MAG Systems Management and Operations (SM&O) Plan

Task 2 Report – ITS Infrastructure and SM&O Practices

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ICF INTERNATIONAL

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List of Acronyms

ADOT – Arizona Department of Transportation
ADOT – Arizona Department of Transportation
ALERT – Arizona Local Emergency Response Team
ARID – Anonymous Re-Identification Detection
ARIS – AZTECH Regional Information System
ASU – Arizona State University
ATM – Active Traffic Management
AZDPS – Arizona Department of Public Safety
CAD – Computer-Aided Dispatch
CCTV – Closed Circuit Television Camera
CMAQ – Congestion Mitigation and Air Quality
CV/AV – Connected Vehicle/Autonomous Vehicle
DMS – Dynamic Message Sign
FMS – Freeway Management System
FSP – Freeway Service Patrol
FTE – Full-Time Equivalent
HCRS – Highway Conditions Reporting System
ICM – Integrated Corridor Management
ITS – Intelligent Transportation Systems
MAG – Maricopa Association of Governments
PIO – Public Information Officers
PSA – Public Service Announcement
RADS – Regional Archived Data Server
RCN – Regional Community Network
REACT – Regional Emergency Action Coordination Team
RTP – Regional Transportation Plan
SM&O – Systems Management and Operations
TAG – Technical Advisory Group
TIM – Traffic Incident Management
TIP – Transportation Improvement Program
TMC – Traffic Management Center
TOC – Traffic Operations Center
TSM&O – Transportation System Management and Operations
TSOP – Traffic Signal Optimization Program
VID – Video Image Detection
VSL – Variable Speed Limit

1 INTRODUCTION

This review documents the status of existing and planned (near-term) intelligent transportation systems (ITS) infrastructure and Systems Management and Operations (SM&O) practices in the Maricopa Association of Governments (MAG) region. The ITS infrastructure review examines ITS infrastructure features and coverage for both the freeway and arterial roadway networks and systems. The SM&O practices documents currently established practices across the MAG region, identify key business processes, and estimate the potential benefits and return on investments for these operations. This is the second in a series of reports for the MAG System Management and Operations Plan.

1.1 Purpose and Objectives

This document includes the following sections:

Section 2: Freeway Operations and Management – identifies the infrastructure, systems and processes used by ADOT for freeway operations and management within the Phoenix metro area.

Section 3: Arterial Operations and Management – identifies the infrastructure, systems and processes used by local agencies within the MAG region (including Maricopa County and Pinal County) for arterial and local traffic operations and management.

Section 4: Regional SM&O Functions and Operations – identifies and discusses the operations and management at the regional level including regional systems and processes.

Section 5: Lessons Learned and Recommendations – identifies areas and functions that must be improved as well as key enablers that will facilitate those improvements.

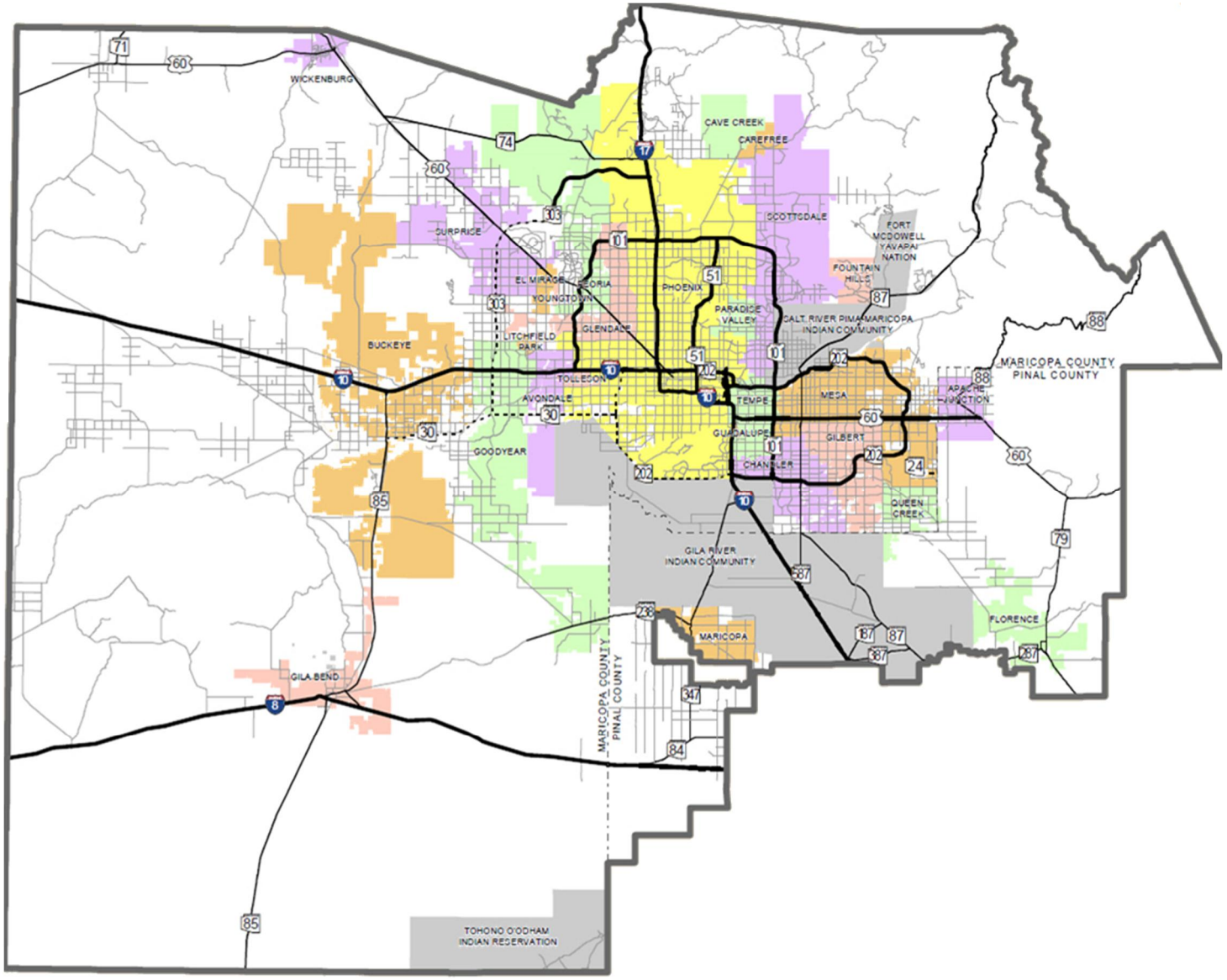
The purpose of this document is to examine the freeway and arterial ITS infrastructure and current SM&O practices that exist across the MAG region. Based on the inventory findings and key lessons learned/advance from SM&O experts as well as gaps and needs related to infrastructure, systems and processes will be identified. This will include potential improvements to institutional processes, staff training, and resource allocation in the MAG region as well as an evaluation of ITS equipment needs, challenges and cost-effectiveness. In addition, this analysis will evaluate Traffic Management Center (TMC) staffing and training available to staff, funding sources for costs associated with ITS infrastructure and operations, and existing performance measurement and reporting.

1.2 Study Area

The MAG planning area encompasses 27 cities and towns, three Native American Communities, Maricopa County, and a large part of Pinal County, and encompasses an area of 10,654 square miles. Per the MAG 2035 Regional Transportation Plan (RTP), there is a total of 850 existing centerline miles included on the freeway and highway network, with an additional 71 miles planned for future development. The MAG planning area will serve as the study area for this SM&O plan, and the boundary is defined in Figure 1.

1.3 Inventory Methodology

Electronic surveys were distributed to agencies within the MAG planning region to document the status of existing ITS infrastructure and current SM&O functions being performed across the MAG region. One survey targeted the freeway information related to Arizona Department of Transportation's (ADOT) systems operations and management-related practices and freeway ITS infrastructure. A different survey was sent to agencies who operated arterial roadways, including local municipalities and Maricopa and Pinal counties, to collect information on MAG member agencies' SM&O practices and arterial ITS infrastructure.



Source: MAG RTP

Figure 1 – MAG Planning Area

2 FREEEWAY OPERATIONS AND MANAGEMENT

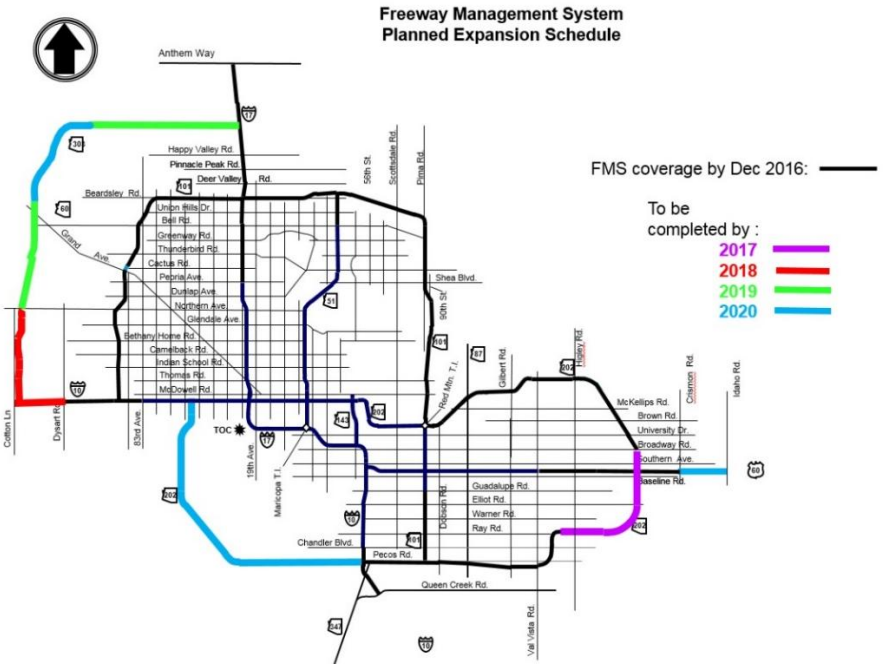
All freeways within the Phoenix metro area are owned and operated by ADOT, using a variety of equipment, systems, and processes to actively manage traffic, incidents, and related events. This section discusses the operations and management components of the freeway system.

2.1 Freeway Management System

ADOT has had the ability to proactively monitor and manage traffic on the region's freeways since the implementation of initial phases of the Freeway Management System (FMS) in 1995. The FMS is in place in the Phoenix and Tucson metro areas and is centrally controlled and managed at ADOT's Traffic Operations Center (TOC), which is responsible for traffic and incident management on state corridors. ADOT's FMS consists of closed circuit television (CCTV) cameras, large overhead dynamic message signs (DMS), ramp meters, mainline detectors, and fiber communications. Key components of the FMS system include the following:

- CCTV cameras at 1-mile spacing capable of viewing each direction of travel.
- Vehicle detector stations at 1-mile spacing in each direction of travel.
- DMS that display messages and travel times at approximately 3-mile spacing along the corridor.
- Ramp meters operate during the AM/PM peak periods and are linked to the adjacent mainline detection for traffic responsive metering rates.

Currently, the FMS covers 219 miles, and the MAG RTP has provided $143 million in funds for ADOT to add additional coverage within the next five years. As shown in Figure 2, the FMS system covers most the Loop 101 and Loop 202, with anticipated full coverage by 2020. Coverage currently exists along portions of the US 60, I-10, and I-17 within the urbanized freeway loop system. Additional FMS coverage is expected including the entirety of the Loop 303 and additional portions of the US 60, I-10, and I-17 outside of the freeway loop system. The FMS is funded by the MAG Regional Transportation Plan and does not extend to rural areas outside within the MAG planning area.



