LOOP 101 Mobility Project

CONCEPT OF OPERATIONS

Final

Led by:

U.S. Department of Transportation Federal Highway Administration

ADOT

MARICOPA COUNTY

In Partnership with:

Department of Public Safety State Trooper Arizona

ASU

Chandler Arizona

Glendale Arizona

mesa·az

Peoria Arizona

City of Phoenix

City of Scottsdale

Tempe

Maricopa Association of Governments

Salt River Pima-Maricopa Indian Community

The University of Arizona

Valley Metro

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Version History

Version	Date	Author	Comments
1	10/31/2021	KH	Draft for review by PMT
2	11/23/2021	KH	Updated draft for review by L101 stakeholders
3	5/12/2022	KH	Draft final that addresses stakeholder comments and incorporates additional feedback from modeling, small group/one-on-one discussions and ramp metering exploration
4	6/24/2022	KH	Updated draft final that addresses PMT comments prior to full stakeholder distribution
5	7/29/2022	KH	Final document submitted to PMT
6	7/31/2023	KH	Updated Final Draft submitted to PMT after further clarification on roles and responsibilities between MCDOT and ADOT
7	9/12/2023	KH	Address final PMT comments and distribute to L101 Mobility stakeholders
8	10/31/2023	KH	Final Document incorporating all feedback received

List of Acronyms

ADOT – Arizona Department of Transportation

ARC-IT – Architecture Reference for Cooperative and Intelligent Transportation

ARID – Anonymous Re-Identification Device

ARIS – AZTech Regional Information System

ASCT – Adaptive Signal Control Technology

ASU – Arizona State University

ATCMTD – Advanced Transportation Congestion Management and Technology Demonstration

ATSPM – Automated Traffic Signal Performance Measures

ATIS – Advanced Traveler Information System

AVL – Automatic Vehicle Location

CAD – Computer-Aided Dispatch

CCTV – Closed-Circuit Television

CM – Configuration Management

ConOps – Concept of Operations

CV – Connected Vehicle

DMS – Dynamic Message Sign

DPS – Department of Public Safety

DSS – Decision Support System

EGT – Executive Governance Team

ERS – Event Reporting System

FHWA – Federal Highway Administration

FMS – Freeway Management System

FSP – Freeway Service Patrol

GEC – General Engineering Consultant

ICM – Integrated Corridor Management

IGA – Intergovernmental Agreement

IRU – Incident Response Unit

IT – Information Technology

ITS – Intelligent Transportation Systems

MAG – Maricopa Association of Governments

MCDOT – Maricopa County Department of Transportation

MMITSS – Multi-Modal Intelligent Traffic System

OBU – On-Board Unit

OCC – Operations and Control Center

OET – Outreach and Education Team

PAT – Program Administration Team

PIO – Public Information Officer

PMP – Project Management Plan

PMT – Project Management Team

PS&E – Plans, specifications and estimates

RADS – Regional Archive Data System

RCN – Regional Community Network

REACT – Regional Emergency Action Coordinating Team

RFI – Request for Information

RFP – Request for Proposal

RIA – Regional ITS Architecture

SE – Systems Engineering

SEMP – Systems Engineering Management Plan

SR – State Route

SRPMIC – Salt River Pima-Maricopa Indian Community

TIRC – Traffic Information for Road Closures

TMC – Traffic Management Center

TOC – Traffic Operations Center

TSMO – Transportation Systems Management and Operations

TT – Technical Team

UA – University of Arizona

WZDx – Work Zone Data Exchange

1 INTRODUCTION

The Arizona Department of Transportation (ADOT) and Maricopa County Department of Transportation (MCDOT) partnered to successfully secure funding through joint leadership through the Federal Highway Administration (FHWA) Advanced Transportation Congestion Management and Technology Demonstration (ATCMTD) program in 2017 to implement Integrated Corridor Management (ICM) systems on the Loop 101 corridor in the Phoenix metropolitan area.

1.1 LOOP 101 MOBILITY PROGRAM OVERVIEW

The Loop 101 corridor is a 61-mile loop freeway corridor in the Phoenix metropolitan area that connects residents and visitors to key event centers, educational institutions, and all interstate corridors in the Phoenix metro area, as well as traverses throughout the entire region interacting with seven of the region's major cities as well as the Salt River Pima-Maricopa Indian Community (SRPMIC).

