Draft Working Paper
Current Status and Future Needs of the Metropolitan Phoenix Freeway Management System

FMS Working Group
MAG Intelligent Transportation Systems Committee

December 2005

1. The Concept of Freeway Management

Freeway traffic management involves:

- Understanding both the nature and magnitude of a particular congestion and/or safety problem, including current issues (i.e., reactive), and potential future ones (i.e., proactive).
- Combining various operational strategies, policies, and systems into a comprehensive program.
- Using technology, detection and verification systems, communication links, traffic operations centers, motorist information systems, and information sharing among systems.
- Implementing a high degree of interagency coordination and cooperation to provide emergency services and to restore accident scenes to normal operation in the shortest possible time.
- Deploying and implementing highly sensitive and sometimes controversial management strategies, such as ramp meters and high-occupancy lanes.
- Managing extremely popular services such as tow trucks and patrols to rapidly remove disabled vehicles from freeways.

Ref: Freeway Management and Operations Handbook, FHWA, Sept 2003

1.1. Need and Justification for Urban Freeway Management Systems

- The major problem on urban freeways is increasing congestion.
- Lost productivity due to congestion costs approximately $100 billion each year in the U.S.
- Traffic accidents - many caused by congestion drain another $70 billion per year.
- Congestion is characterized by slower-than-desired speeds, increased travel times, increased accident frequencies, and increased operating costs.
- Congestion is caused either by an excessive demand in traffic (such as due to a special event) or reduction in roadway capacity (such as due to a disabled vehicle blocking a lane).
- Congestion is of two types: a) recurring and b) non-recurring.
- Non-recurring congestion is considered a more serious problem for the operating agency.

- The most common factors contributing to non-recurring congestion are accidents, disabled vehicles, spilled vehicle loads, construction and maintenance activities, presence of emergency vehicles, and vehicles or people on the shoulders.

Source: http://www.az511.com/Documents/adot_its.pdf

1.2. Benefits of FMS

- Reduces congestion by identifying and determining the nature of incidents so that they can be quickly cleared.
- Saves lives, saves time, and saves money.
- Improves safety, reduces congestion, enhances mobility, minimizes environmental impact, and saves energy.
- Increases speeds and reduces delays.
- Minimizes or eliminates freeway breakdown conditions during peak periods.
- Maximizes the utilization of physical capacity.
- Increases vehicle throughput.
- Rapid detection and clearing of accidents will reduce congestion and secondary collisions that frequently result and cause additional delays.
- Similar systems in U.S. have reduced accidents by 25 percent.
- Can reduce peak emissions by 10 percent.

Source: http://www.az511.com/Documents/adot_its.pdf

2. Goals and Objectives

The goals and objectives of the FMS can be summarized as follows:

- Make optimum use of the freeway system by employing effective freeway management techniques.
- Provide a safe and efficient environment for the freeway users.
- Manage traffic flow affected by freeway incidents, special events, and abnormal conditions.
- Implement the infrastructure needed for long-term ITS enhancements of freeway system.
- Operate a system that builds and maintains credibility with the motoring public.
- Provide automatic sharing of freeway information with adjacent jurisdictions as well as control of traffic-interchange signals.
- Centralize the management of the freeway system.
- *Collect data for planning purposes **
- *Gather data for system management and operations **
- *RCN – Operate and maintain the systems to a high level of reliability **
- *Provide reliable traffic, traveler information and data that supports traveler information services **

Source: http://www.az511.com/Documents/adot_its.pdf
* additional goals and objectives identified by the FMS Working Group

2.1 FMS Success Stories

Dynamic Message Signs: **To be added**

Ramp Meters: **To be added**

5-1-1 Phone System: **To be added**

3. The Phoenix Freeway Management System

The Arizona Department of Transportation has implemented a Freeway Management System (FMS) to monitor and manage traffic on freeways in the Phoenix area.

The first phase of the ADOT FMS was completed in 1994 and covered 29 miles of freeway. Since then other phases have built full FMS coverage on 87 freeway miles. The FMS provides equipment on freeways in the "Valley of the Sun" with state-of-the-art transportation technologies to help reduce congestion, enhance safety, and save fuel.