Source: ADOT TOC

Figure 2– Current and Planned FMS in the Phoenix area

A project identified in the 2003 MAG RTP for improving the I-17 corridor resulted in a joint ADOT-MAG investigation of the feasibility of a suite of innovative technology applications known as Active Traffic Management (ATM) to improve traffic management, traffic information dissemination and response to traffic incident. Two examples of applications include the use of Variable Speed Limits (VSL) and adaptive ramp metering. This investigation was performed as part of the I-17 Spine Near Term Improvement Project.

2.1.1 Detection

Loop detectors are the most commonly used detection device for the Maricopa Region freeway system and are currently used for traffic detection, ramp metering, and queue detection for on-ramps. ADOT collects data such as traffic speeds, volumes, and occupancy from the loop detectors. Data from the detectors is used to support calculating travel time estimates, which are displayed on several DMS in the metropolitan area. Data also is used for performance monitoring of freeway travel times, volumes, speeds, and congestion.

2.1.2 CCTV Cameras for Traffic Monitoring

ADOT's freeway system in the Phoenix metro area contains a total of 274 CCTV cameras which are situated at one mile intervals and are monitored by ADOT's TOC. The freeway CCTV cameras are largely used for congestion management, incident detection and location confirmation, and streaming images that can be shared with other local transportation agencies throughout the MAG region. Streaming freeway CCTV images are shared with other local transportation departments in the metropolitan area through the Regional Community Network (RCN) with fiber communications. Freeway CCTV images are also provided to the media, through direct access, as requested for use in broadcasts or news coverage.

ADOT manages the 360 Surveillance Camera Cameleon license statewide, which is used to control CCTV and DMS throughout the state. ADOT currently uses the Camera Cameleon interface, which was also used by local agencies in the region to manage CCTV infrastructure. Under a pilot program, MAG redistributes ADOT's camera feeds to participating agencies using the RCN and the Luxriot Video Management Software.

2.1.3 Traffic Signals

ADOT owns and operates some of the traffic signals at freeway interchanges in the region using the Transcore's TransSuite software, which is the same software is used to control ramp meters. Some of the traffic signals located at interchanges are owned and/or controlled by local agencies as part of their local signal system through established agreements. The Intelight's MaxView ATMS controls and monitors the traffic signal operations, including vehicle detection cameras, time of day plans, and signal communications. ADOT owns and maintains 181 signalized interchanges in the metropolitan area. There is a Signal Centralization project to connect traffic signals back to the TOC to operate pre-approved timing plans in response to traffic conditions.

2.1.4 DMS

ADOT owns and operates 142 DMS in the metropolitan area (example shown in Figure 3). DMS are used to warn motorists of obstructions and reduce secondary incidents. Large overhead DMSs display Public Service Announcements (PSA), AMBER/Silver/Blue Alerts, travel times, work zone information, incident or weather warning/alerting, and event traffic notification. A cohesive travel time system posts messages to strategically chosen DMSs providing motorists real-time information regarding the route on which they are traveling. The

information provided is intended to help travelers make informed decisions regarding the most appropriate route for their travel purposes.

Figure 3 – Example of ADOT DMS

2.1.5 Ramp Meters

Ramp meters are deployed on the freeway system in the Phoenix area. They are currently activated by time-of-day scheduling and have adjustable activation thresholds based on mainline detection near the ramp. In Fall of 2016, ADOT is conducting a test of an algorithm for adaptive and responsive ramp metering on SR 51.

2.1.6 Communications

ADOT primarily relies on fiber optic communications, which traverses on one or both sides of most freeways, to connect their ITS field devices to the FMS. The freeway fiber and conduit network is leveraged to support the RCN that connects transportation and public safety agencies in the region to one another for CCTV image and other data sharing. The freeway fiber network is also leveraged by local agencies with fiber sharing agreements where the local agency utilizes freeway infrastructure to connect to different parts of their own cities. ADOT also uses wireless radios and cellular devices to connect to other infrastructure that is not directly serviced by a fiber line.

2.1.7 Loop 202 South Mountain Freeway

A 22-mile section of freeway extension of Loop 202 to the west, a key component of the MAG RTP, has begun construction in September 2016. This freeway, as shown in Figure 4, is being constructed through a public-private partnership, the first of its kind in Arizona. ADOT will operate the freeway through traditional FMS tools that have been designed as part of the freeway infrastructure. The freeway is expected to be open by late 2019.

Figure 4 – Loop 202 South Mountain Freeway Alignment

2.2 Traffic Operations and Management

ADOT has placed a significant amount of emphasis on traffic operations and management through their investments in infrastructure and systems but also through agency reorganization, which has established a Transportation Systems Management and Operations (TSM&O) Division. The TSM&O Division is currently in the process of identifying and establishing priorities for improving traffic operations and management throughout the state.

2.2.1 Traffic Operations Center (TOC)

Figure 5 – ADOT TOC

The ADOT TOC operates 24 hours a day and 7 days a week, responding to recurring and non-recurring congestion on state-owned road facilities. A key function of the TOC is to monitor and manage the freeway system in the Phoenix metropolitan region. The FMS also provides central management of the statewide transportation network. The TOC control room, as shown in Figure 5, was renovated in 2012 with funds provided by the MAG RTP, and this renovation included a new and expanded video wall and updated operator workstations. In addition, space within the TOC operations room was re-configured to provide workspace for a public information officer (PIO) and for Arizona Department of Public Safety (AZDPS) officers. More recently, ADOT has included a part-time trained meteorology student in the ADOT TOC, through a partnership program with Arizona State University (ASU) in order to provide meteorologist forecasting of weather activity that may impact the traveling public.

The TOC uses incident notification information to verify the incident, notify the public on freeway DMS with appropriate messages, enter incident restriction information into the Highway Conditions Reporting System (HCRS) for posting on the 511 website and phone service, notify ADOT employees through PageGate, and dispatch the Arizona Local Emergency Response Team (ALERT) or maintenance team if necessary.

Key activities at the TOC include:

- Monitor CCTV, loop detectors and AZDPS computer-aided dispatch for any incidents or abnormal traffic activity on state routes/highways;
- Monitor Google and 511 to support traffic monitoring/surveillance of the metropolitan area;
- Implement advisory or alert messages on DMS boards;
- Coordinate in real-time with responders in the field during incident management and incident clearance;
- Coordinate with partner agencies (city and county arterial management, emergency services, other state and regional/local agencies as needed) during traffic incidents or emergencies;
- Disseminate alerts about crashes, closures or other impacts on the road network; this includes updating 511 when there is a major event; distributing alerts to agency/media email distribution lists; and updating social media (Twitter, Facebook) with alert information as needed;
- Update databases with current closure/restriction information (these databases feed the 511 systems and data/alerts are provided to private sector subscribers); and
- Implement traffic management strategies in response to real-time network conditions, such as incidents, hazards, work zones, special events.

Training is provided to TOC supervisors and operators to cover basic diagnostics of ITS equipment such as DMS and CCTV cameras through software systems (such as Camera Cameleon). As ADOT develops a centralized traffic signal system, TOC Operators are going to be trained to use traffic signals for more proactive traffic management.

2.2.2 Incident Management

The ADOT TOC plays a key role in incident management on the freeways in the MAG Region. With real-time access to the AZDPS computer-aided dispatch (CAD) system, TOC operators can assess traffic incidents and the impacts

that these incidents have on travel conditions. ADOT PIO will provide a press release for any major freeway closures, but ADOT consistently reports on impacts, closures, and other alerts from the ADOT TOC. An ADOT PIO is stationed at the TOC 20 hours a day, seven days a week. ADOT actively uses social media, such as Twitter, Facebook and the ADOT Blog, to disseminate incident notifications statewide; media around the state are followers of the ADOT social media outlets. ADOT also uses a pop-up alert on their website home page when significant incidents occur.

Speed data is used as early detection of unplanned obstructions. CCTV cameras are used (if available) to verify the incident location and impacts. If the road is obstructed DMS will be activated and appropriate field personnel/law enforcement will be dispatched. As unplanned obstructions are reported to 911 call-takers, CCTV cameras are utilized to visually verify incidents, DMS activated, and appropriate field personnel dispatched. By helping law enforcement reduce response time, through verifying the location of incidents on CCTV, obstructions to the road are removed faster, which in turn reduces congestion, emissions and the likelihood of secondary crashes.

In 2014, ADOT and MAG jointly funded a three-year pilot project in a collaborative effort to facilitate greater coordination between the ADOT personnel and AZDPS troopers for efficient Traffic Incident Management (TIM). This effort included locating a DPS trooper at the ADOT TOC, which has significantly increased operational efficiency for both agencies. By locating a DPS trooper in the TOC, ADOT operators no longer must relay information to AZDPS. Instead, ADOT TOC operators and DPS troopers can collaborate to determine the type of resources needed to address an incident. DPS has full use of the CCTV cameras and staffs a console in the TOC control room.

2.2.2.1 Freeway Service Patrol

The Freeway Service Patrol (FSP) Program is operated by AZDPS which patrols the region's highways to assist stranded motorists and eliminate road hazards and distractions that pose safety concerns. This program is fully funded by the MAG RTP through FY 2026. Fully staffed, the FSP primarily supports morning and evening commute times on weekdays, but can be available for weekends as needed based on weekend traffic-generating events.

2.2.2.2 ALERT

ADOT's ALERT is operated by ADOT and is a 24-hour, 7 day a week response team for traffic management and roadway restrictions during incidents involving major crashes, emergencies, or weather-related events along freeways in the Phoenix metro area. The primary purpose of ALERT is to ensure the safety of the public and incident responders in scenarios involving incidents and special events, while also minimizing the delay of travelers. In the event of an incident, law enforcement will determine if assistance from the ALERT team is necessary. If deemed necessary, law enforcement will contact AZDPS dispatch who will then contact ADOT's TOC. Upon notification from DPS, the ADOT TOC will determine which ALERT responders are best suited to respond to the incident based on the incident's location.

2.3 Emerging Technologies

A summary of emerging technologies and applications that ADOT is piloting or is planning to consider are as follows:

- Dynamic ramp metering – Ramp metering has been incorporated as an important technology application as part of FMS deployments region wide. ADOT is in the process of selective implementation of dynamic ramp metering which will apply real-time data collection from detection on the mainline and the ramps to automatically adjust the metering rate of the ramp meter. This type of an application increases throughput on the freeway and surrounding arterial network.
- Active traffic management – New applications for providing dynamic messages to travelers to warn of queues ahead, incidents and slow traffic ahead, and potentially speed reductions have all been considered for implementation. These new kinds of information provided to travelers requires a heightened awareness

of vehicle movement on the freeways and will require additional detection and confirmation equipment. As ADOT nears the completion of its traditional FMS deployment, new or updated applications on the freeway system will be needed.

- Comprehensive freeway software system – ADOT currently operates several disparate software systems to manage the freeway network of FMS infrastructure and traffic signals. With the inclusion of additional detection capabilities and 'big data' potentially coming from connected vehicles, ADOT is considering the introduction of a comprehensive freeway management software system that will be a one-stop shop for operations of the freeway systems.

3 ARTERIAL OPERATIONS AND MANAGEMENT

The MAG region has invested in a vast network of equipment and infrastructure that has been critical to supporting traffic management in the region. The infrastructure deployed for local agencies throughout the region has created the opportunity for agencies to maximize the existing capacity of the roadway network.

A total of 18 responses were received for the 2016 survey, and these represent the cities and towns that have either initiated or have well-established arterial operations. For those agencies that did not respond, many do not own or operate any arterial operations and management infrastructure. It is envisioned that in future years, this number will increase as more of the smaller jurisdictions (populations < 50,000) begin to implement and operate traffic signals, cameras, or detection.

3.1 Traffic Management Centers

There are currently 13 arterial TOCs/TMCs in the region all operating their own infrastructure and arterial networks. There are two TMCs being planned for in the next five years. Figure 6 provides a map of the existing TMCs.