This Loop 101 Mobility Project leverages significant investments over the years by ADOT, MCDOT, Valley Metro, the Maricopa Association of Governments (MAG) and local agencies in freeway, arterial, and transit operations and management strategies. Building on the successful ADOT Freeway Management System (FMS) and several regional/local agencies' traffic operations and management systems, ICM will facilitate improved real-time freeway-arterial coordination when incidents impact Loop 101 and divert traffic onto local streets. While this Loop 101 ICM concept is focused on non-recurring congestion events on the Loop 101, the ICM lifecycle and operational approaches outlined in this ConOps may be applied to ICM events due to recurring congestion if that is a direction that the Loop 101 Mobility stakeholders choose to pursue in the future.

As part of the ATCMTD grant efforts for the Loop 101 Mobility Project, agencies identified several preliminary concepts for technology-based projects aimed at improving overall traffic and incident management within the corridor. Key applications that were identified in the grant include:

- Multi-agency Decision Support System (DSS) to support ICM
- Adaptive Ramp Metering
- Adaptive Signal Control Technology (ASCT) for special event traffic management near the sports arena in Glendale
- Connected Vehicle (CV) applications for transit and incident responder communications
- Integrated Traveler Mobility Application

Centered around the advanced technology concepts included in the grant, the Loop 101 Mobility Program goals, as defined in a multi-agency project charter signed in advance of the grant submittal, were outlined:

- Improve safety and the use of existing arterial capacity in the Loop 101 corridor by deploying technology and systems to support ICM through a DSS.
- Enhance public transportation service and incident response by using lessons learned from the MCDOT SMART*Drive*SM Program Connected Vehicle testbed in Anthem, Arizona to deploy intelligent signal priority within the corridor.

- Elevate transportation operations partnerships with public sector agencies and innovative private sector partners.
- Use regional experience, combined with advanced technologies, to improve traffic management operations for large-scale planned special events.
- Improve data availability and consistency of traveler information to assist with traveler decision-making and influence traveler behavior toward shared mobility.

1.2 CONCEPT OF OPERATIONS OVERVIEW

The development of the ConOps for the Loop 101 Mobility ICM Program is an important step in the overall process to plan and implement ICM for the corridor. The development of the Loop 101 ICM is based on the principles of "systems engineering", which is a formal process which results in a system designed to meet goals that reduces the risk of costly additions or changes at a later stage in development when it would be better to evaluate those changes earlier in the process. The systems engineering process is shown as a "V" diagram in **Figure 1** and the individual project phases involved in this Loop 101 Mobility project have been circled and identified where they reside along the path toward implementation.