A major study of the I-17/I-10 corridor in Phoenix in 1986 recommended a variety of improvements to enable the freeway system in the Phoenix area to operate at reasonable levels of service and safety through the 21st century. Proposed for the I-17/ I-10 corridor were freeway widening, frontage road improvements, new and improved interchanges, high-occupancy vehicle (HOV) and transit applications, and a freeway management system (FMS). A study to determine the feasibility of a freeway management system confirmed that such a system was indeed needed, and design subsequently began in 1988. The features and functions of the FMS implementation in the Phoenix metropolitan area are briefly described below.

3.1 FMS Elements

The key elements of the Phoenix FMS are:

- Vehicle Detectors – two types are used: induction loops embedded in the concrete or overhead mounted Passive Acoustic Detectors
- Ramp Meters – at most on-ramps
- Variable Message Signs (VMS) also called Dynamic Message Signs
- Traffic Interchange signal (TIS)
- Closed-Circuit Television (CCTV) Monitoring System
- Communications System
- Traffic Operations Center (TOC)

As of December 2005 the Phoenix FMS consists of the following numbers of components:

- 112 Inductive Loop Detectors – buried in the pavement

- 91 Passive Acoustic Detectors – mounted overhead on a structure
- 117 Ramp Meters
- 66 Dynamic Message Signs
- 11 of 150 traffic signals on a centralized system
- 110 CCTV cameras
- 8 Node Buildings
- 1 Traffic Operations Center

3.2 FMS Functions

The following is a brief description of the functions supported by each FMS element:

Vehicle Detection

- Provides Volume, Speed, and Occupancy (VOS) data.
- Both in-pavement loop detectors and passive-acoustic detectors are used.
- Data is used for incident detection, measurement of effectiveness, and freeway operational capability.
- Consists of double loops in each mainline travel lane at one-mile spacing.
- Model-179 controllers are used in the field for detector data processing.
- Future use of national standards-based controllers – 2070 controllers currently being tested for adaptive ramp metering

Manage Traffic via Ramp Metering

- Regulates rate of entering vehicles from on-ramps.
- Spreads out platoons of entering vehicles.
- Increases average freeway speeds and throughput volumes.
- Improves overall safety of operation on freeway and ramp.
- Keeps freeway flow at its optimum.
- HOV bypass lanes have been replaced with dual metered lanes
- No freeway-to-freeway connectors are metered.
- Model 179 controllers are used in the field for ramp metering data processing.
- Model 2070 controllers that are based on National ITS Standards are currently being tested at seven on-ramp locations on I-10 for future adaptive ramp metering

Deliver Traffic Advisories via Dynamic (Variable) Message Signs

- Primary method/device for delivery of traffic information to the motorists.
- Capable of quickly changing messages remotely from the TOC.
- Fiber-optic, permanent and overhead signs used throughout the state, furnished by a single vendor to facilitate operations and maintenance.
- All signs are alphanumeric, character matrix with 18-inch-high character, and three-line display.
- Signs are generally placed at the following locations: a) at intermediate locations based on volume-to-capacity ratio, accident rate, and diversion potential; b) in advance of freeway-to-freeway interchanges; c) at entrances to system; and d) at approximately three-mile spacing in urban areas.
- Total-life-cycle cost—based on initial, maintenance, and electrical costs—were used to select the vendor for multi-year procurement contract.

Future DMS requirements
-- to be filled in --

Traffic Control via Interchange Traffic Signals

- Historically ADOT has operated traffic signals at freeway interchanges at arterials. ADOT has turned over operation of traffic signals to local governments wherever possible.
- A central traffic signal control system manages signals remotely and alerts the TOC operators of any malfunctions. ADOT has deployed the Siemens i2 system within the Phoenix area

Surveillance via Closed-Circuit Television (CCTV) Cameras

- Color CCTV cameras with pan, tilt, and zoom capabilities.
- Located on both sides of freeway between interchanges, at approximately one-mile spacing
- Provide continuous freeway monitoring.

Communications Between Field Devices and Control Center

- Provides interconnection between central computer at the TOC and field devices.
- Accommodates data and video.
- Communications trunk lines are placed along both sides of freeway to provide redundancy.
- Twisted-pair copper was used on the first phase and fiber-optic cables have been used on all subsequent phases.
- Communications node buildings are placed in the field to collect information from field devices and transmit the information to the TOC over fiber-optic cables.
- Currently assessing wireless communications.
- Currently deploying Coarse Wave Division Multiplexing in place of proprietary communication equipment.
- Fiber backbone construction -- encasement in concrete to be abandoned resulting in saving of construction costs