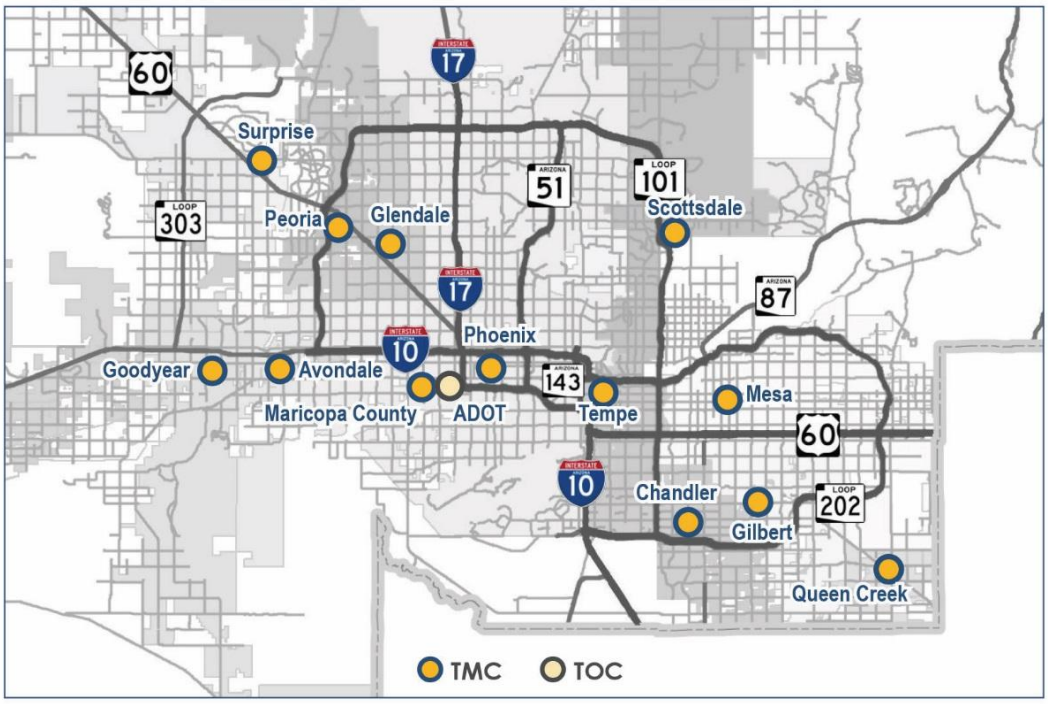


Figure 6 –Metropolitan Area Traffic Management Centers

3.1.1 TMC Staffing

Of the 13 local TMCs for which information was provided:

- One of them is not regularly staffed (where there were not regular hours of operations);
- Two of them are staffed only during peak travel times;
- Two are staffed during only city business hours;
- Six are staffed during city business hours and some additional hours to support planned special events; and
- No local TMCs are staffed 24-hours a day, 7 days a week, although some did provide on-call staffing if necessary.

Eight out of 13 agencies with a TMC reported to have a TMC supervisor or manager while six agencies reported to have TMC operators. All but one TMC in the region is staffed with at least one person who is responsible for TMC operations. In total, 39 staff members were reported who are dedicated to TMCs throughout the region (including TMC managers, TMC operators, and traffic engineers working for TMC functions). The cities of Phoenix, Mesa, and Scottsdale as well as Maricopa County reported over 10 FTE are responsible for TMC/traffic operations in their jurisdictions, with Mesa being the highest at 33 FTE. Additional training was cited as a need for most TMC or traffic engineering personnel.

There are 87.5 full-time equivalent staff (FTE) signal technicians that are employed by the 16 responding agencies. These signal technicians server as responders and maintainers of the ITS infrastructure in the MAG region.

3.1.2 TMC Functions

Every TMC in the region conducts signal operations, CCTV operations, and inter-agency coordination functions as well as planning for traffic management related to special events and work zones. 42% of TMCs coordinate with their local law enforcement during incidents and special events. TMCs primarily use Google and AZ511.com to view web-based traffic maps to show the combination of freeway and arterial speeds (red, yellow, green). Most agencies say that the TMC staff are notified of planned road restrictions in advance so that proactive preparations can be made. Half of TMCs are utilizing the AZTech Regional Information System (ARIS) system (described in the regional section in this document). Only a few agencies are using Inrix or HERE data to view traffic conditions on arterials. All data and functions that are served by each TMC can be shared internally within the jurisdiction's agencies as well as externally with departments outside of each jurisdiction.

Most local traffic management agencies provide information to travelers about the status, events or incidents impacting the arterial network. Nearly all local agencies in the MAG region provide some level of information through city web sites and social media, such as current and upcoming construction, special events and traffic restrictions, or major road closures. Maricopa County is the only agency that reported that the TMC is responsible for social media use. All other agencies reported that PIOs outside of the TMC were responsible for disseminating traveler information via social media. As shown in Figure 7, almost half of agencies in the MAG region provide information via an email alert, which is typically sent to an established distribution list of other agencies, the media and in some cases travelers who have subscribed.

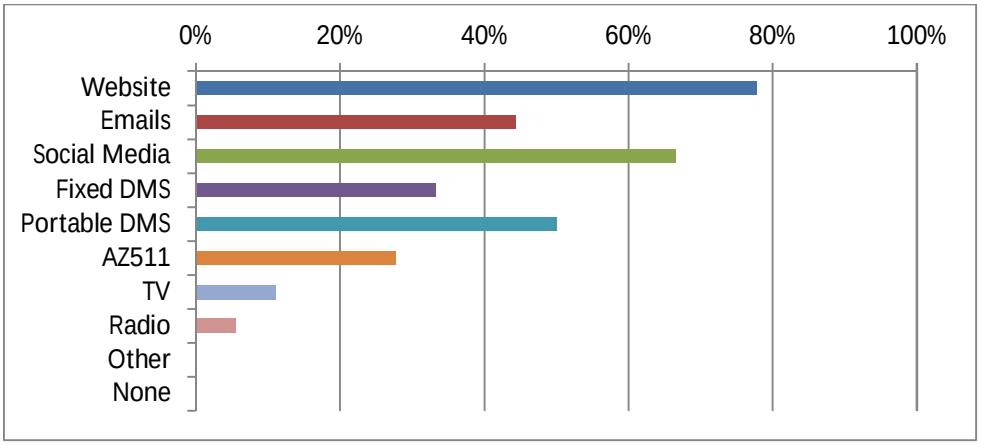


Figure 7 –Percent of Jurisdictions Reporting Using Arterial Traveler Information Dissemination Methods

There is a robust set of TMC operational capabilities in the region and nearly every jurisdiction with a TMC anticipates updates or enhancements to their ITS program and TMC in the next five years. This means additional functions, communications, staff, and regional connectivity.

3.2 Traffic Signal Operations

Traffic signals represent the single largest arterial management and operations strategy in use by agencies in the MAG region. There are more than 3,300 traffic signals in the MAG region, and almost 90% of signals are monitored, controlled, and operated from agency traffic management and operations centers. Some agencies operate traffic signals that are owned by another agency; this primarily occurs with freeway interchanges where traffic signals are owned by the ADOT but operated by the local agency. Figure 8 shows the percent of signals operated from local TMCs.

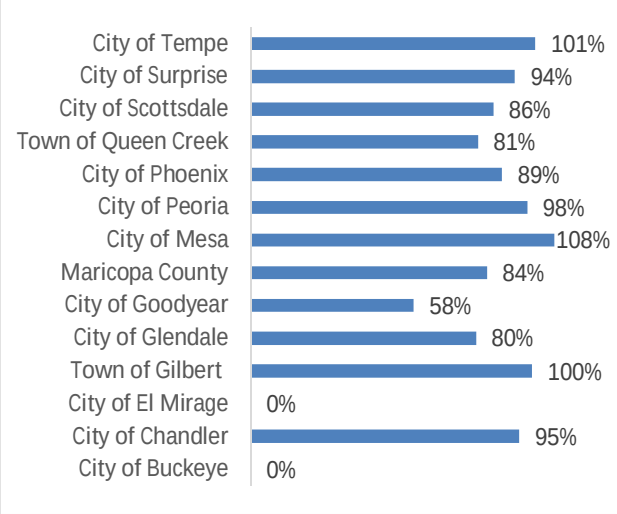


Figure 8 – Percent of Traffic Signals Operated from Local TMC/TOC

Every jurisdiction operates its own central traffic control system: either TransSuite, Centracs, KITS, Tactics, ATMS.now, or MaxView. While most agencies have ASC3 traffic signal controllers, there are some other controller types being used and some will need to be upgraded or replaced.

Local agencies managing traffic in the MAG region are responsible not only for operating signals, but for operating them in a manner that improves overall progression and reduces delay on the arterial network. Traffic signal timing strategies vary by agency and those agencies that reported using a traffic signal timing strategy do not necessarily dismiss the importance of or exclude the use of other strategy types.

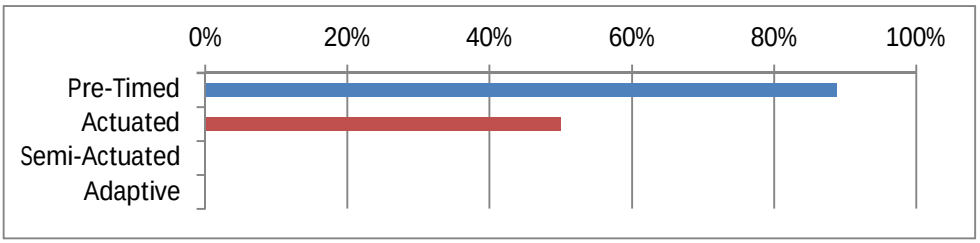


Figure 9 –Percent of Jurisdictions Reported Using Traffic Signal Timing Approaches

As shown in Figure 9, most the agencies in the region utilize coordination by pre-timed and time-of-day approach for their traffic signals although most agencies reported that they typically use a combination of traffic signal operational approaches for their signals. Very few agencies are currently using traffic-responsive or adaptive signal operations strategies as of yet. A large and complex adaptive traffic signal project along Bell Road has been funded by MAG involving seven agencies and three different systems, discussed further in the regional section of this document.

As shown in Figure 10, half of agencies update their traffic signal timing plans on a needs-basis, such as changes in volumes on certain corridors or to accommodate events or activities such as work zones that trigger traffic signal timing updates. Almost 40% of agencies

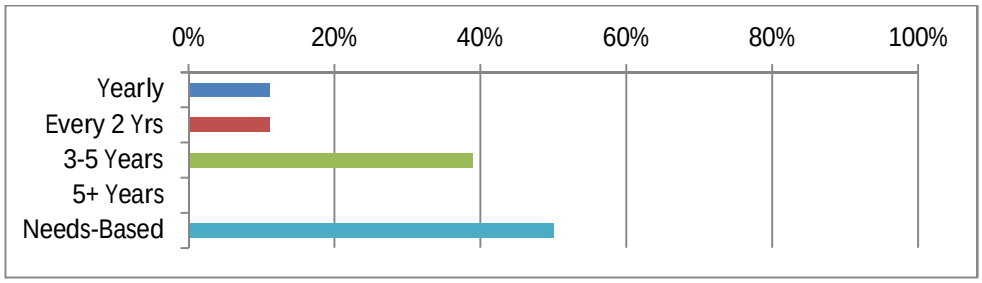


Figure 10 – Percent of Jurisdictions Reporting Frequency of Updates to Traffic Signal Timing

update timing plans every 3-5 years. The agencies Surprise, Goodyear, Gilbert, and Buckeye update their signal timing on a more frequent basis. Nearly 69% of agencies develop their traffic signal timing plans in-house and the rest use contract support to develop their plans.

Agencies use a variety of tools to support updates to their signal timing. Traffic signal timing software (such as Synchro) and engineering judgement are the most popular methods in use in the MAG region, followed by 24-hour traffic counts (mainline volumes). The CCTV camera images, where available, are used in engineering judgement to make more immediate adjustments based on conditions such as incidents or events that cause increased traffic demand.