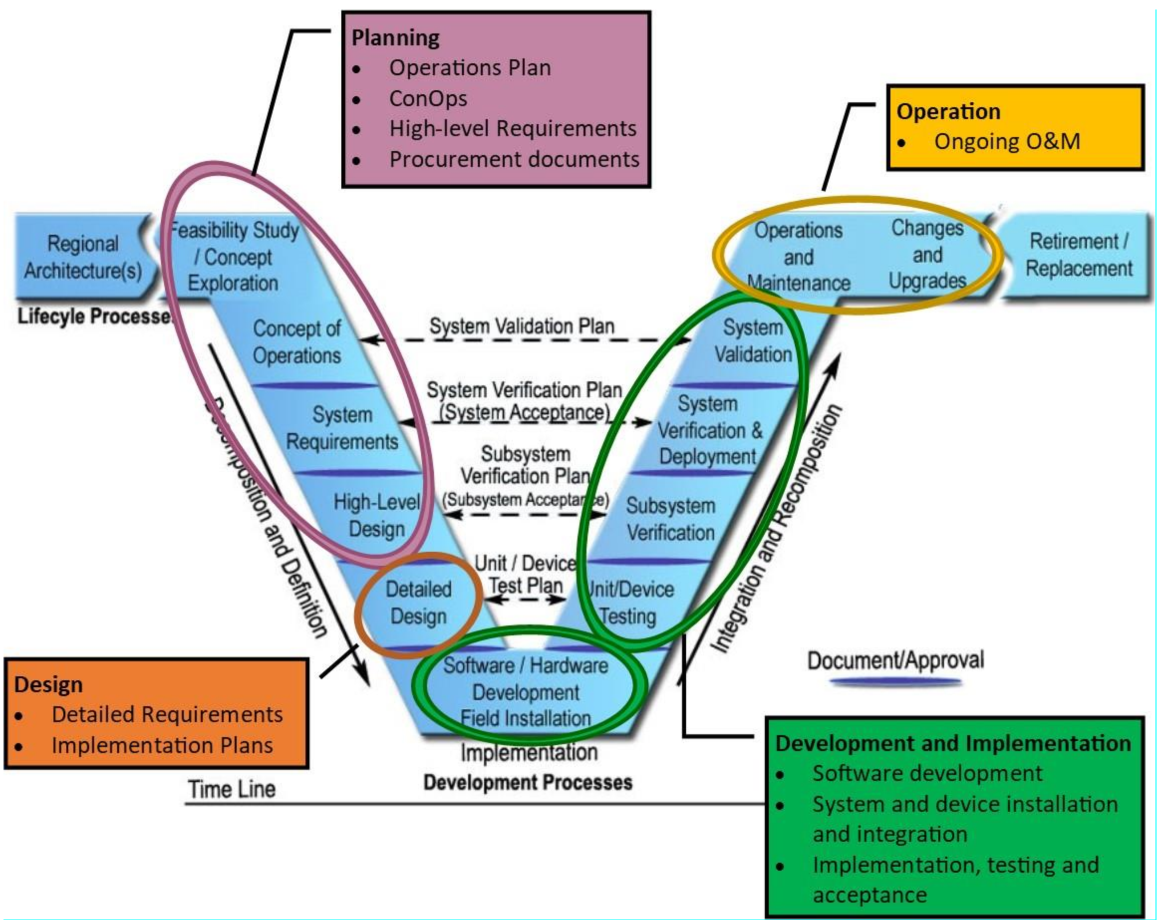


Figure 1 – Loop 101 Mobility Project Phases Context Within Systems Engineering Process

As part of the "Planning" activities in the systems engineering process, the stakeholders undertook the development of an Operations Plan that was finalized in 2021 and included the roles and responsibilities, operational scenarios, and response considerations as related to the "people and processes" involved when implementing ICM along the Loop 101 corridor. This ConOps will focus on the "systems and tools". The Operations Plan formalizes a significant amount of the ultimate ConOps (as shown in **Figure 2**) that will help the development of the remaining elements by using consensus-based and scenario developed processes for the ultimate ICM concept.

