departments that are targeted to transition over to the regional fiber network after the year 2006. This section focuses on the recommended steps that need to take place before a particular agency can transition to the regional fiber network.

6.1 Chandler Police Department

It is recommended that the Chandler PD have a WAN extension off the Chandler TMC. In order for this to occur, new fiber optic infrastructure needs to be installed between the Chandler PD and the Chandler TMC.

Once the plan for the fiber optic path is in place, it is recommended that the Chandler PD have a communications technology evaluation performed to decide what equipment best suits its needs (See 4.3, Proposed Telecommunications Infrastructure). The Chandler PD will need to coordinate this technology evaluation effort with the Chandler TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Chandler TMC.

6.2 Emergency Operations Centers

Three emergency operation centers (EOC) have been identified for connection into the regional WAN: the Arizona Division of Emergency Management, the Emergency and Military Affairs Department, and Maricopa County Emergency Management. Due to the location of these facilities, it is recommended that they obtain a direct fiber connection into the regional WAN from an ADOT SONET node location or the ADOT TOC.

Once the plan for the fiber optic path is in place, it is recommended that the EOCs have a communications technology evaluation performed to decide what equipment best suits their needs (See 4.3, Proposed Telecommunications Infrastructure).

6.3 Glendale Police Department

It is It is recommended that the Glendale PD have a WAN extension off the Glendale TMC. In order for this to occur, new fiber optic infrastructure needs to be installed between the Glendale PD and the Glendale TMC.

Once the plan for the fiber optic path is in place, it is recommended that the Glendale PD have a communications technology evaluation performed to decide what equipment best suits its needs (See 4.3, Proposed Telecommunications Infrastructure). The Glendale PD will need to coordinate this technology evaluation effort with the Glendale TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Glendale TMC.

6.4 Gilbert Police Department

It is recommended that the Gilbert PD have a WAN extension off the Gilbert TMC. In order for this to occur, new fiber optic infrastructure needs to be installed between the Gilbert PD and the Gilbert TMC.

Once the plan for the fiber optic path is in place, it is recommended that the Gilbert PD have a communications technology evaluation performed to decide what equipment best suits its needs (See 4.3, Proposed Telecommunications Infrastructure). The Gilbert PD will need to coordinate

this technology evaluation effort with the Gilbert TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Gilbert TMC.

6.5 Mesa Police and Fire Dispatch Center

It is recommended that the Mesa Police and Fire Dispatch Center have a WAN extension off the Mesa TMC. In order for this to occur, new fiber optic infrastructure needs to be installed from the Mesa Police and Fire Dispatch Center to the Mesa TMC.

Once the plan for the fiber optic path is in place, it is recommended that the Mesa Police and Fire Dispatch Center have a communications technology evaluation performed to decide what equipment best suits its needs (See 4.3, Proposed Telecommunications Infrastructure). The Mesa Police and Fire Dispatch Center will need to coordinate this technology evaluation effort with the Mesa TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Mesa TMC.

6.6 Mesa Transit

It is recommended that Mesa Transit have a WAN extension off the Mesa TMC. In order for this to occur, new fiber optic infrastructure needs to be installed between Mesa Transit and the Mesa TMC.

Once the plan for the fiber optic path is in place, it is recommended that Mesa Transit have a communications technology evaluation performed to decide what equipment best suits its needs (See 4.3, Proposed Telecommunications Infrastructure). Mesa Transit will need to coordinate this technology evaluation effort with the Mesa TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Mesa TMC.

6.7 Peoria Police Department

It is recommended that the Peoria PD have a WAN extension off the Peoria TMC. There is existing fiber optic infrastructure along 83rd Avenue down to the Peoria TMC. There will be some new infrastructure needed between the Peoria TMC and the Peoria PD building. It is recommended that the Peoria PD coordinate with the Peoria TMC to identify available fibers within the existing infrastructure and tie-in points between the new and existing infrastructure that is needed between the Peoria PD and the TMC.

Once the plan for the fiber optic path is in place, it is recommended that the Peoria PD have a communications technology evaluation performed to decide what equipment best suits its needs (See 4.3, Proposed Telecommunications Infrastructure). The Peoria PD will need to coordinate this technology evaluation effort with the Peoria TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Peoria TMC.