Most agencies in the region indicated they implement special timing plans for work zones and special events. There has been an increased focus on coordinating traffic signal timing and signal operations on cross-jurisdictional corridors, and more than half of the agencies in the region indicate they coordinate with neighboring jurisdictions on traffic signal timing plans and strategies.

Nearly 59% of traffic signals within the MAG region are equipped with emergency vehicle preemption. There are a limited number of traffic signals currently equipped with priority capability for transit or light rail, but that capability is expected to increase with continued expansion of light rail routes and transit priority routes throughout the Region in the coming years.

3.3 Field Infrastructure and Systems

Local agencies engaged in arterial traffic management in the region often operate different field infrastructure and systems. While there are no standards set in the region for the types of device that should be used for what function of transportation operations, many agencies have leveraged each other's experiences and have chosen the same or similar devices to apply in their jurisdiction. Typically, there are two or three jurisdictions that are willing to be the first deployer of a new type of technology or application, which allows others in the region to monitor its effectiveness to evaluate if they should be using the same technology as well. About half of agencies incorporate lifecycle of their devices in their planning process and because of that planning can focus on replacing ITS devices prior to reaching that end of lifecycle timeframe. This section reviews the technologies in use in the region.

3.3.1 Detection

Agencies reported using five different types of detection at their traffic signals. It was reported that, of the total number of traffic signals in the region:

- 24.7% are equipped with in-pavement detection;
- 29.1% are equipped with video image detection (VID);
- 0.1% are equipped with microwave detection
- 0.4% are equipped with radar detection; and
- 0.1% are equipped with infrared detection.

Most agencies (89%) use some combination of loop detection and VIDs, depending on the type of application required at each intersection and date of original detection installation. The survey indicated that only 26% of traffic signals in the region have in-pavement loop detection or VID, which leaves three-quarters of signalized intersections in the region unmanaged. Half of agencies use radar detection as well, although in very small numbers (12 devices in the entire region). This information is shown in Figure 11.

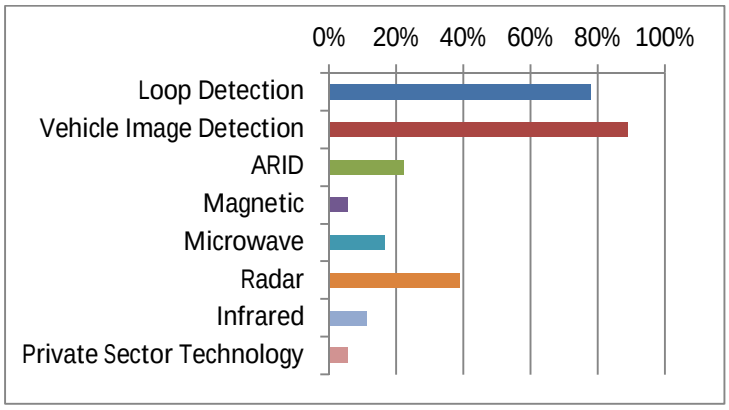


Figure 11 – Percent of Jurisdictions Reporting Detection Technology Used

Stop bar intersection detection is a preferred detection strategy because it provides the most basic signalized intersection data, however, not all agencies have even stop bar detection. Half of all agencies reported also use advanced intersection detection which helps support traffic responsive and adaptive applications.

While 90% of all signals in the region are connected to a TMC, only 33% of agencies indicate that real-time traffic data from detection is sent to the TMC. Those agencies that are collecting real-time traffic data from detection are using that data to monitor transportation system performance in real-time operations as well as in a post-analysis method.

ARID/Bluetooth Detection

Mesa, Tempe, Peoria, Chandler and Gilbert are deploying Anonymous Re-Identification (ARID) detection for use in travel time data collection for real-time operations management. The use of Bluetooth detection is accounted for as a type of ARID device. ARID deployments are relatively new applications that are anticipated to be adopted by more agencies region wide. The ARID detection provides those agencies with continuous travel times that can support before and after evaluations to signal or ITS improvements.

3.3.2 CCTV

Arterial Closed-Circuit Television (CCTV) cameras are an integral component to managing the arterial network. The number of cameras in the region are reported to total nearly 1,100. All agencies that have a TMC also have CCTVs in place that are operated and managed from the TMC during their hours of operation, with exception of a few cameras that are currently establishing connections to their TMCs. Using the RCN, most of those existing CCTV images can be shared with adjacent agencies. An additional 281 CCTV cameras are planned in the next three years, which is a 26% increase in coverage. Major mile-mile intersections across the grid network in the region as well as major roads that provide traffic accessibility through multiple jurisdictions are being focused on for CCTV coverage. A City of Phoenix CCTV camera is shown in Figure 12.

Figure 12 – City of Phoenix CCTV Camera

A few agencies in the region utilize VID detection for the camera images they provide rather than deploying CCTV at major intersections even though there is no pan, tilt, or zoom capability with VID technology. A few agencies provide their city's police departments or fire departments with access to view and control CCTV images as warranted through established agreements.

Camera Cameleon in the region was facilitated through an ADOT contract. The software provides agencies with the ability to control CCTV's owned by their jurisdiction, while also enabling agency access to CCTV cameras owned by partner agencies throughout the region. Over time, the deployment of new CCTV and DMS technologies have made it difficult for some agencies using Camera Cameleon to continue to update their systems and they are increasingly recognizing the camera control software Luxriot supported by MAG, as a cost-effective and user-friendly alternative. Most agencies utilize some combination of Camera Cameleon for their own local device control and Luxriot for their inter-agency sharing of camera images.

3.3.3 Arterial DMS

Arterial DMS, both permanent and portable, are a way for agencies to provide real-time or planned event information to travelers who are already en-route. The most common types of information displayed include construction/work zone information or planned special event information (such as restrictions, event notifications or parking guidance). These signs are also used to warn travelers of incidents or emergency conditions. Two agencies, City of Chandler and Maricopa County, provide arterial travel times using DMS.

Figure 13 – City of Chandler Dynamic Message Sign

Nine arterial agencies in the region have reported owning a total of 69 permanent DMS and have 23 planned permanent DMS. The reported DMS are generally located on major corridors that may cross into neighboring jurisdictions or may be a detour route for a freeway. A City of Chandler DMS is shown in Figure 13. There are currently 53 portable DMS used for special circumstances such as work zone or special event management. Skyline and Daktronics are the only two providers of DMS in the region. Most agencies in the MAG region indicated that fixed and portable DMS are used to support traveler information including special event management and construction/work zone management.

59% of arterial DMS in the region are connected and remotely controlled by a local TMC, and eight agencies have 100% connectivity to their permanent arterial DMS. Agencies throughout the region have primarily used Camera Cameleon to operate their DMS, though a substantial number of agencies have also used other software such as Skyline. Through Camera Cameleon, agencies can post messages on other agency DMS signs when granted permission, while maintaining priority control over their own DMS signs. Each partner jurisdiction is responsible for maintaining their own DMS system and control software, in addition to the DMS interface to the Camera Cameleon system. The DMS guidelines established for local agencies in the region identify procedures for interagency posting of messages on DMS signs and identify the types of messages that are appropriate for DMS locations. An example of this is the Bell Road corridor, where Maricopa County can control the City of Surprise DMS.

3.3.4 Communications

To properly operate and manage an arterial ITS network, communications are required to each device in physical or wireless form. Agencies in the MAG Region prefer the deployment of fiber optic cable where feasible and resort to wireless device deployment if needed. There is 770 miles of fiber optic cable installed to connect arterial ITS infrastructure. Where fiber cable cannot be reached due to physical or financial constraints, there are 486 wireless devices, two cellular devices, and 48 miles of leased lines. Tempe connects half of their existing traffic signal network with leased lines and is in the process of transitioning out leased lines for wireless and fiber communications.

All agencies that have a TMC also coordinate from the same department the ownership and maintenance responsibility of the communications network. Only in the rare case is the information technology (IT) department or the maintenance department responsible for maintenance.

As noted in the freeway section, the freeway fiber network is leveraged by Phoenix, Glendale, Peoria, and Mesa where the local agency utilizes freeway fiber infrastructure and in some cases just the conduit infrastructure to connect to different parts of their own cities. This is managed through fiber and conduit sharing agreements between ADOT and the local agencies.

MAG continues to look for opportunities to expand RCN connectivity to additional agencies. Even agencies without a TMC can benefit from access to neighboring agency cameras to facilitate incident clearance and public safety coordination. Connectivity also provides opportunities for management of signal and sign operations by a neighboring agency with a TMC.

3.4 Arterial Funding

Nine of the 13 TMCs were constructed with Congestion Mitigation and Air Quality (CMAQ) funds provided through the MAG Transportation Improvement Program (TIP) (with local match funding requirements) and four of the TMCs were constructed using only local funds. All TMCs are operated and maintained using local funding. Generally, the agencies that originally constructed their TMC utilizing MAG TIP funding also have upgraded their TMC through the same process. Agency budgets for TMC operations and ITS device maintenance (not including traffic signals) varies by agency and ranges from $50,000 and $675,000 per year.

Local agencies have utilized federal CMAQ funding through the MAG TIP and local funds to procure their signal systems. Only three of the local agencies surveyed only use one source for funding to support the capital cost of their ITS infrastructure, either CMAQ or local funds; the rest of agencies utilize both funding sources to procure their ITS infrastructure.

3.5 Emerging Technologies

Traditional ITS technologies such as cameras, CCTV cameras, arterial DMS, and loop detection deployed in the region are consistent and reliable for agencies to operate. As implementation of these traditional technologies advances within a jurisdiction that the network can be monitored adequately, many agencies are choosing to pilot or test newer technologies to support operations. A summary of emerging technologies that agencies are beginning to pilot or are planning to pilot are as follows:

- New types of detection – Traditional loop and stop bar detection, while serving its purpose well, are limited in functionality for other types of applications or data collection. There are numerous cities in the region that are piloting Bluetooth technology for obtaining travel time data along corridors to understand where congestion or incidents may be occurring that is impacting traveler speeds. Wi-Fi detection has not been piloted in this region yet, although the private sector is approaching agencies to test on this region's network. Video detection is continuing to transition to 360-degree viewing, automatic data collection, machine-vision processing, and a myriad of other applications that may replace the traditional CCTV camera.
- Adaptive signals – The cities of Peoria and Mesa have implemented adaptive signal technology along specific corridors in their jurisdictions. The adaptive traffic signal application is intentionally applied to areas that experience consistently high and variable volumes that do not lend well toward time-of-day or actuated traffic signal timing plans. Bell Road is a corridor that spans multiple jurisdictions and is receiving four segments of adaptive signal control systems that will demonstrate that disparate adaptive systems in each region can work together to facilitate traffic movement across jurisdictions. Evaluations of existing adaptive systems will show application considerations for other agencies interested in pursuing such systems.

- Integrated corridor management – Integrated corridor management (ICM) has helped to elevate the importance of freeway-arterial coordination and identify gaps in corridor signal management capabilities, as well as foster improved collaboration between ADOT and local agencies. Several ICM efforts in freeway corridors on Loop 101, US 60 and I-10 are providing good lessons learned. As part of the nationally recognized I-10 ICM planning effort involving MAG, the City of Phoenix and ADOT, a regional ICM strategy is in development. This could be beneficial to help guide ICM planning efforts on other freeway corridors and to establish a consistent approach including analysis, modeling and simulation, use of performance measures, and consistent approach to agreements needed for ICM.

Many agencies in the region are becoming more comfortable with piloting new technologies and sharing lessons learned with others to help the decision-making process for it to use that technology in their jurisdiction. This leveraging of information and resources over time saves the region time and funds.