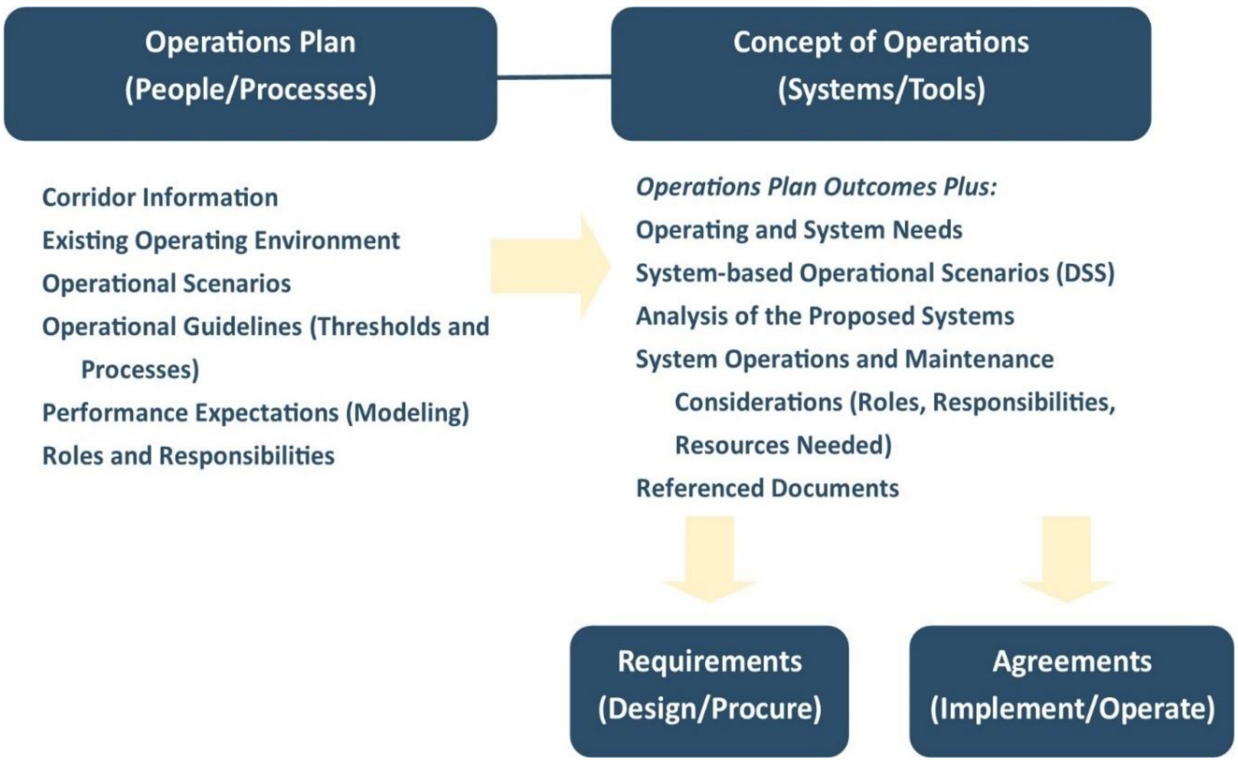


Figure 2 – Loop 101 Operations Plan Context Within Systems Engineering Process

The systems and tools will introduce the ability to automate some currently manual processes like notifications, threshold identification, identification of ICM response actions, and aggregation of data to support after-action debriefs. In addition, new processes or methods may be identified which fill an existing gap in existing procedures. Many of the processes and responsibilities outlined in the Operations Plan as manual processes will remain manual processes that are the responsibility of one or more stakeholders. The ConOps will complete the people/process and systems/tools collection of ICM strategies to identify high-level system requirements and specifications to be used to procure design consultants for the detailed system requirements and system design efforts of desired resulting systems.

1.3 DOCUMENT OVERVIEW

This ConOps document provides an overview of the Loop 101 Mobility ICM concept, current operations in the region along the Loop 101 corridor, how the operations will remain the same or be changed once the ICM concept is operational and identifies current and future responsibilities of the stakeholders. The intended audience are the system designers, for development of systems consistent with this concept;

the project stakeholders, for applications and references; and the general public, which has an interest in what ICM will look like in the region.

The sections of this document work through the Loop 101 ICM concept, explain how people and systems are expected to function and coordinate once it is in operation, and identify the roles and responsibilities of the various stakeholders. The ConOps does not delve into technology or detailed requirements of the ICM system, but it does address the operational scenarios and objectives, information needs, and overall functionality of ICM strategies along Loop 101. The following sections are provided in this ConOps:

- **Introduction** – This section reviews the systems engineering process being undertaken by project stakeholders and the importance of ICM in the region.
- **Referenced Documents** – This section identifies all referenced materials in the development of the ConOps.
- **Existing Systems and Operations** – This section outlines the agency stakeholders, their current operational conditions, agency resources, policies and agreements. It also summarizes and connects the key challenges and gaps to be addressed by ICM and the goals for ICM.
- **Operating and System Needs** – This section summarizes the needs from the operational (people) and system perspectives, as they are separate but related categories, and are used specifically to drive the concept development.
- **ICM Systems Overview** – This section describes the proposed ICM concept, including high-level description, overall graphic depiction, agency roles and responsibilities, and identification of specific sub-systems to be developed.
- **Operational Environment** – This section documents the corridor operating principles, processes to be undertaken from both the people side and the system side to make full use of the concept that has been developed, and recognition of the permissions and agreements that need to be developed to support this operational environment.
- **Support Environment** – This section discusses long-term needs such as operations and maintenance identification, role and responsibility changes needed, training and workforce development, performance metrics to track, and how the processes and systems will be finetuned over time as agencies use ICM.
- **Use Cases and Operational Scenarios** – This section describes the real-world experience of this ICM concept in an overall perspective but also from the perspective of the operators, first responders, incident support teams, transit users, and the traveling public.