6.8 Phoenix Police Department

It is recommended that the Phoenix PD have a direct fiber connection to the ADOT TOC. Currently there are some resource sharing agreements for dark fibers between the City of Phoenix ITD and communication service providers in the downtown area. It is recommended that Phoenix PD coordinate with ITD to identify and reserve four single-mode fibers along Washington to the existing ADOT infrastructure at I-17. Phoenix PD will need to design and install any missing pieces of the conduit and/or fiber infrastructure needed to connect to existing ADOT infrastructure. The Phoenix PD will also need to coordinate its efforts with ADOT to reserve four fibers within the existing ADOT conduit/fiber infrastructure.

Once the plan for the fiber optic path is in place, it is recommended that the Phoenix PD perform a communications technology evaluation and decide what equipment best suits its needs for connection to the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Phoenix PD).

6.9 Scottsdale Police Department and Transit

It is recommended that the Scottsdale PD and Transit have WAN extensions off the Scottsdale TMC. In order for this to occur, new fiber optic infrastructure needs to be installed from the Scottsdale PD and Transit to the Scottsdale TMC.

Once the plan for the fiber optic paths are in place, it is recommended that the Scottsdale PD and Transit have a communications technology evaluation performed to decide what equipment best suits its needs for connection to each of the fiber paths (See 4.3, Proposed Telecommunications Infrastructure). These agencies will need to coordinate this technology evaluation effort with the Scottsdale TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Scottsdale TMC.

6.10 Sky Harbor Airport

It is recommended that the Sky Harbor Airport have a direct regional WAN connection to the ADOT TOC. In order for this to occur, a fair amount of new fiber infrastructure needs to be installed to connect to ADOT's existing infrastructure. It is recommended that Sky Harbor Airport coordinate with ADOT and install new conduit and a minimum of four single-mode fibers to a point on ADOT's existing infrastructure. In order to complete this fiber path for Sky Harbor Airport, it is recommended that ADOT identify and reserve four fibers between the Airport tie-in point and the ADOT TOC.

Once coordination has taken place to identify the communications path, Sky Harbor Airport needs to perform a communications technology evaluation and decide what equipment best suits its needs for interconnection into the regional WAN (See 4.3, Proposed Telecommunications Infrastructure). This equipment will need to be placed at both ends of the fiber path (at ADOT TOC and Sky Harbor Airport).

6.11 Tempe Police Department and Transit

It is recommended that the Tempe PD and Transit have WAN extensions off the Tempe TMC. In order for this to occur, new fiber optic infrastructure needs to be installed from the Tempe PD and Transit to the Tempe TMC.

Once the plan for the fiber optic paths are in place, it is recommended that the Tempe PD and Transit have a communications technology evaluation performed to decide what equipment best suits their needs (See 4.3, Proposed Telecommunications Infrastructure). The Tempe PD and Transit will need to coordinate this technology evaluation effort with the Tempe TMC to ensure that the technology selected fully utilizes the connectivity level into the regional WAN being provided at the Tempe TMC.