3.6 Arterial Technology Utilization

Effective implementation and use of an ITS system can produce multiple benefits to a transportation network, such as reduced travel times, vehicle delay/wait times, and crashes. Many of these benefits have been quantified by DOTs and researchers for applications around the country. For the local agencies in the MAG region, quantifiable benefits or costs have not been well documented nor are they consistent from agency to agency. Some agencies, such as the City of Chandler, have established travel time study activities that occur on an annual basis that evaluate level of service and travel times along major corridors. Other agencies participate in travel time studies as needed through signal optimization projects. MAG incorporates before and after studies as part of some Traffic Signal Optimization Program (TSOP) projects for signal optimization into each fiscal year of funding. A benefit/cost analysis for a 2016 TSOP project for the I-17 Signal Timing Project along Indian School Road and Camelback Road cite the following benefits:

- $6.2 million annual savings in travel time for the traveling public.
- $72,460 project cost executed over a period of 3 months
- Project benefit-to-cost ratio of 86:1

The cost of some components of agency ITS programs was provided in traffic/signal operations, signal system maintenance, TMC operations, and ITS device maintenance categories. The total cost for agency ITS programs, inclusive of all of those components listed above, fell within a range of $800 - $8,000 per ITS device (ITS device is calculated by adding total number of signals + total CCTV + total DMS + number of miles of fiber maintained). Considering that half of responding agencies indicated that they factor in lifecycle timeframes into device maintenance needs, it is important for these agencies to track the costs associated with their ITS programs to be able to plan for lifecycle costing appropriately.

The benefits that have been accrued for using specific technologies within the local jurisdictions has not been well documented thus far to be able to quantify the potential return on investment. There is an opportunity in the region to be able to document performance metrics to quantify investments and their benefits to the traveling public, if benefit/cost and return on investment is a desired activity.

4 REGIONAL CONCEPT OF OPERATIONS

Agency data sources have played a critical role in enhancing traffic operations and management throughout the MAG region, in addition to facilitating improved coordination between various agencies. There have also been several innovative strategies implemented throughout the region that have played a significant role in improving both recurring and non-recurring regional operations and management. These strategies have placed a significant amount of emphasis taking multi-agency approaches to managing traffic congestion, incidents, and other events. The combination of the data systems made available to various agencies throughout the region and the implementation of these traffic management strategies has facilitated greater regional coordination and has enabled agencies to enhance traffic operations and management throughout the region.

This section serves to summarize regional systems and processes that involve the freeway and arterial agencies in their management and operations of the transportation network. Figures 14-16 provide high-level overviews of regional operations/connectivity of agencies to regional functions and tools as they relate to normal day-to-day conditions (where no incident is present), a freeway incident, and an arterial incident. It is important in this context to view the 'network' as a whole rather than as freeways or arterials because drivers use a combination of routes to travel to their destination and require (or expect) that the network function together. Work zone restrictions typically function as planned events because the traffic can be managed through an existing work zone. It is the unplanned, unexpected incident that restricts lane use and travel patterns that can throw network mobility off, which is why incidents are being focused on in this context to describe regional operations.

During normal conditions, as shown in Figure 14, transportation departments and public safety departments are monitoring activity on the freeway and arterial networks but have limited engagement because traffic conditions run smoothly with no incident or work zone present. Typical congestion during peak periods are monitored, but no alerting, messaging, or response is needed. Agencies feed data into the Regional Archived Data Server (RADS) continuously during normal conditions.

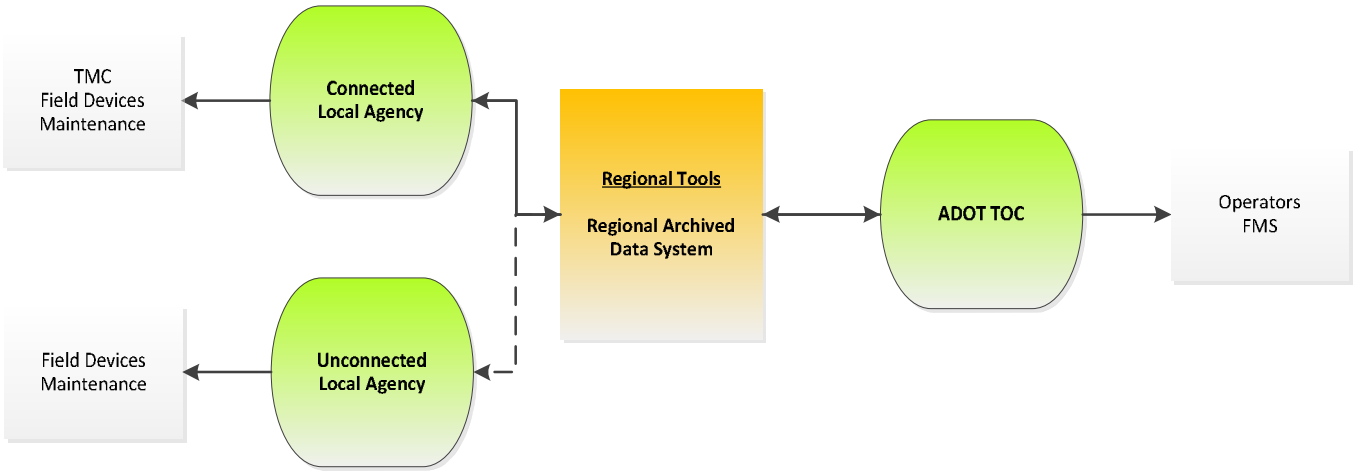


Figure 14 – Regional Operations/Connectivity During Normal Conditions

During a freeway incident, agencies that respond to freeways (ADOT and AZDPS) are active in managing, responding to, and clearing the incident. Arterial agencies are impacted if drivers detour onto arterials to avoid the freeway incident. The use of regional tools and functions support freeway/arterial coordination during these instances, although the dashed lines indicate opportunities for improvement in coordination. Figure 15 describes existing operations during freeway incidents.

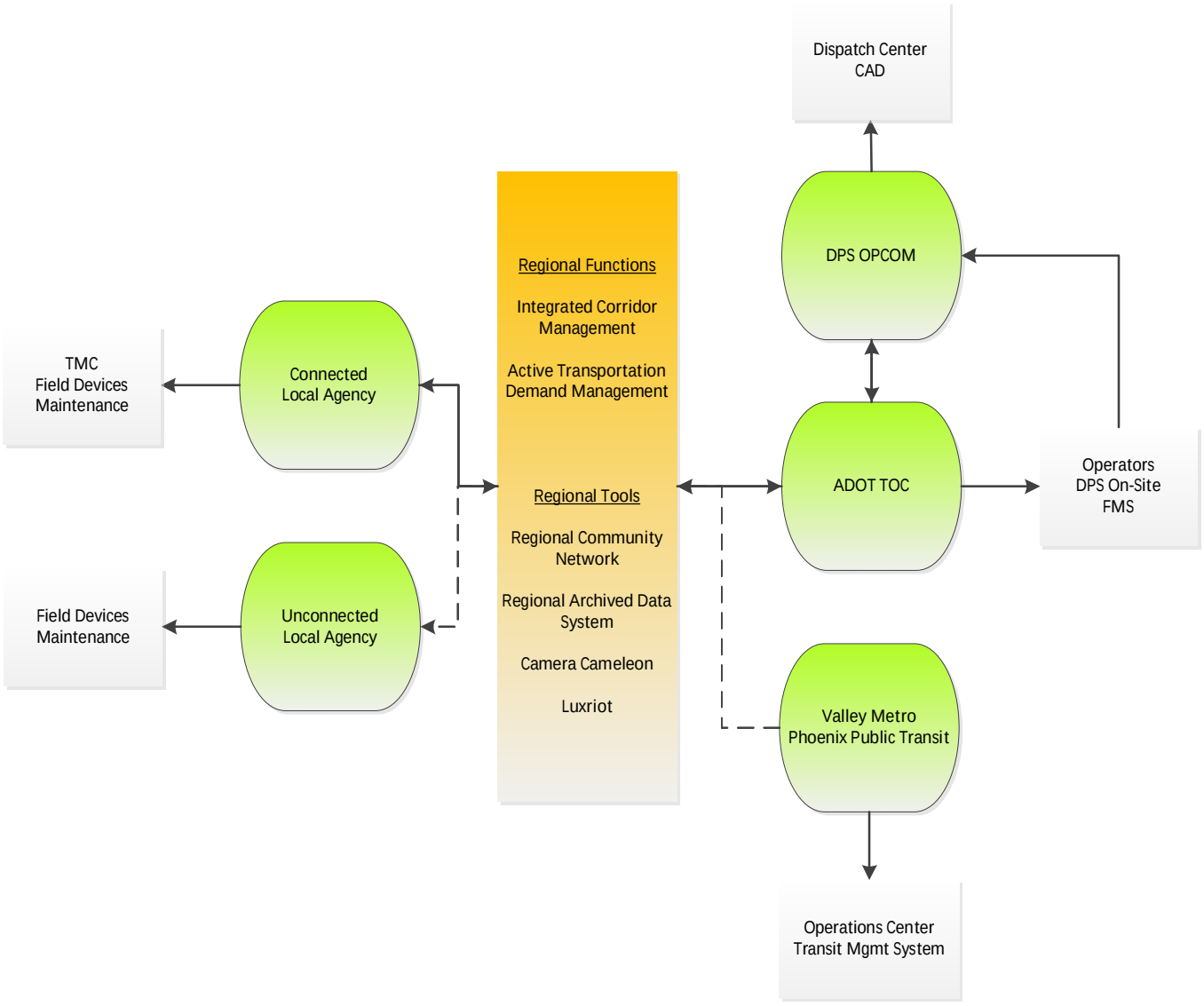


Figure 15 – Regional Operations/Connectivity During A Freeway Incident

During an arterial incident, arterial agencies coordinate as required including transportation and public safety departments within a single jurisdiction as well as across jurisdictional boundaries depending on where the incident occurs. If the incident occurs in proximity to a freeway, ADOT will be able to monitor conditions on the freeways as created by the arterial incident. Figure 16 describes this existing operations during an arterial incident.