Gather Freeway Traffic Flow Data for Planning Purposes

- Better level of service on the freeways through implementation of timely and effective traffic management strategies
- Gather traffic data for MAG transportation planning purposes
- Partnerships with private sector information providers
- Provide system data for planning and HPMS reporting

Centralized Control and Management - Traffic Operations Center (TOC)

- Statewide facility operating 24 hours a day, 365 days a year.
- The 18,000-square-foot building was designed and constructed specifically for the FMS operations, serving as the hub of ADOT's incident management facility.
- The building includes a 2,100-square-foot control room, which serves as the center of activity for the operation of the system.
- Four operator workstations, 32-monitor video display wall, and two large projection screens are installed in the control room, which show the real-time

traffic conditions in the Phoenix area and statewide weather and roadway conditions.

- Two large equipment rooms house the communications and computer equipment, and an electronic maintenance area is used for maintenance of the system's electronic equipment.
- Office spaces are provided for the FMS operations staff and contractors.
- Three conference rooms are used for meetings and training sessions, and in the event of a major emergency, the main conference room can be converted into an emergency operations center.

3.3 Operating the FMS

Operating Principles

The fundamental operating principle of the FMS is to maintain safe and efficient flow of traffic on the freeway system by minimizing adverse impacts due to both planned events and freeway incidents, and the timely delivery of freeway status information to motorists on the freeway as well as those enroute or planning to enter the freeway system.

The two major functions of the FMS are **monitoring** (using vehicle detectors and CCTV cameras) and **control** (ramp metering, DMS, and traffic-interchange signals).

In the Field

- Sensors detect traffic flow patterns and identify congestion.
- Remote CCTV cameras provide visual confirmation of problems.
- Ramp meter controllers regulate access to the freeway.
- Dynamic message signs inform motorists of freeway conditions ahead or upcoming closures.
- Data and video from field devices are transmitted over twisted-pair and single-mode fiber optic cables to communications nodes.
- Data and video are multiplexed at the communications nodes and transmitted to the TOC over single-mode fiber-optic cables.

At the TOC

- A UNIX- and PC-based computer system, interconnected with a local-area network, processes the data arriving from the field.
- Video wall of 32 monitors and the large traffic projection screen for the Phoenix freeways provide traffic conditions and incidents.
- The operators use the Highway Condition Reporting System (HCRS) to log and document the observed incidents. The HCRS supplies up to date road status information to the 511 travel information hotline.

FMS Central Computer System

The central computer system is located at the TOC to receive volume, occupancy and speed data from the vehicle detectors, to monitor ramp metering controllers, and to provide the capability for the operators to document and organize the observed incidents. The FMS software has been designed, developed, tested, integrated, and documented by consultants to meet the specific needs of the ADOT TOC operations. However, much of the original FMS software is now outdated and basically have been abandoned, except for the gathering of detector information. The ramp-

metering module is estimated to be reliable only about half the time. The central computer systems perform the following:

- Monitors all of the equipment for prompt detection of malfunctions and quick dispatch of maintenance personnel.
- Transmit traffic information to the media for dissemination to their listeners and viewers, and advise local signal system operators of freeway conditions, enabling them to implement appropriate responses.
- Provide the interface between the system hardware and the operators and process all of the traffic flow data.

Table 3.1 FMS Device Spacing and Functions

Device	Spacing	Original Function/s
Loop vehicle sensors	1/3rd mile in each lane prior to mid 2004	Vehicle Detection
	1 mile in each lane since mid 2004	
PAD sensors	1 mile in each lane since mid 2004	Vehicle Detection
Ramp metering	At all On-Ramps	Manage Flow to Freeway
Dynamic/Variable Message Signs	At Strategic Locations	Inform Motorists
Ramp metering	At all On-Ramps	
Cameras	One-mile	Traffic Surveillance
Fiber backbone	In conduits along the freeway	Data & Video Communication

3.4 Human Resources for FMS Operations

Nearly all of the traffic management functions associated with freeway management are performed manually by trained FMS operating personnel. The exceptions are continuous traffic data collection, and ramp metering set to operate at different time-of-day settings. Therefore, having an adequate number of qualified and well trained staff is key for effective current and future FMS operations. A review of FMS related operating practices in other states have resulted in the following table:

Table 3.2 Human Resources Required for FMS Operations

1995 data:				
CITY /ATMS	**DOT**	**TOC Personnel**	**Hours**	**TOC Budget**
Houston	Texas DOT	7 traffic eng+3 techs	6am-10pm	$750k w/o personnel costs
Seattle	Washington DOT	9 traffic eng+3 techs	6am- 7pm	$1.3m
Detroit	Michigan DOT	3 traffic eng + 6 techs	6am – 7pm	$800k
SLC	Utah DOT			
2005 data:				
Phoenix	ADOT	13 operators	24/7	$1.4m

3.5 Resources for FMS Maintenance

Funds for ITS Equipment Maintenance:

The ADOT Phoenix Maintenance District has allocated a total of $535,500 in maintenance funds for ITS Maintenance. This includes $150,000 for personnel services, $50,000 for employee related expenses, $5,300 for professional and outside services, $200 for in-state travel, $100,000 for other operating expenses and $230,000 from the District's unspecified maintenance funds.

ITS Maintenance Funds:

Personnel Services	=	$ 150,000
Employee Related Expenses	=	$ 150,000
Professional/Outside Services	=	$ 5,300
In-state travel	=	$ 200
Other operating expenses	=	$ 100,000
District maintenance funds	=	$ 230,000

		$535,000

In addition, the State Transportation Board has set aside $1,250,000 per year for the preservation of ITS. The Transportation Technology Group is responsible for administering these funds, and have budgeted a total of $850,000 per year to be spent within the Phoenix Region as follows:

ITS Preservation Funds:

Warehouse Parts	=	$200,000
Dynamic Message Signs	=	$150,000
PAD installation	=	$150,000
Camera replacement	=	$200,000
Camera repair	=	$100,000
Fiberoptic repair	=	$ 50,000

		$850,000

It should be noted that a portion of the DMS maintenance cost and a portion of the warehouse parts would be utilized for ITS infrastructure outside of Phoenix.

In total there is approximately $1.4 million (= $850,000 + $535,000) being spent per year in the Phoenix Maintenance District to support the operation and maintenance of ITS devices in the region. The 1998 ADOT study, *PECOS ITI Data Models*, generated estimates of FMS maintenance and operating cost. ADOT has recently updated these estimates more accurately reflect existing FMS infrastructure and cost information. The updated cost figures are shown in the table below. The estimated O&M cost for 2005 exceed available resources by $250,000.

Table 2 reflects the projected costs to operate and maintain the FMS elements. The costs include considerations for inflation and increasing FMS coverage as reflected by the number of FMS elements.

Table 3.3 FMS O & M Cost Projections & Labor Requirements

Year	O & M Cost ($ Million)	Person Hours
2005	1.65	11,816
2006	1.70	11,816
2007	1.75	11,816
2008	2.13	14,252
2009	2.26	14,749
2010	2.44	15,528
2011	2.61	16,166
2012	2.69	16,166
2013	2.77	16,166
2014	3.56	20,616
2015	3.67	20,616
2016	3.94	21,580
2017	4.17	22,218
2018	4.83	25,176
2019	5.07	25,674
2020	5.32	26,171
2021	5.48	26,171
2022	5.85	27,191
2023	6.23	28,210
2024	6.56	28,848
2025	6.75	28,848

Source: ADOT, 2005

<u>O&M Costs (Excludes Traffic Operations Center costs)</u>
Operating Cost -- includes power and telecommunication costs
Maintenance Cost -- includes on-demand maintenance, scheduled maintenance and equipment replacement at the end of life cycle
Labor-Man Hrs – Labor effort required to carry out all of the maintenance activities

<u>Human Resources for FMS Maintenance</u>

ADOT Employees:

The ADOT Phoenix Maintenance District recently dedicated a total of seven full time positions to the task of maintaining the FMS. Two of these are limited positions that are due to expire in 2008. These positions have been included in the ADOT personnel unit called Org 7894. The supervisor of this unit is an experienced ITS Maintenance Area Manager. One position is a Traffic Signal Crew Supervisor and five of the positions are at the level of Traffic Signal Technician II. Six of these positions have been filled as of December 2005. The unit supervisor has been maintaining ITS infrastructure for 12 years. The remaining five employees have less than fifteen months in experience.