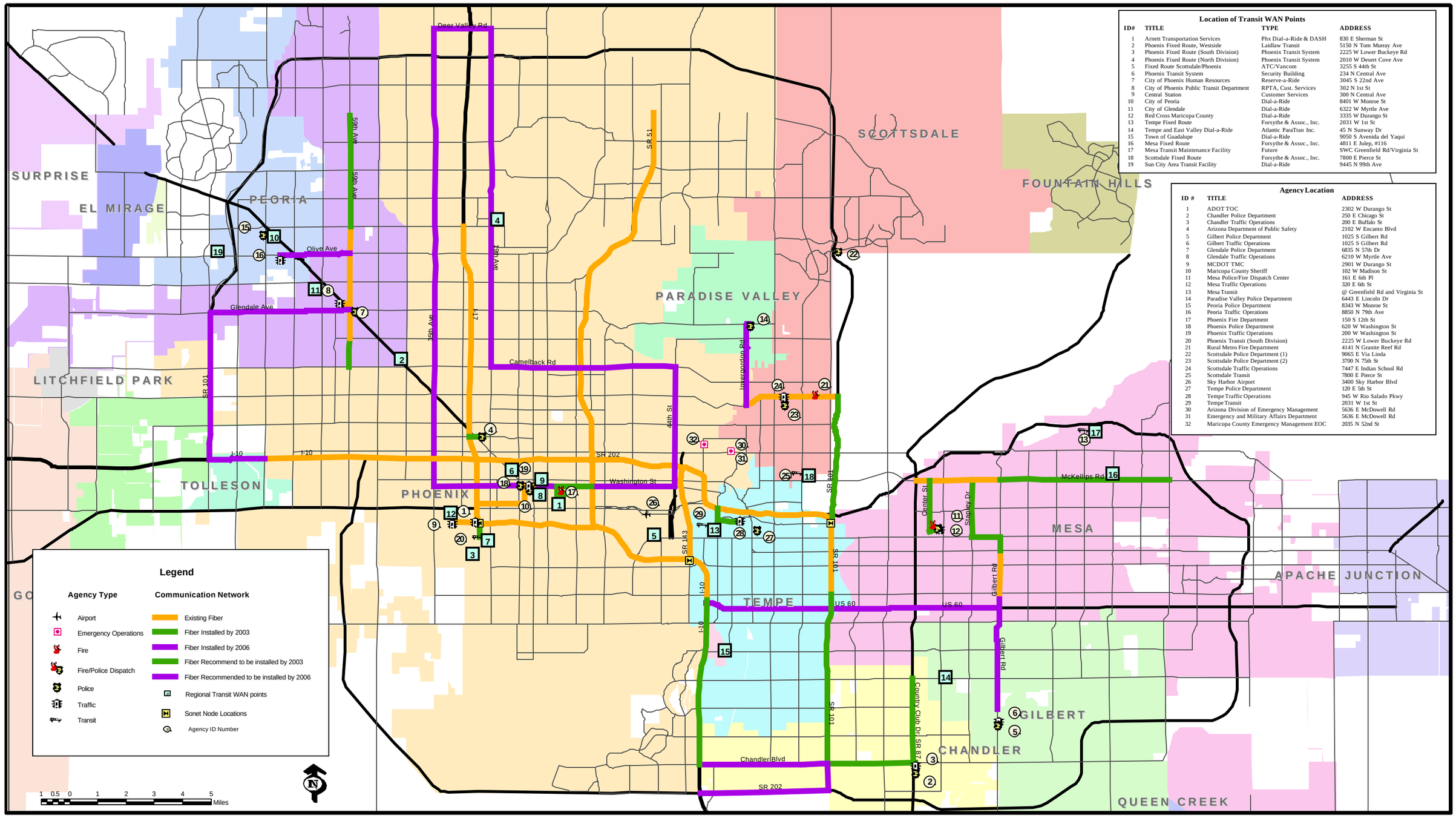
7. COLLABORATION WITH THE PRIVATE SECTOR

When considering resource sharing opportunities with the private sector, there are two fundamental considerations: 1) negotiate for conduit installation by an agency that is already trenching down that route for your use; and/or 2) negotiate for use of spare fibers.

Timing is critical when working with private agencies as well as other public agencies with different agendas and deadlines. Therefore, the ability to act quickly on another agency's deployment of fiber may not always produce the desired results. This could potentially cause an overestimate of fiber in a particular area, not enough fiber in another, or even a fiber cable that is stranded along a corridor due to lack of connection to any other communication routes. In cases where a route under evaluation is only a portion of the total network, it may be advisable to only provide for an empty conduit to be installed at the time of trenching. With this approach, the high cost of trenching is offset by two or more parties, thereby reducing the future cost of deploying fiber. When the time is right and a design plan is complete, the appropriate sized fiber cable can be pulled or blown through the existing conduit system to its end destination.

It is recommended that agencies in the MAG region coordinate with local utilities including Salt River Project, U.S. West, Cox Communications, and Arizona Public Service to explore infrastructure sharing opportunities. These utilities were contacted for this ITS Telecommunications Plan, but were not available. MAG and its partner agencies will need to work further to establish mutually agreeable relationships with these potential partners.

APPENDIX



Location of Transit WAN Points

ID#	TITLE	TYPE	ADDRESS
1	Arnett Transportation Services	Phx Dial-a-Ride & DASH	830 E Sherman St
2	Phoenix Fixed Route, Westside	Laidlaw Transit	5150 N Tom Murray Ave
3	Phoenix Fixed Route (South Division)	Phoenix Transit System	2225 W Lower Buckeye Rd
4	Phoenix Fixed Route (North Division)	Phoenix Transit System	2010 W Desert Cove Ave
5	Fixed Route Scottsdale/Phoenix	ATC/Vancom	3255 S 44th St
6	Phoenix Transit System	Security Building	234 N Central Ave
7	City of Phoenix Human Resources	Reserve-a-Ride	3045 S 22nd Ave
8	City of Phoenix Public Transit Department	RPTA, Cust. Services	302 N 1st St
9	Central Station	Customer Services	300 N Central Ave
10	City of Peoria	Dial-a-Ride	8401 W Monroe St
11	City of Glendale	Dial-a-Ride	6322 W Myrtle Ave
12	Red Cross Maricopa County	Dial-a-Ride	3335 W Durango St
13	Tempe Fixed Route	Forsythe & Assoc., Inc.	2031 W 1st St
14	Tempe and East Valley Dial-a-Ride	Atlantic ParaTran Inc.	45 N Sunway Dr
15	Town of Guadalupe	Dial-a-Ride	9050 S Avenida del Yaqui
16	Mesa Fixed Route	Forsythe & Assoc., Inc.	4811 E Juley, #116
17	Mesa Transit Maintenance Facility	Future	SWC Greenfield Rd/Virginia St
18	Scottsdale Fixed Route	Forsythe & Assoc., Inc.	7800 E Pierce St
19	Sun City Area Transit Facility	Dial-a-Ride	9445 N 99th Ave