2 REFERENCED DOCUMENTS

The following references were used in developing this ConOps:

- ANSI (American National Standards Institute)/ AIAA (American Institute of Aeronautics and Astronautics) Outline for Operations Concept Documents (G-043-1992).
- IEEE (Institute of Electrical and Electronics Engineers) Outline for Concept of Operations (1362-1998).
- "Systems Engineering Guidebook for ITS," California Department of Transportation, Division of Research and Innovation, Version 1.1, February 14, 2005
- FHWA Rule 940, Federal Register/Vol. 66, No. 5/Monday, January 8, 2001/Rules and Regulations, Department of Transportation, Federal Highway Administration 23 CFR Parts

655 and 940, [FHWA Docket No. FHWA–99–5899] RIN 2125–AE65 Intelligent Transportation System Architecture and Standards.
- Loop 101 Mobility Project – Project Management Plan. December 2019.
- Connected Corridor: I-210 Pilot Integrated Corridor Management System Concept of Operations. June 2015
- Des Moines Metropolitan Area Integrated Corridor Management Program-Level Concept of Operations. June 2019.
- I-10 Integrated Corridor Management Plan. Concept of Operations. October 2018.
- Final Report. Concept of Operations. Dallas Integrated Corridor Management (ICM) Demonstration Project. FHWA-JPO-11-070. December 2010.
- Final I-15 ICM Concept of Operations. San Diego I-15 Integrated Corridor Management System. May 2009.
- MAG Regional ITS Architecture. December 2019.
- National ITS Architecture ARC-IT Version 8.1. April 2018.
- Elements of Business Rules and Decision Support Systems within Integrated Corridor Management: Understanding the Intersection of these Three Components. FHWA-HOP-17-027. October 2017
- Integrated Corridor Management and Freight Opportunities. FHWA-HOP-15-018. December 2015.

3 EXISTING SYSTEMS AND OPERATIONS

This section outlines the agency stakeholders, their current operational conditions, agency resources, policies and agreements, and sheds light on the gaps to be addressed by ICM.

3.1 CORRIDOR OPERATING PARTNERS

Loop 101 is a 61-mile urban beltway around the Phoenix metropolitan area that connects major cities, freeways, and destinations, including major event venues, in the region. Loop 101 traverses several cities and communities, including Phoenix, Glendale, Peoria, Scottsdale, Tempe, Mesa, and Chandler, , as well as portions of the SRPMIC and Maricopa County. Loop 101 also connects to all major freeways in the Phoenix area, including Interstates 10 and 17, US 60, State Route (SR) 202L (Loop 202), and SR 51. Multiple transit agencies, including Valley Metro, Phoenix Public Transit and Scottsdale Transit, operate transit services within, adjacent to or crossing the Loop 101 corridor and are important operational partners. **Figure 3** provides a map of the Loop 101 corridor.