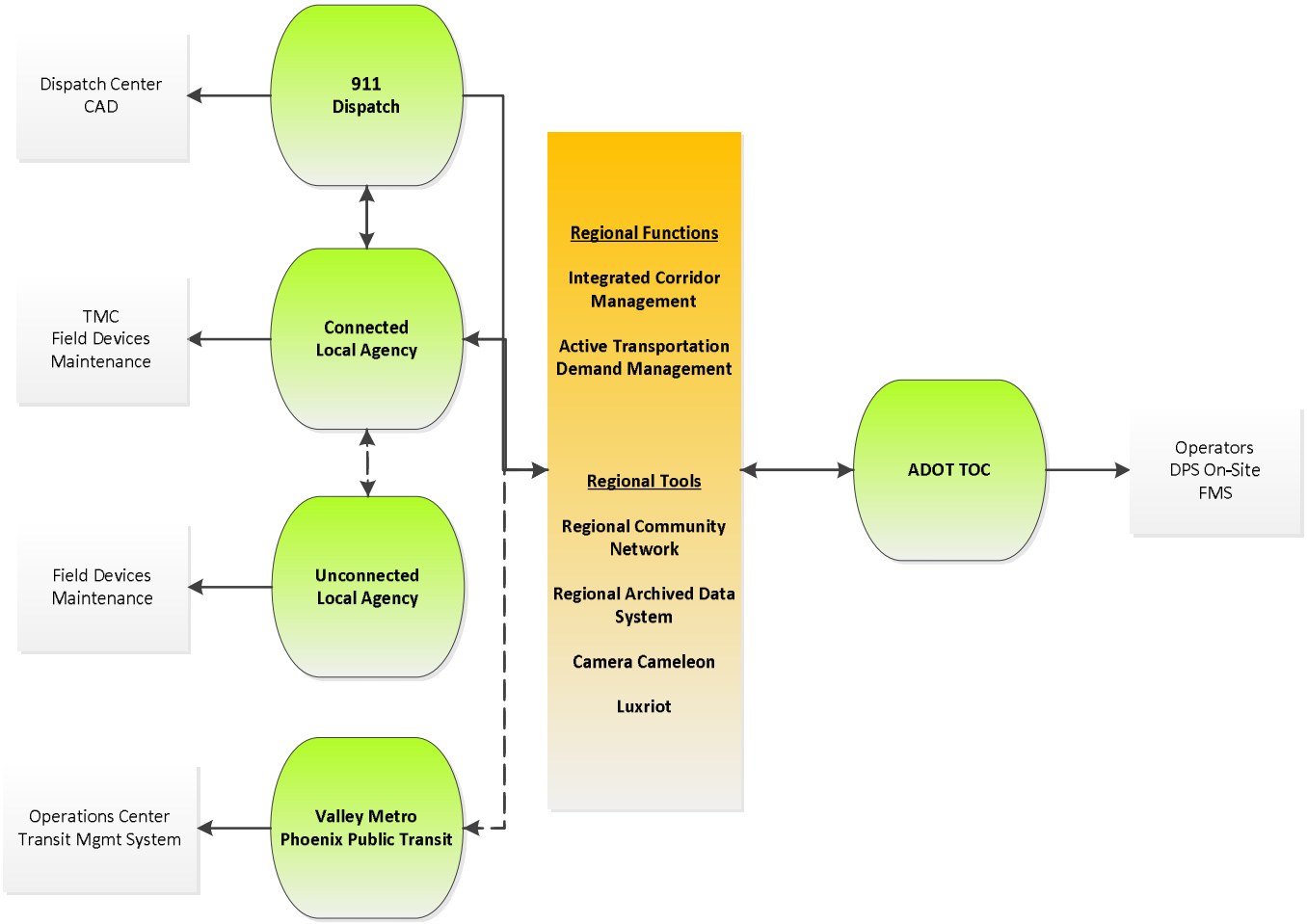


Figure 16 – Regional Operations/Connectivity During An Arterial Incident

The following sections describe regional systems, functions, and tools in more detail that are used by agencies in the MAG region.

4.1 Regional Systems for Operations and Management

The institutional partnerships that have been established for many years in the MAG region have created several regional systems that are being used for collaboration on cross-jurisdictional corridors and real-time condition reporting on those corridors. There are advancements being made in each of the regional systems that will provide additional functionality. The agency use of regional systems is reflected in Figure 17.

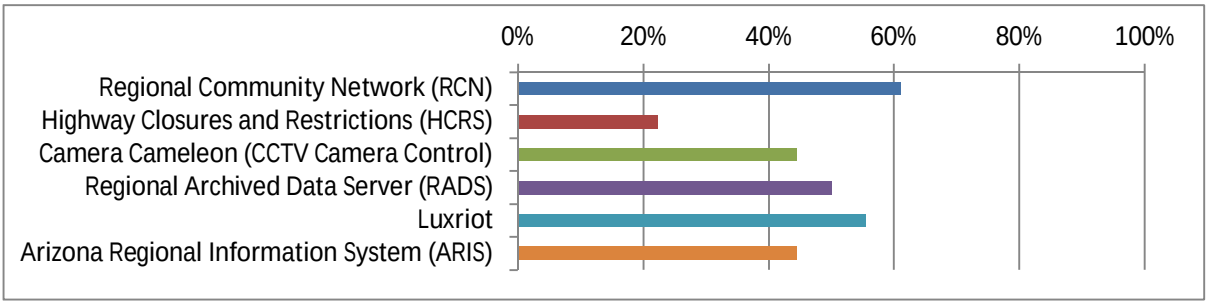


Figure 17 – Percent of Jurisdictions Reporting Regional System Use by Agencies

4.1.1 Regional Community Network

The MAG region contains a vast network of data systems, some of which have been made available to jurisdictions that are linked to the RCN. The RCN provides the communications infrastructure necessary to interconnect numerous transportation and public safety centers (such as police or fire). Throughout the region to improve traffic management, public safety, and incident response. The RCN enables agencies to share CCTV video, detector data, and a variety of other types of data through a high speed optical fiber-based communication system. The RCN consists of the conduit, fiber optic cable, routers, switches, and other communications hardware that provides a path between network nodes. The network is widely considered the region's communication backbone, supporting interagency congestion mitigation efforts, and reducing costs by providing an additional fiber communications path for shared use. A total of 14 TMCs, including ADOT, are connected to RCN. The eventual goal would be to connect all MAG member agencies as infrastructure becomes available. The system has played a significant role in reducing the number of jurisdictional barriers and enhancing coordination between agencies.

The RCN Working Group develops recommendations for the management of the RCN and its future expansion. All recommendations for RCN expansion, modification or repair that require funding are carried forward through the MAG approval process jointly sponsored by the MAG ITS Committee and the Technology Advisory Group (TAG). No-cost changes may be approved by the ITS/TAG committees on the recommendation of the Working Group.

4.1.2 Highway Conditions Reporting System

The ADOT HCRS is the main repository for traffic data from field devices as well for information on lane closures and work zones. The HCRS enables multiple agencies to share information regarding planned lane closures, special events, incidents, and other advisories. It is from HCRS that the state's 511 traveler information system (5-1-1 telephone and AZ511.gov website) and other forms of traveler information systems are populated. Detector data is automatically populated into HCRS to support the AZ511.gov website red, yellow, green representation along corridors of current travel speed.

4.1.3 Regional Archived Data System

The AZTech RADS is an ITS data archive, funded by the MAG RTP, for the transportation system in the Phoenix metro area that is integrated into many partner agency systems in the region. RADS archives operational data in a

centralized server and then makes the data available to users through a web-based interface. Data from RADS is included in the ADOT HCRS which is then used to populate the region's 511 system. The three main components of RADS consist of freeway and arterial data, public safety data, and traffic signal data. Local agencies are linked to RADS to provide traffic signal timing data. Travel times that are displayed on ADOT DMS are calculated in RADS using ADOT FMS data. RADS also includes data from the Phoenix Fire Department's CAD system, which provides filtered incident data from emergency dispatch and 911 calls.

4.1.4 AZTech Regional Information System

The AZTech ARIS was initiated in 2014 as a Phoenix metro area ITS tool that supports traffic management during incidents. ARIS automatically assimilates a range of useful information related to an incident and presents the information in a web-based "tactical screen" that is emailed or texted to the user for ease of use and accessibility. Information includes a map identifying the incident location, speed (and trend) of the nearby freeway traffic detector stations, DMS and message being displayed, and CCTV cameras with snapshots. ARIS also provides charts (histograms) of nearby freeway detector stations showing both the speed and volume distributions since the time of incident.

ARIS is closely integrated with RADS and was developed and deployed to improve the usefulness of RADS data related to incident monitoring and notification. ARIS has proven to be an effective tool for coordinating incident management with multiple agencies. A total of 35 clients representing more than 10 agencies and organizations are currently registered to receive real-time notifications. ARIS generates over 900 notifications per day which represents an average of 18 closures, 200 lane restrictions, and 60 maintenance events on a typical day.

4.2 Regional Signal Coordination

4.2.1 Traffic Signal Optimization Program

For local agencies and for arterial operations, the top priority is traffic signal operations. Improving the coordination, timing, and overall operations has shown significant return-on-investment in the form of increased throughput, reduced stops, and reduced delay. Many agencies in the Valley rely on MAG's TSOP to provide the funding and support to improve key corridors in their jurisdictions. Some agencies have capabilities in-house to do traffic signal timing assessments and improvements, and the TSOP program helps provide external consultant support for data collection, timing strategies and implementation support.

Various agencies throughout the region have made several efforts to address issues with recurring congestion. MAG's TSOP has been a catalyst for these efforts by providing funding and assistance for projects that aim to optimize traffic signal timing to reduce congestion. In addition, there have been collaborative efforts made by various jurisdictions to improve traffic operations and management along shared corridors.

In 2004, MAG developed the TSOP program which provides funding to agencies to update and coordinate traffic signal timing on key corridors. In addition, MAG provides training on the Synchro signal analysis software for partner agencies through the TSOP. TSOP project applications are evaluated by the MAG ITS Committee and supported by MAG staff. From 2004 to 2015, $2,689,498 was used to fund 112 projects. There are four types of projects that are eligible for the TSOP program:

- Regional ICM project involving signal optimization: These projects are developed collaboratively between two or more agencies, and consider updated signal timing plans required for arterial detouring on parallel arterials to improve traffic management during a freeway incident. These projects involve data collection, analysis/modeling to develop new signal timing, and field implementation.
- Single/multi-agency signal timing projects: Agencies are only permitted to submit one single-agency TSOP project, however, agencies are permitted to submit an unlimited number of multi-agency TSOP projects. In

addition, single agency projects cannot exceed $30,000 and multi-agency projects can be funded up to $60,000.

- Single-agency traffic data collection projects: Agencies can submit applications for data collection projects that can last up to a maximum of four months. All traffic data collection projects must include before-and-after evaluations using the MAG methodology for travel time comparison, which can be carried out by a consultant. Before-and-after studies assess the travel time, number of stops, and travel speed for the coordinated phases before and after the implementation of the project.
- SYCHRO network development projects: These projects involve the development of SYNCHRO networks for an agency's signal system.

4.2.2 Coordinated Arterial Signal Operations

Operating traffic signals is a critical agency function that requires a significant amount of agency staff time and resources. Most agencies in the region strive to continually improve their signal operations by improving their ability to remotely monitor and control them. Agencies have also been striving to provide more advanced signal operations to improve the performance and efficiency of signalized intersections, including adaptive or responsive signal timing as well as collection of data and performance measures to assess the performance of signal operations. Traffic signal controllers are the key component to achieving success in any of these areas as they provide the central intelligence for the signal operations.

All partners agree that signal timing, operations, and maintenance is an owning-agency responsibility. This includes signal timing updates, coordination with other jurisdictions as needed, and funding to support ongoing operations of signals. Half of agencies report that it is standard practice within their jurisdiction to conduct before and after studies of traffic signal improvements, which provides a baseline for how improvements are impacting travelers.

Non-recurring congestion is a focus for local agencies because even the smallest incident or work zone can have a detrimental impact to a large section of the network. Agencies typically coordinate together on a management strategy that will successfully achieve the most efficient traffic movement along a major corridor that crosses multiple jurisdictions, particularly prior to a special event or work zone. In response to an incident, the jurisdiction in which the incident occurs shall inform partner agencies of the need for timing changes and they work together until the incident has cleared and signals have been returned to normal operating conditions.

To reduce congestion along Bell Road, the cities of Surprise, Peoria, Glendale, Phoenix, and Scottsdale along with Maricopa County worked together to develop a Concept of Operations and System Requirements to implement adaptive traffic control for four different segments along Bell Road. Adaptive signal operations are being implemented along this corridor in order to provide adaptive response to changing traffic conditions particularly at freeway intersection locations and also to demonstrate multi-jurisdictional coordination of adaptive systems.

4.3 Regional Operations and Management Processes

The MAG region has placed a considerable amount of emphasis on addressing non-recurring issues with traffic operations and management. The efforts made have required a significant amount of coordination between various agencies and jurisdictions, and have enabled agencies to establish a number of procedures for coping with various incidents and events that inconvenience travelers.

4.3.1 Traffic Incident Management

The region's TIM Coalition is a multi-disciplinary partnership lead by DPS that includes local and state transportation agencies, MAG, fire agencies, local and state police, and towing companies. The TIM Coalition, which was established in 2010, provides TIM training to all first responders throughout the state and has made significant strides in improving clearance time for incidents and other blockages on the roadway.