Agency Location

ID #	TITLE	ADDRESS
1	ADOT TOC	2302 W Durango St
2	Chandler Police Department	250 E Chicago St
3	Chandler Traffic Operations	200 E Buffalo St
4	Arizona Department of Public Safety	2102 W Encanto Blvd
5	Gilbert Police Department	1025 S Gilbert Rd
6	Gilbert Traffic Operations	1025 S Gilbert Rd
7	Glendale Police Department	6835 N 57th Dr
8	Glendale Traffic Operations	6210 W Myrtle Ave
9	MCDOT TMC	2901 W Durango St
10	Maricopa County Sheriff	102 W Madison St
11	Mesa Police/Fire Dispatch Center	161 E 6th Pl
12	Mesa Traffic Operations	320 E 6th St
13	Mesa Transit	@ Greenfield Rd and Virginia St
14	Paradise Valley Police Department	6443 E Lincoln Dr
15	Peoria Police Department	8343 W Monroe St
16	Peoria Traffic Operations	8850 N 79th Ave
17	Phoenix Fire Department	150 S 12th St
18	Phoenix Police Department	620 W Washington St
19	Phoenix Traffic Operations	200 W Washington St
20	Phoenix Transit (South Division)	2225 W Lower Buckeye Rd
21	Rural Metro Fire Department	4141 N Granite Reef Rd
22	Scottsdale Police Department (1)	9065 E Via Linda
23	Scottsdale Police Department (2)	3700 N 75th St
24	Scottsdale Traffic Operations	7447 E Indian School Rd
25	Scottsdale Transit	7800 E Pierce St
26	Sky Harbor Airport	3400 Sky Harbor Blvd
27	Tempe Police Department	120 E 5th St
28	Tempe Traffic Operations	945 W Rio Salado Pkwy
29	Tempe Transit	2031 W 1st St
30	Arizona Division of Emergency Management	5636 E McDowell Rd
31	Emergency and Military Affairs Department	5636 E McDowell Rd
32	Maricopa County Emergency Management EOC	2035 N 52nd St

MAG ITS Strategic Plan Update
ITS Telecommunications Plan

Kimley-Horn and Associates, Inc.