Contractors:

There are a number of state procurement contracts available to obtain parts and services. The following is a listing of vendors along with the products and services that they are under contract to furnish:

1. Contractor's West – Passive Acoustic Detector repair, replacement and parts
2. CopperState – CCTV repair and parts
3. Fiberoptic Display System (FDS) – DMS repair, replacement and parts
4. ITS Engineers – on call consultant for ITS including loop detector and fiberoptic repair

3.6 FMS Equipment Replacement

It is assumed that cameras, loop detectors, passive acoustic detectors and modems will be replaced as they reach the end of their life cycle as part of routine maintenance. The costs of those replacements are assumed to be included in routine O&M costs. The key FMS elements that would need to be replaced under separate contracts in the next 20 years are all existing DMSs, new DMSs installed in the next five years, all existing copper-wiring, all existing controllers and all existing node equipment.

The table below provides projected replacement costs over the 20-year program, on the basis of the above described plan to replace equipment.

Table 3.4 FMS Equipment Replacement Costs

Description	Quantity	Replacement Cost	Total
Current DMS	60	100,000	$6,000,000
Future DMS	30	100.000	$3,000,000
All copper wiring (miles)	29	100,000	$2,900,000
Controllers	200	4,000	$800,000
Node equipment	10	200,000	$2,000,000
Video Wall at TOC	1	850,000	$850,000
Total replacement cost			$15,550,000

4. FMS Performance & Reliability

The overall performance of the FMS depends on how effective the system is in achieving its primary objectives. However, in order for the system to function in a reliable manner its individual components must also meet certain levels of reliability. The system is operational 24-hours a day and 7-days a week. The current ADOT goal for FMS performance and component reliability is to ensure that their failure rate is less than 5%. Failure rate is defined as:

$$\% \text{ Failure} = \frac{\text{Number of Units that failed during the month}}{\text{Total number of Units}} \times 100$$

Figure 4.1 below show the DMS failure rates for the period August 2003 through October 2005.