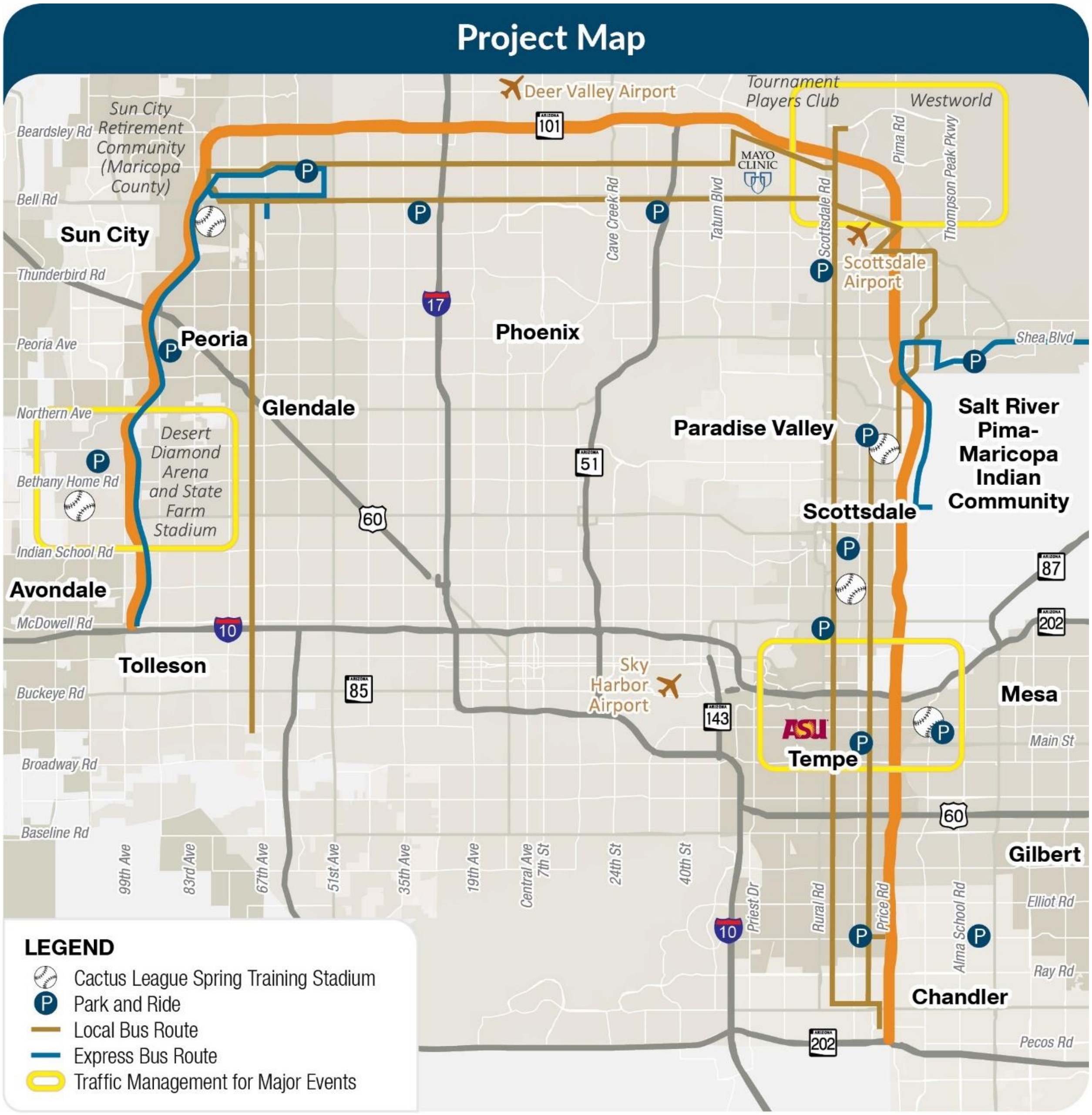


Figure 3 – Loop 101 Corridor Map

The project is co-managed by ADOT and MCDOT, with oversight by FHWA, which is a full participant in the Loop 101 Mobility Project. FHWA is a member of all project management committees developed for the project and is invited to participate in operations and technical discussions to develop the key deliverables across all phases.

Project partners are those who have formal intergovernmental agreements (IGAs) in place to provide financial resources to support the Loop 101 Mobility Project. These include Valley Metro and the cities of Phoenix, Glendale, Peoria, Scottsdale, Tempe, Mesa, and Chandler. A variety of representatives from multiple departments within each of the project partner agencies have been involved in the key phases of the project to garner their unique perspectives, as applicable, including traffic engineering, transit, traffic operations, maintenance, law enforcement, public information office, and information technology. The Loop 101 Mobility Project will also involve several additional project stakeholders as part of operations discussions, concept planning, requirements development and future implementation and operations. These additional project stakeholders include the Arizona Department of Public Safety, the Maricopa Association of Governments, and the Salt River Pima-Maricopa Indian Community. Arizona State University and the University of Arizona will participate in technical tasks. All project partners are considered stakeholders and the term stakeholder is used throughout this document unless there is a need to specifically differentiate partner agencies.

Specific project stakeholders have been involved in the development of each technical application area, as detailed in **Table 1**.

Table 1– Loop 101 Mobility Project Technical Task Teams

Technical Task Teams	Stakeholder Agency Participants
DSS team	All agency stakeholders
Adaptive Signal Control Technology team	City of Glendale staff, ADOT, and MCDOT.
Adaptive ramp metering team	ADOT
Connected Vehicle team	ADOT [Transportation Systems Management and Operations (TSMO)] staff, MCDOT [TSMO and Regional Emergency Action Coordinating Team (REACT) staff], Scottsdale [Traffic Management Center (TMC) and Transit], University of Arizona
Traveler information and mobility application team	ADOT, MCDOT, Valley Metro and the Outreach and Education Team (OET)

3.2 STAKEHOLDER INVOLVEMENT

The Loop 101 stakeholder agencies were involved with the development of the Operations Plan and ConOps as primary owners, operators, and responders for the freeway, arterial and transit transportation networks. Input was collected from staff related to traffic management/traffic operations, transit operations, incident response, and public information and communications through a variety of workshops and meetings.

Workshop #1 *– June 24, 2020 –* Presented Operations Plan development process in context with the ConOps and the outlined framework for the document. Introduced ICM use cases and scenarios, and formalized operational environment that will form the basis for future system needs and high-level requirements development. Introduced proposed performance objectives and targets as they related to future modeling to assess feasibility of the operations strategies or potential adjustments to performance thresholds. The workshop was attended by all project stakeholder agencies.