MARICOPA ASSOCIATION of GOVERNMENTS

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department	Task Description		Target Date	Estimated Cost
ADOT	1.	Evaluate existing infrastructure, develop a plan for interconnecting spare fiber segments, and perform the fiber connections needed to for each of the WAN links identified.	2003	$75,000
	2.	Configure SONET equipment to support the various WAN links.	2006	$125,000
	3.	Program the installation of fiber cable within the conduit infrastructure along U.S. 60 beyond Dobson Road to Gilbert Road (fiber design and installation).	2006	$125,000
	4.	Installation of fiber optic cable within programmed conduit infrastructure along SR-101 between Chandler Boulevard and Guadalupe RD (fiber installation).	2003	$100,000
	5.	Install new fiber within existing conduit infrastructure along Loop 101 between Glendale Ave and I-10.	2006	$137,500
	6.	Design and install new conduit and fiber infrastructure along I-10 between Loop 101 and 83rd Ave.	2006	$370,000
	7.	Upgrade the existing video switching system.	2003	$250,000
	8.	Upgrade WAN hub data equipment (ATM/Ethernet switches)	2006	$100,000
Arizona Department of Public Safety	1.	Provide WAN connection on the regional fiber network that supports DPS (evaluation and installation).	2003	$30,000
	2.	Install new fiber connection between the DPS and I-17.	2003	$400,000
Chandler TMC	1.	Design and install the fiber connections between ADOT and Chandler infrastructure.	2003	$50,000
	2.	Provide WAN connection on the regional fiber network that supports both Chandler TMC and PD (evaluation and installation).	2003	$170,000
Glendale TMC	1.	Design and install new conduit and fiber infrastructure within Glendale city limits for the fiber path between Peoria TMC and Glendale TMC.	2006	$277,500
	2.	Design and install new fiber and conduit infrastructure along Glendale Ave between 59th Ave and 75th Ave.	2006	$370,000
	3.	Design and install new fiber within existing City of Glendale conduit infrastructure along Glendale Ave between 75th Ave and Loop 101.	2006	$75,000
	4.	Provide WAN connection on the regional fiber network that supports Peoria TMC and PD, the Glendale TMC and PD (evaluation and installation).	2006	$150,000
Gilbert TMC	1.	Design and install new conduit and fiber infrastructure within Gilbert town limits for the fiber path along Gilbert Road between Baseline and the Gilbert TMC.	2006	$647,500
	2.	Provide WAN connection on the regional fiber network that supports Gilbert TMC and PD.	2006	$170,000
MC Sheriff's Office	1.	Design and install new conduit and fiber infrastructure within Phoenix City Limits to connect to existing infrastructure for the fiber path between MCSO and ADOT TOC.	2006	$92,500
	2.	Provide WAN connection on the regional fiber network that supports MCSO (evaluation and installation).	2006	$30,000
Mesa TMC	1.	Design and install new conduit and fiber infrastructure within Mesa city limits for the fiber path along Gilbert Road between U.S. 60 and Baseline.	2006	$185,000
	2.	Design and make fiber connections within programmed fiber infrastructure for fiber optic path between the Mesa TMC and U.S. 60.	2006	$50,000
	3.	Provide WAN connection on the regional fiber network that supports Mesa TMC, Fire, Transit and PD.	2006	$120,000

PRELIMINARY ESTIMATE OF PROBABLE COST
YEARS 2000 TO 2006

Agency/Department	Task Description		Target Date	Estimated Cost
Paradise Valley PD	1.	Design and install new conduit and fiber infrastructure within Paradise Valley town limits for the fiber path between Paradise Valley PD and Scottsdale TMC.	2006	$92,500
	2.	Design and install new conduit and fiber infrastructure within Phoenix city limits for the fiber path between Paradise Valley PD and Scottsdale TMC.	2006	$92,500
	3.	Design and install new conduit and fiber infrastructure within Scottsdale city limits for the fiber path between Paradise Valley PD and Scottsdale TMC.	2006	$92,500
	4.	Provide WAN connection on the regional fiber network that supports Paradise Valley PD (evaluation and installation).	2006	$30,000
Peoria TMC	1.	Design and install new conduit and fiber infrastructure within Peoria city limits for the fiber path between Peoria TMC and Glendale TMC.	2006	$277,500
	2.	Provide WAN connection on the regional fiber network that supports Peoria TMC and Police Department (evaluation and installation).	2006	$60,000
Phoenix Fire	1.	Design and install new fiber within the programmed conduit infrastructure along 12th St. and Washington between Phoenix Fire and the existing ADOT conduit/fiber infrastructure at SH 51.	2003	$50,000
	2.	Provide WAN connection on the regional fiber network that supports Phoenix Fire (evaluation and installation).	2003	$30,000
Phoenix Transit	1.	Design and install new conduit and fiber infrastructure between Phoenix Transit and the ADOT TOC.	2003	$92,500
	2.	Provide WAN connection on the regional fiber network that supports Phoenix Transit (evaluation and installation).	2003	$30,000
Rural Metro	1.	Design and install new conduit and fiber infrastructure between the Scottsdale existing infrastructure and the Rural Metro building.	2003	$92,500
	2.	Provide WAN connection on the regional fiber network that supports Rural Metro (evaluation and installation).	2003	$30,000
Scottsdale TMC	1.	Program the installation of 12 single-mode fibers into existing conduit infrastructure along SR-101 between Indian School Road and SR-202 and provide fiber connection within existing fiber infrastructures(fiber installation).	2003	$112,500
	2.	Provide WAN connection on the regional fiber network that supports Scottsdale TMC, Transit, PDs (1 and 2) and Rural Metro (evaluation and installation).	2003	$150,000
Tempe TMC	1.	Design and install the fiber connections between the ADOT and Tempe infrastructure.	2003	$30,000
	2.	Provide WAN connection on the regional fiber network that supports Tempe TMC, Transit, and PD (evaluation and installation).	2003	$90,000