System reliability/performance goals - % up time, failure rates

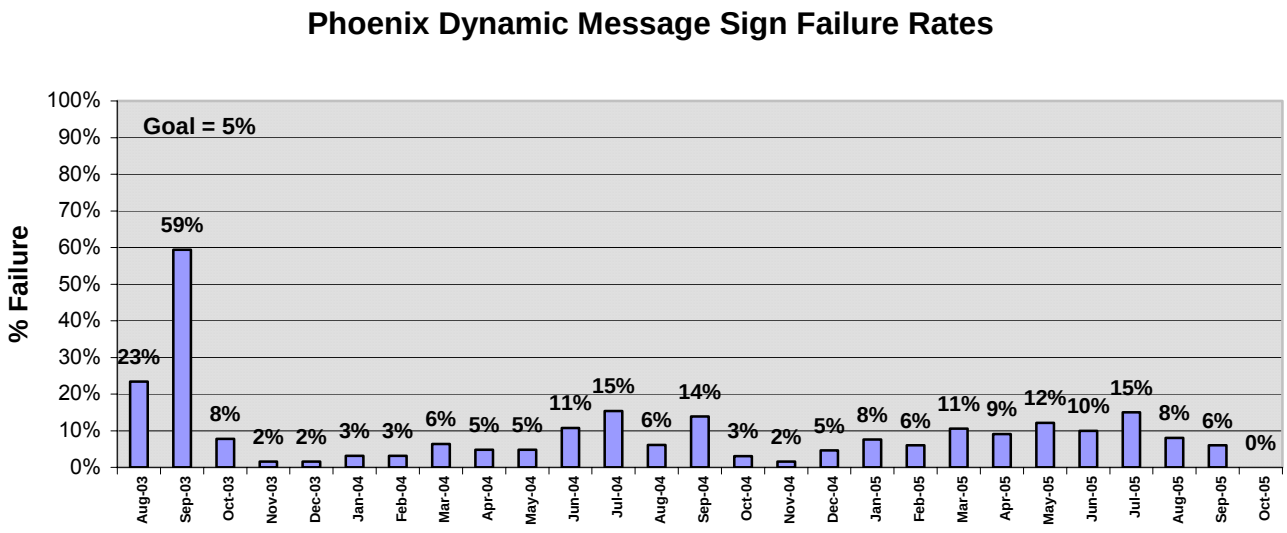

Figure 4.1 DMS Failure Rates

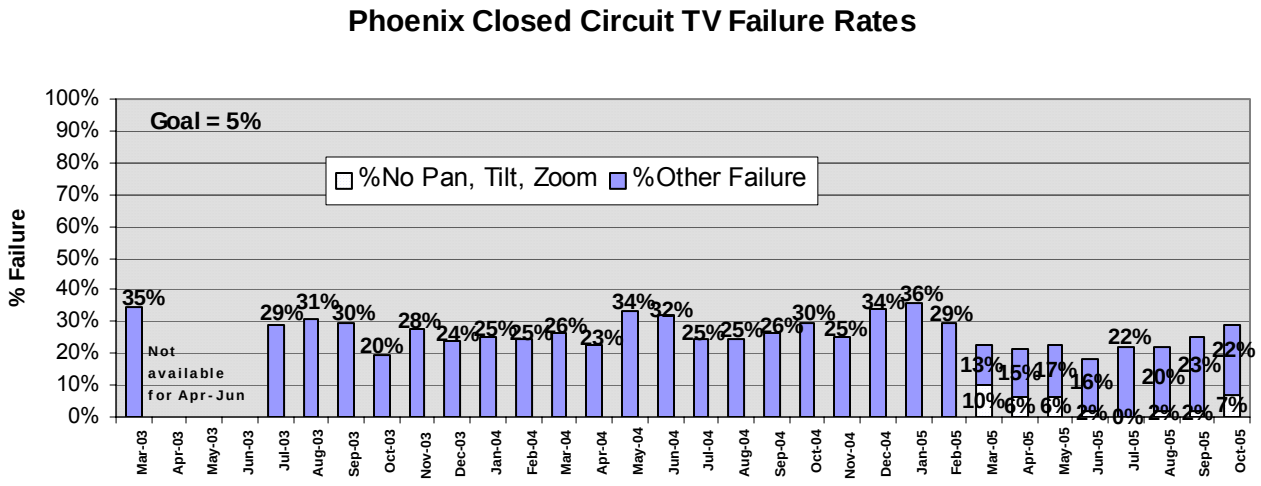

Figure 4.2 CCTV Failure Rates

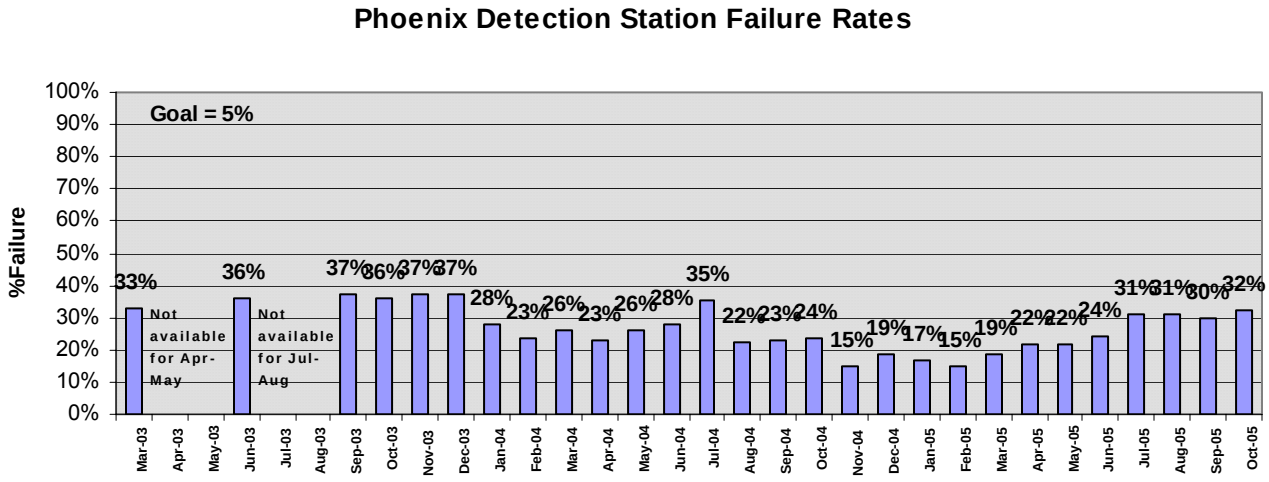

Figure 4.3 Vehicle Detector Failure Rates

4.1 System Accuracy and Calibration

To ensure that system management decisions are made on reliable information it is necessary to verify the accuracy of the system on an annual basis. This requires the calibration of vehicle detection devices installed across the system, which provide the most basic information and data on vehicle speed and occupancy. It is recommended that an independent agency be contracted to carry out an assessment of the accuracy of FMS data. Initially, the entire system would need to be checked for data accuracy at a certain minimum level and the necessary equipment calibration carried out. Thereafter, it would be necessary to check the calibration of devices at least once every three years.