Workshop #2 *– July 22, 2020 –* Presented and discussed ICM operational scenarios for planned freeway restrictions, a freeway incident without full closure, and a concurrent freeway and arterial incident to capture current processes and future desired processes to improve coordination and response. The workshop was attended by all project stakeholder agencies.

Workshop #3 *– August 18, 2020 –* Presented and discussed thresholds and triggers for ICM activation, the role of REACT to support alternate routing needed, and operational guidelines. The workshop was attended by all project stakeholder agencies.

Segment Working Sessions *– September 30, October 1 (two sessions held), and October 5, 2020 –* Assessed the Loop 101 Corridor through discussions of four segments to take a closer look into specific and unique operating environments and agency preferences for each segment. Segments included: *Segment 1 – 202L (Santan) to Rio Salado Parkway*, *Segment 2 – Rio Salado Parkway to Scottsdale Road*, *Segment 3 – Scottsdale Road to 67th Ave*, and *Segment 4 – 67th Ave to I-10*. Participants included the local, regional and state agencies who had a key operational role in the specific segment, including staff from traffic/TMC, maintenance, public safety/incident response, transit, and public information/communications. These working sessions included discussions on specific strategies, alternate routing, and operations process to understand what is needed to successfully implement and operate ICM strategies at the local level. Between the four working sessions, all project stakeholder agencies participated.

Workshop #4 *– October 20, 2020 –* Regrouped with stakeholders to report back on segment working session outcomes, confirm overarching principles of the Operations Plan, and discuss remaining gaps or disconnects for ICM operations. Presented and discussed ICM Goals and Objectives for the Loop 101 Mobility Project and how the proposed ICM concept aligns with the goals.

Workshop #5 *– December 17, 2020 –* Presented the full Operations Plan and walked through the individual sections with stakeholders to gain final feedback prior to completion of the Plan. The workshop was attended by all project stakeholder agencies. The project stakeholders were able to review the manner in which their comments were addressed during a comment resolution meeting on January 21, 2021 to result in a final draft of the Operations Plan distributed March 19, 2021 for final review.

Workshop #5 *– April 6, 2021 –* Presented the final Operations Plan in a brief review and transitioned stakeholders to the upcoming ConOps development process including user needs prioritization, gaps in current operations, proposed use cases, and a user needs survey that was distributed in the week following the workshop.

Workshop #6 *– May 26, 2021 –* Presented project status updates and feedback received from the user needs survey that resulted in user needs statements to be addressed by the concept development. The group was presented with the initial concept in diagram form following the ICM activation steps outlined in the Operations Plan. The purpose of this walkthrough was to discuss the system interactions and where manual processes need to be supplemented or replaced by automated processes as part of the ICM system. The workshop was attended by all project stakeholder agencies.

Stakeholder Small Group Discussion #1 *– June 14, 2021 –* A small group discussion was conducted with TMC/operations staff from the Cities of Glendale, Peoria and Phoenix to talk more specifically through the systems interactions that the stakeholders envisioned for the DSS system. These small group meetings did not have a formal agenda but did provide opportunities to talk through the results of the user needs survey to understand how agencies envision the system to function and how they would interact with it.

Workshop #7 *– June 21, 2021 –* Presented project status updates and provided some perspective on the overall ConOps document and the key decisions that the document needs to answer. The group discussed the role of the ConOps in articulating interactions and touch points with legacy systems and identifying technology layers might be needed to bridge gap between existing systems and between existing systems and new systems. The concept of 'business rules' was introduced and how thresholds for things like notifications, recommendations, and clearance will be part of the defined business rules, although these specifics will be defined in detail during the system design task. The group discussed how the ConOps will identify roles and responsibilities related to overall ICM governance. The workshop was attended by all project stakeholder agencies.

Stakeholder Small Group Discussion #2 *– June 30, 2021 –* A small group discussion was conducted with transit planning and operations staff from the Cities of Glendale, Scottsdale and Phoenix and Valley Metro to talk more specifically through the systems interactions that the stakeholders envisioned for the DSS system. These small group meetings did not have a formal agenda but did provide opportunities to talk through the results of the user needs survey to understand how agencies envision the system to function and how they would interact with it.