Maricopa County's Regional Emergency Action Coordinating Team (REACT) serves as the response team for arterial incidents in some local jurisdictions within Maricopa County. There are currently two response teams (East Valley and West Valley) that consist of trained staff that are available to respond to incidents 24 hours a day 365 days a year. REACT provides traffic control and assistance during incident response and recovery. REACT responds to incidents on Maricopa County roadways in unincorporated areas, but they also respond to incidents on arterial roads through the establishment of an agreement with an agency. There are currently agreements in place with seven agencies where REACT provides services, including ADOT, Glendale, Peoria, Avondale, Scottsdale, Salt River Pima-Maricopa Indian Community and Phoenix.

Phoenix Fire is responsible for dispatching local fire and emergency medical dispatching services for 23 jurisdictions in the Phoenix metro area. The Mesa Police Department operates a Mesa 911 Dispatch Center which provides emergency dispatch services for an additional four agencies in the east valley. Because the Phoenix Fire Department's Regional Dispatch Center and Mesa 911 Dispatch Center is considered a "secondary answering point," after the local law enforcement agency, or the "primary answering point," determines that an emergency requires fire and/or medical services, the dispatch center is responsible for confirming the location of the emergency, the phone number, and the nature of the emergency before conveying the information into the CAD system. Phoenix Fire operators are in constant communication with the responders from the moment that the incident is received and acknowledged to the moment the incident reaches its conclusion. Coordination between fire/police response to an incident and transportation departments is important for effective traffic incident management.

4.3.2 Integrated Corridor Management

ICM has been identified as an important priority in the MAG region. ICM will facilitate the proactive management of traffic during recurring and non-recurring congestion along select key corridors. The region has deployed completed ICM projects:

- I-10 ICM through West Phoenix from Loop 101 to I-17 – ADOT and Phoenix are currently in the process of implementing the solutions identified in the "Playbook" developed as part of that project that addresses traffic signal strategies for all possible freeway closure scenarios in this corridor at all times of the day.
- Loop 101 ICM through Scottsdale – This effort leveraged many years of pioneering work by staff at the City of Scottsdale and includes traffic management protocols between operating and responding agencies to safely detour freeway traffic to preferred alternate routes, and maximizes the dense ITS network on Scottsdale arterials. Following this plan, Phoenix and ADOT identified preferred alternate routes for the northern portion of Loop 101.
- US-60 through City of Tempe – This project identified parallel detour routes for travelers to take during major freeway incident/closure and developed signal timing plans for those routes to facilitate faster movement of traffic during the detours. The signal timing plans have been implemented.
- US-60 through City of Mesa in partnership with Town of Gilbert – This project identified parallel detour routes for travelers to take during major freeway incident/closure and developed signal timing plans for those routes to facilitate faster movement of traffic during the detours.

In 2015, MAG was awarded a federal grant to conduct an ICM Development Planning Study along the I-10 corridor through the heart of the region. In December of 2015, the first phase of the project was completed through the development a Project Management Plan and a Systems Engineering Management Plan, which document foundational aspects of the ICM planning process that will guide the project through later development stages.

4.3.3 Regional Special Event Planning

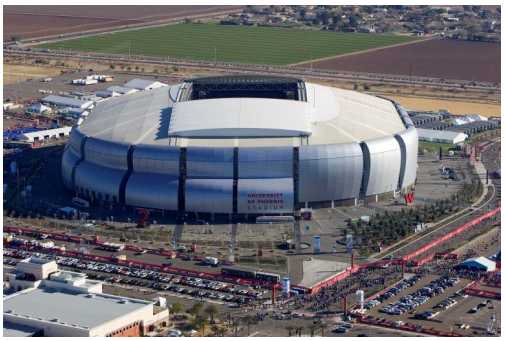


Figure 18 – University of Phoenix Stadium in the City of Glendale

The MAG region is home to a variety of attractions and venues that attract large-scale events and subsequently generate significant traffic when these events take place. Several recent national events have required coordination between multiple agencies throughout the region. The 2015 Super Bowl, which was held in Glendale at the University of Phoenix Stadium shown in Figure 18, required coordination between the City of Glendale, ADOT, Maricopa County, and the City of Phoenix to effectively manage the amount of traffic generated because of the event. The Glendale TMC was staffed with additional ADOT personnel to assist in managing the I-10 and Loop 101 freeways. ADOT ALERT, AZDPS, and Maricopa County REACT were available on-site for traffic and incident management purposes. Several events held in downtown Phoenix related to the Super Bowl required significant input and cooperation from multiple divisions within the City of Phoenix. Overall, the method improved collaboration between agencies and established a procedure for managing traffic the following year when Glendale hosted the 2016 College Football National Championship. Using the RCN, the agencies also provided traffic camera access to the Multi Agency Coordination Center. This allowed emergency responders to better coordinate incident response and enhance public safety on and off the transportation system.

In addition to nationally recognized events, several cities have developed strategies to cope with the impacts of traffic generated from more locally and regionally significant events. The City of Glendale has developed a set of signal timing plans specifically for events at the Arizona Cardinals stadium, which is based on historical Police control at intersections. The City of Glendale also collects data during ingress and egress for every large event for post-analysis purposes. In 2014, the City of Tempe Transportation Management Group, in coordination with Tempe and ASU Police departments, began working towards providing special event traffic signal management for ASU football games. This effort resulted in the staffing of the Tempe TMC for special events, special signal timing for 25 signals, and improved traffic flow during special events. The City of Chandler's TMC retimed 82 signalized intersections and developed four plans per intersection to respond to traffic impacts generated from special events. The City of Scottsdale TMC has a total of 96 signal timing plans available, 92 of which are used for managing special events and traffic incidents.

5 COMPARISON TO THE 2011 SURVEY

The 2016 results that have been presented in this report provide an update of a similar survey completed by partner agencies in 2011. This section provides a comparison of the results of the two surveys and discusses the observations that can be derived.

Traffic Signals

There are more traffic signals deployed in the region as compared to what was reported in 2011, and there is a much higher percentage of traffic signals that are connected to a central system. Table 1 shows the comparison of the number of signals that were reported to be connected to and operated from the TMC by agency.

Table 1 – Comparison of Agency Signal Ownership and Connectivity (2011 to 2016)

Jurisdiction/Agency	# of signals owned (2016)	# of signals operated from TMC (2016)	# of signals owned (2011)	# of signals operated from TMC (2011)
City of Buckeye	20	0	10	0
City of Chandler	218	208	199	187
City of El Mirage	12	N/A	-	-
Town of Gilbert	188	188	174	167
City of Glendale	201	161	193	130
City of Goodyear	88	51	74	18
Maricopa County	143	120	154	93
City of Mesa	422	455	379	404
City of Peoria	118	116	108	105
City of Phoenix	1120	1000	1092	615
City of Scottsdale	290	250	301	280
City of Surprise	49	46	41	25
City of Tempe	206	208	221	199
Pinal County Public Works	29	0	-	
City of Tolleson	13	0	-	
City of Maricopa	15	0	-	
Total	3132	2803	2946	2223

ITS Devices and Communications

In addition to the increase in the number of traffic signals on the regional transportation network, the 2016 survey showed that the deployment of ITS devices in general has skyrocketed from their 2011 levels. Table 2 shows the comparison in the number of CCTVs and arterial DMS that were reported by agencies in 2011 and 2016. The total number of CCTVs reported in the region has increased by 177% since 2011.

Table 2 – Comparison of Agency CCTV Device Deployment (2011 to 2016)

Jurisdiction / Agency	Number of Arterial CCTV Owned (2016)	Number of Arterial CCTV Owned (2011)
City of Chandler	800	300+
Town of Gilbert	95	45
City of Glendale	116	93
City of Goodyear	53	15
Maricopa County	61	42
City of Mesa	191	112
City of Peoria	62	29
City of Phoenix	200	12
City of Scottsdale	120	83
City of Surprise	47	24
City of Tempe	87	7
Total	1032 (+117% than 2011)	475

As compared with the drastic increase in the number of arterial CCTV cameras, there were mixed responses related to the number of arterial DMS. While the overall number of agency-owned DMS has increased since 2011, there are some agencies that reported having fewer arterial DMS in their network in 2016 than in 2011, as shown in Table 3.

Table 3 – Comparison of Agency Arterial DMS Deployment (2011 to 2016)

Jurisdiction / Agency	# of Permanent Arterial DMS Owned (2016)	# of Permanent Arterial DMS Owned (2011)
City of Chandler	3	3
Town of Gilbert	2	2
City of Glendale	13	8
City of Goodyear	2	0
Maricopa County	3	0
City of Mesa	2	2
City of Peoria	0	2
City of Phoenix	10	2
City of Scottsdale	28	35
City of Surprise	8	6
City of Tempe	0	0
Total	71 (+18% than 2011)	60

Table 4 provides a comparison of the number of miles of fiber that are owned by agencies in the region and that is for transportation use. There amount of fiber to provide communications connectivity within the region has almost doubled since 2011.

Table 4 – Comparison of Miles of Fiber Reported by Agency (2011 to 2016)

Jurisdiction / Agency	# of Miles of Fiber Owned (2016)	# of Miles of Fiber Owned (2011)
City of Chandler	85	57
Town of Gilbert	57	29
City of Glendale	110	62
City of Goodyear	36	20
Maricopa County	45	12
City of Mesa	80	150
City of Peoria	50	70
City of Phoenix	100	70
City of Scottsdale	170	85
City of Surprise	24	18
City of Tempe	2	0
Total	769 (+47% from 2011)	539

Arterial Traveler Information

Methods for disseminating traveling information has been revolutionized in recent years with the emergence of social media and other methods of connecting with the public that have been led by the private sector. Figure 19 provides a comparison of the methods that agencies report using disseminate information to travelers about the transportation network. The graph shows a huge increase in the number of agencies that use social media, while there was a decrease in the number of agencies that reported using methods such as websites, emails and arterial DMS.

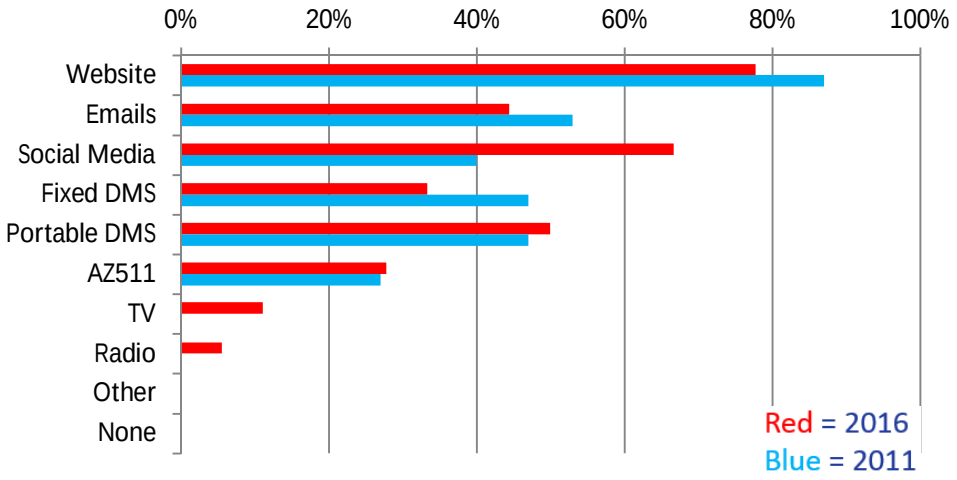


Figure 19 – Percent of Agencies that Reported Using Methods for Traveler Information Dissemination

Regional Systems

Since the 2011 survey, new regional systems have been developed and deployed to support transportation operations and management at agencies in the region. Two examples of these newer systems are the ARIS and the Luxriot video management system. Luxriot has recently become available to agencies to improve CCTV video sharing between agencies and is an alternative to the Camera Cameleon video management system. Because of this, there is a reduction in the number of agencies who report using Camera Cameleon as a camera management system from 2011, shown in Figure 20. Another significant observation in the figure is the dramatic increase in the use of the RCN. There has been significant investment in the expansion and outreach for the RCN, and the results of these efforts is apparent.