A plan, schedule and a budget needs to be developed for the on-demand as well as periodic or routine calibration of all installed FMS vehicle detection equipment. Results of the annual system accuracy assessment carried out by the independent agency could be utilized to schedule on-demand calibration tasks.

The current MAG contract with Texas Transportation Institute (TTI) is a good example for an independent agency used for verifying the accuracy of FMS data.

5. Capital, Design and Construction Costs

Approximately $143 million in regional transportation funds have been allocated toward the expansion of the FMS.
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What will not be covered by RTP FMS funds – South Mountain 202 & Loop 303 and I-10 Reliever

$143m in four planned RTP phases

Table 5.1 – FMS Phases Programmed in the 20-Year Regional Transportation Plan

PHASE	ROUTE	TYPE	SEGMENT	MILES	RTP $ (millions)	FUND PRIORITY
6B	202L	FMS	RM: 101L to SR87	6	$6.6	2009
6B	101L	FMS	90th Street to 202L	9	$9.9	2007
12A	101L	FMS	Princess to 90th St.	6	$6.6	2007
9	101L	FMS	Baseline to 202L	5	$5.5	2010
8	US60	FMS	Val Vista to Power	4	$4.4	2008
13 A	US60	FMS	Power to Crismon	4	$4.4	2007
3A	I-17	FMS	AZ Canal to 101L	7	$7.7	2013
3B	I-17	FMS	101L to Carefree	8	$8.8	3013
12B	101L	FMS	I-17 to SR51	7	$7.7	2013
12B	101L	FMS	SR51 to Princess	6	$6.6	2013
12B	SR51	FMS	Bell Rd to 101L	2	$2.2	2013
14A	202L	FMS	SN:1-10 to Dobson	5	$5.5	2013
14B	202L	FMS	SN: Dobson to -Val Vista	7	$7.7	2015
10	101L	FMS	Grand to I-17	12	$13.2	2017
7C	10	FMS	Chandler Blvd to Queen Cr	4	$4.4	2018
11A	I-10	FMS	Dysart to 83rd Ave	5	$5.5	2016
11B	101L	FMS	I-10 to Grand	9	$9.9	2017
13 B	US60	FMS	Crismon to Meridian	2	$2.2	2017
15A	202L	FMS	RM: SR 87 to Higley	4	$4.4	2019
15B	202L	FMS	RM: Higley to US60	8	$8.8	2022
16	202L	FMS	ST: US60 to Val Vista	8	$8.8	2022
17	I-17	FMS	Carefree to Anthem Way	5	$5.5	2023

5. Organizational Structure

How different state DOTs are organized to manage and operate systems such the FMS and deliver essential services to the traveling public needs to be examined. Perhaps there are lessons to be learned from other agencies engaged in performing similar functions. The following state DOTs were identified as suitable agencies for this purpose.

CITY/ATMS	DOT
Chicago	Illinois DOT
Houston	Texas DOT
Seattle	Washington DOT
Detroit	Michigan DOT

The task of gathering information on the organizational structure is underway and is not complete at this time.

6. Innovative Traffic Control Technology and Practice in Europe

This is a brief summary of a report from a Technology Scanning Tour sponsored by USDOT, written by Dr. Samuel Tignor, formerly with FHWA. The team consisting of US transportation professionals visited a number of countries in Europe. The team found a number of interesting technologies and operational procedures.

Summary Information

A traffic management system of detection, lane control, variable message signs, and variable speed limits is used in Gotherberg, Sweden. Called Motorway Traffic Management it is used in the Lundby tunnel and utilizes a system of loop detectors and video cameras to measure traffic volumes and speeds, for classifying vehicles, and for incident detection. Information is provided to motorists through a series of variable message signs. Lane control and variable speed limits are used to control traffic flow. Similar systems have provided a variety of documented benefits. In Amsterdam, the system reportedly reduced the “overall accident rate” by 23%, reduced the “serious accident rate” by 35%, and reduced the “secondary accident rate” by 46%. In Germany, the accident rate fell by 20% in areas where variable speed limit signs and lane control signals were used to warn drivers of congested conditions on the A5 autobahn between Bad Homburg and Frankfurt/West. On a comparable section of autobahn without control, accidents increased by 10% in the same time period. The Germans estimated that the payback in savings from the reductions in accidents would equal the cost of the system within two to three years after deployment.

Intelligent Speed Adaptation (ISA) monitors the difference in speed between a vehicle’s current speed and its suitable speed. Corrective action can then be taken, for example, if the vehicle is traveling too fast for the current speed limit. Road beacons are used to transmit a signal to the car and warn the driver. The systems can also be automatic. A test of a prototype system was conduced in Eslov, Sweden, in which vehicles where limited to 50km/hr. Once the speed was exceeded drivers experienced resistance in the

accelerator and were unable to increase speed further. The test drivers indicated that the system was well received as a safety control feature and that it was not an unpleasant control or source of irritation. Behavior studies also showed that the interaction between the test drivers and other road users improved.

According to officials in England, automated enforcement is important in maintaining compliance with variable speed limits. Detectors identify vehicles exceeding the speed limit while cameras mounted on overhead freeway signs photograph the license plate. The system has shown a very high compliance rate with speed limits, an increase in capacity by 5% to 10%, and a 25% to 30% decrease in rear-end accidents on the approaches to queues on the freeway.

Several European cities are also making use of real-time parking information. Primarily these systems are utilized in downtown areas. They usually consist of a set of detectors to count the number of vehicles entering or exiting garages or lots. Display of available parking can then be transferred to variable message signs informing drivers of availability of parking. Benefits have shown a reduction of up to 25% in downtown traffic volumes related to searching for parking spaces. These timely messages have also shown enhanced use of transit and improved use of park-and-ride lots serving transit when drivers are informed that parking is full.

7. RECOMMENDATIONS FOR FUTURE FMS

7.1 Future FMS Objectives

- Implement strategies and tools necessary for proactive control and management of traffic on freeway-arterial corridors
- Strategies and tools to operate the freeway close to its peak performance
- Ability to monitor freeway flow rates on congested segments and compare them to where the freeway is operating with regard to its q-k curve
- Adaptive control of ramp metering rates responsive to mainline traffic flows
- Strategic location of sensors, Dynamic Message Signs and cameras based on location specific conditions
- Freeway lane control signs on the most congested segments
- Gather accurate data for planning purposes
- Implement an alternate traffic operations center - Peoria
- Program adequate resources for FMS operations and maintenance
- Provide interoperability of the FMS with arterial management and emergency management systems that are being deployed. Support center-to-center standards.
- Upgrading current and Implementing future equipment to IP-addressable devices and digital communication equipment.

7.2 Technological considerations

The following technological considerations are recommended for future design and construction of the FMS:

DMS - improved accessibility for maintenance by increasing length of catwalks and improving safety appurtenances on the structures, reduce maintenance costs by upgrading to LED signs instead of fiber optic signs. Install more cost effective signs.

Detectors – evaluate new alternatives to traditional induction loops and passive acoustic detectors

Communications – replace all existing twisted pair with fiber optics. Assess the viability of using wireless connections in certain areas. Delete fiber paths on both sides of the freeway when an entire fiber loop is available. Replace proprietary communications equipment with open systems such as SONET or Gigabit Ethernet.

Controllers – migrate from 179 controllers to 2070 for ramp meters and detection and NEMA TS2 for interchange traffic signals.

Cameras – convert analog images to digital images in the field so that redundant paths can be obtained. Assess the feasibility of complete conversion to digital camera equipment and IP addressable devices.

Vehicle Infrastructure Integration (VII) – Ensure that future FMS infrastructure is compatible emerging technological developments in VII that are likely to improve safety and are determined to be cost effective, considering the vehicle fleet in the region.

7.3 Recommendations

Based on this assessment of current status and future needs the FMS, the FMS Working Group has generated a number of recommendations. It is recommended that:

Approximately 10% of the funds currently allocated for the expansion of the FMS in the 20-year RTP ($143 million) should be reallocated to FMS maintenance. This would equate to approximately $725,000 per year. It is also recommended that future FMS phases be reduced in scope to accommodate the reduced budget.

ADOT pursue additional outsourcing of maintenance activities

ADOT and MAG initiate an annual FMS performance measurement/assessment by an independent agency such as TTI, producing an annual report on the FMS.

It is recommended that FMS device maintenance include vehicle detector calibration as part of regular maintenance such that each detection device is calibrated no less than every three years.

It is recommended that $16 million be set aside within the 20 year RTP for replacement of existing FMS elements that reach the end of the useful life cycles.

It is recommended that ADOT incorporate the technical consideration in Section 7.2 into all future design and construction of FMS.