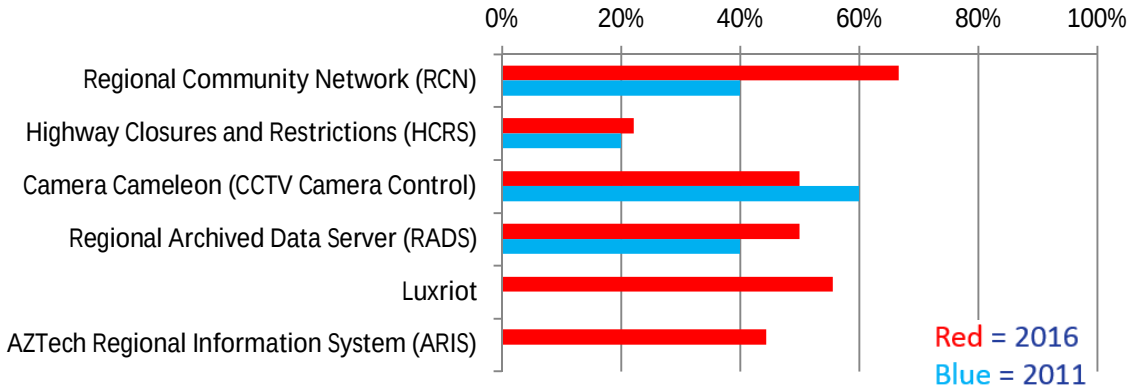


Figure 20 – Percent of Agencies Using Regional Systems

6 LESSONS LEARNED AND RECOMMENDATIONS

ITS is more than a tool to monitor traffic; agencies throughout the region and throughout the country are elevating the use of these tools to be proactive traffic management systems. Active management strategies for freeways and arterials, including adaptive ramp metering, adaptive traffic signal systems, and decision support systems, are important next steps in the ITS and system operations lifecycle.

6.1 Areas and Functions that Need Improvement

The following section highlights some of the key SM&O areas and functions that need improvement based on the current state of the region. These areas for improvement were identified by agencies as part of the survey that was disseminated. The identification of improvement areas also serves as opportunity areas where regional support can help foster significant improvements for regional operations and management.

Operations staff – *A key area that must be improved in the region is local TMCs ability to support real-time traffic and incident monitoring and response in the region.* While agencies in the MAG region have many successes they can identify and areas where they excel, there are also some challenges and areas for improvement related to operations and systems management. One of the most prevalent challenges was a deficiency in staff levels to perform SM&O functions. Four agencies who all have well-established operations programs and TMCs cited a need for additional staff in the TMC to support traffic monitoring and incident response.

Asset management and lifecycle planning – *The region could benefit from improved asset management processes and planning which would improve system reliability and improve the use of funding for devices.* Six agencies cited that their preventative maintenance program is a strength in their overall operations program and eight agencies responded that they factor in lifecycle timeframes and costs into device maintenance needs. However, there were four agencies who also reported doing lifecycle planning that cited asset management and/or preparing for equipment lifecycles (i.e. having adequate funding to replace end of life devices) as was an area for improvement. There were also seven additional agencies that reported that they did not conduct lifecycle planning procedures or factor in lifecycle timeframes and costs into maintenance planning.

Emerging Technologies – *There is a need for improved information on the direction of ITS technology and technology innovation as well as the availability of technology specifications that agencies should use when looking to procure new devices.* Related to technology lifecycles is technology evolution and the challenge of outdated equipment. Agencies have found that for some devices, by the time they update all their outdated equipment a new version or model is released which makes their new equipment also outdated. This will allow agencies to make informed decisions regarding their technology investments. *Further, an improved process for programming projects related to device upgrades is needed to reduce the amount of time between when a project is submitted and when a project receives funding.*

Using performance measures – *In general, agencies in the region must improve their data collection abilities and processes so that they collect and analyze greater amounts of data in real-time.* Four agencies indicated that an area for improvement involves 'better' use of data and performance measures to evaluate system performance and make operational decisions. Six agencies reported that the TMC staff is responsible for capturing system performance data and reporting it internally. Much of this data is collected automatically and in-real time, such as speeds and turning movements, while event-specific data, such as ingress duration during a special event, is collected post-event. However, only two agencies responded that they used performance measures to assess the performance of ITS/operations infrastructure. One example of a performance monitoring program is signal performance measures, where real-time traffic signal data is used to make changes to signal timing to improve efficiency of signalized intersections. Agencies in the region should improve their data management and operational capabilities to allow for integration of signal performance measures as part of operational procedures.

Arterial data – *There is a need to support agencies in using the data they collect to inform real-time decisions regarding the operational parameters of the transportation network.* There is not enough detection deployed on arterials to be able to collect accurate, real-time, and useable information to inform operations. This puts arterial TMCs in a reactive mode when responding to congestion or incidents. Arterial agencies are piloting projects to collect more data and are not willing to rely only on free private sector data (Google, Waze, etc.), but there are significant gaps in arterial data that hinders operations in the region.

Signal timing – Some agencies within the region indicated that they lacked the staff expertise and systems to adequately set and update signal timing at their signalized intersections. MAG does provide SYNCHRO training on a bi-annual basis and has the TSOP program to support agencies in improving traffic signal timing and coordination. However, these responses uncover *a need for improved outreach on these programs and considering updating or re-defining parts of the TSOP to better address the needs of smaller agencies who often cannot complete with the larger, more established agencies*.

Signal controller technology deficiencies – *Many agencies indicated that they have out-of-date controllers in the field that must be replaced as soon as possible.* For example, six agencies reported having Econolite ASC-2 controllers deployed with intention of replacing them as soon as funds are available. This model does not support many advanced operations functions that agencies are requiring for improved traffic signal operations. The City of Mesa indicated that even the next model in this line of controllers, the ACS-3, does not support the advanced functionality that they desire related to transit, coordination, and pre-emption. They are looking to replace all their Econolite controllers with a different brand and associated software within the 5 to 10-year planning horizon.

Signal controller software limitations – *There is a challenge in allowing agencies to stay up-to-date with software that would provide them with the greatest functionalities for signal operations without having to replace or spend significant funding on frequent central system enhancements.* Four agencies reported challenges related to compatibility between controller software and central traffic control systems. Signal controller software and firmware is frequently updated, and three agencies indicated that their central signal systems are not compatible with the updated versions of controller firmware. The City of Tempe reported that they are planning to replace a controller model because their controller software is no longer supported, even though the controllers themselves are not at end of life.

Freeway and arterial traffic incident management – The focus on traffic incident management has helped to elevate the attention on best practices for safe, quick clearance. The AZDPS leads the TIM Coalition, which includes representatives from state and local emergency and incident responders, tow operators, fire, and transportation agencies. Much of the focus of the TIM coalition has been on freeway incident management. *Local agency representatives are primarily fire; the Coalition has a goal to increase participation by local law enforcement agencies.* The benefits of the TIM focus have shown notable reductions in incident response and clearance times, which translates into reduced delay caused by incidents and reduced secondary crashes.

Connected and autonomous vehicles – A number of companies are already testing connected and autonomous vehicles (CV/AV) in the MAG region. For the last several years, Maricopa County and the University of Arizona have been testing connected vehicle radio and on-board equipment as part of the Arizona Connected Vehicle Test Bed in Anthem, Arizona. Tests have included transit vehicles and emergency response vehicles. There are plans to expand this to include passenger vehicles, although a definitive timeframe is not yet known. ADOT also would like to deploy the radio equipment at specific locations on I-17, which would connect to the test bed in Anthem. Autonomous vehicles – self-driving cars – are being actively tested in Chandler. Google and other companies are testing vehicles on city streets in many areas of the country, and thus far, no public agency in the US has made any move towards making modifications to road infrastructure or traffic control equipment to accommodate these test vehicles. Arizona's Governor signed an Executive Order allowing testing of self-driving cars in Arizona, and this Executive Order also states that agencies will support this testing. *The deployment of infrastructure to support*

communication with the vehicles that use the roadway (no matter what type of vehicle it is) is on the horizon and agencies in the region are beginning to discuss impacts of connected vehicles on their current systems. Not only will the vehicle be equipped with additional technology, but field infrastructure will be necessary to transmit data and information. Some agencies in the region have pursued federal funding to support connected vehicle pilot project testing of applications that could be proven useful for operations. In September 2016, the United States Department of Transportation and National Highway Traffic Safety Administration released the Federal Automated Vehicles Policy that provides the framework for the next 50 years with guidance for the safe and rapid development of advanced automated vehicle safety technologies. *There are too many unknowns at this point in time for agencies like MAG to consider incorporating CV/AV in infrastructure planning decisions. MAG is actively considering implications of CV/AV within current studies, and more testing results produced over the next few years may provide states and regions a better understanding on how to fit specific CV/AV strategies in to the planning process.*

6.2 Key Opportunities

A resource that agencies identified as a need was various kinds of training that would support improved SM&O in the region. The types of desired training identified by agencies included:

- Situational event training/Traffic Incident Management
- Systems Engineering training
- ITS device installation and maintenance
- Fiber splicing and fiber optics troubleshooting
- Traffic signal design
- TMC operator training and coordinated signal operations

Some of this training is already available in the region. For example, TIM training is available through the region's Traffic Incident Management Coalition. For some of the other requested training, such as ITS device and fiber installation and maintenance, there are many individuals in the region who have significant experience and expertise with those skills. Further, as mentioned earlier, many agencies in the region identified their maintenance programs as a notable strength in their operations and management program. Creating a program or forum to facilitate transfer of knowledge between those with experience in a skill technique or program and those who desire that knowledge would be an effective way to best utilize resources in the region as well as increase intra-regional collaboration, sharing and potentially interoperability amongst agencies.

Less restrictive procurement rules and contracts was cited as an opportunity to improve agencies operations through having the necessary and up-to-date devices and equipment. Agencies cited a lack of flexibility of the ADOT/Federal Highway Administration procurement process as something that limits their ability to purchase and deploy the devices and infrastructure that they need. It was stated that using CMAQ funds to try and acquire TMC equipment is not practical because restrictive procurement contracts make it extremely difficult to acquire a variety of technologies that should be compatible and work together. Developing and establishing regional procurement contracts that provide agencies with the flexibility they need while encouraging interoperability would help improve system lifecycles and reliability as well as compatibility of systems.

A limited number of agencies identified having partnerships and agreements for various tasks related to operations and maintenance of agency roadway networks, infrastructure, and systems. Five agencies reported to operate signals owned by another agency (with many of these being local agencies operating ADOT-owned signals at interchanges), while two agencies, Maricopa County and Buckeye, share operations of arterial DMS signs. An additional three agencies reported being involved in a partnership with another agency in the region to jointly manage a corridor or devices along a corridor. Providing processes, examples, model language and incentives to encourage more joint operations can help create a more coordinated and unified operational environment in the

region and encourage more sharing and collaboration in relation to data, device operations and traffic management.

Similarly, there were agencies that reported having contracts with the private sector or other agencies external to the transportation department for the maintenance of infrastructure and devices. For example, El Mirage uses consultants to assist in operating and maintaining ITS devices and signals. The City of Phoenix has a maintenance agreement with a third party vendor for maintenance on the TMC network equipment. Also, the City of Peoria has an intergovernmental agreement with the Peoria Unified School District for installation and maintenance of some of the City's fiber communication. These kinds of partnerships can be encouraged through similar mechanisms such as providing example intergovernmental agreement language for inter-departmental maintenance or model contract language for third-party maintenance contracts. Collaborating to support operations and maintenance helps more efficiency use the resources in the region and make sure that the systems and infrastructure are properly maintained and supported to provide optimal operations.