Workshop #8 – *October 19, 2021 –* Presented project status updates and reviewed the contents of the "ICM Needs and Goals" working document that was disseminated prior to the meeting. The ICM Needs and Goals document summarized and tied together a variety of activities and inputs that tell the story about the need for ICM on the Loop 101, the goals for ICM, and the ICM operational and system user needs. The meeting also included a walkthrough of the draft DSS operational concept, which included discussion of the capabilities that are required of the DSS during each phase of the ICM lifecycle. The walk through included a mock-up of a DSS user interface/dashboard. The workshop was attended by all project stakeholder agencies.

Workshop #9 *– December 16, 2021 –* An updated draft of the ConOps document was distributed to stakeholders on November 23, 2021. This webinar reviewed the key updates and changes that were made and reflected in the draft distributed to stakeholders. This included a graphic that showed how different tasks and deliverables fit into the overall DSS development, starting with the Operations Plan and continuing through the completion of DSS testing in early 2025. Emphasis for this webinar was on linking the User Needs, Operational User Needs and the System User Needs. Stakeholders were asked to provide feedback on proposed ICM roles and responsibilities; an important role for state, county and local stakeholders is maintenance of ITS equipment and devices that will support real-time ICM operations. This review webinar also discussed a future L101 ICM Operating Agreement and stakeholders were asked to consider what elements they felt were important to include. The workshop was attended by all project stakeholder agencies.

Small Group Technical Discussions and Agency One-on-One Meetings – *January and February 2022 –* Small group and individual agency meetings were held with TMC contacts at the local partner agencies to better understand specific system operating environments and any potential challenges or constraints. These small group and individual discussions were an opportunity to assess specific needs and issues with local agency system interactions and the future DSS, including what types of device status information would be available from agency ATMS. Key takeaways and were incorporated into an updated concept diagram and the overall Concept of Operations document.

Workshop #10 – *June 29, 2022 –* This workshop served as a walkthrough on the final draft Concept of Operations that was distributed to stakeholders for review. Stakeholders were asked to confirm any recent changes to agency processes and systems as part of the Existing Systems section. Updates to the ConOps based on the small group and individual discussions were also reviewed, including how ICM will leverage existing systems, clarifications to show system interactions, and updates to the roles and responsibilities. A Gap Analysis was a new section added to this version of the ConOps document. The workshop was attended by all project stakeholder agencies.

Stakeholder In-Person Regroup Meeting *– May 9, 2023 –* The goal of this in-person meeting was to re-group with all of the project stakeholders to discuss items in the ConOps that needed to be confirmed or that may warrant changes in support of the development of System Requirements, and ultimately a procurement package for a DSS designer and developer. A representative from all project funding partner agencies were present, as well as attendees from MAG. Discussions in the meeting informed updates to the ConOps, including new process graphics that outline current, near-term, and ultimate process diagrams that help identify key activities that the DSS is envisioned to support or fill gaps.

3.3 OPERATIONAL CONDITIONS AND RESOURCES

Agencies along the Loop 101 corridor have several existing tools, systems, and resources that can support traffic management, traffic re-routing, notifications and communications among agencies, and notifications to the public during an ICM activity. This section summarizes the "systems and tools" currently available to support future Loop 101 ICM operations. Many of the manual processes will involve the use of systems or tools.

3.3.1 HOURS OF OPERATIONS

Current operating hours for the traffic/transit and incident management resources within Loop 101 stakeholder agencies is shown in **Table 2.**

Table 2 – Loop 101 Agency Hours of Operations

Agency/Department	TMC Business Hours	Public Information Office (PIO) Hours	After-Hours
ADOT Incident Response Unit (IRU)	5:00 AM – 8:00 PM M-F	-	-
ADOT Traffic Operations Center (TOC)	24x7x365	24x7x365	24x7x365
Arizona Department of Public Safety (DPS)	24x7x365	24x7x365	24x7x365
Chandler TMC	6:00 AM – 6:00 PM M-F	8:00 AM – 5:00 PM M-F	Via remote access to manage and monitor traffic as needed
Glendale TMC	6:00 AM – 4:00 PM M-F	8:00 AM – 5:00 PM M-F	TMC staff and maintenance on-call
MCDOT REACT	24x7x365	-	24x7x365
MCDOT TMC	5:30 AM – 5:30 PM M-F	8:00 AM – 5:00 PM M-F	Via remote access to manage and monitor traffic as needed for TMC staff and through maintenance on-call
Mesa TMC	6:00 AM – 6:00 PM M-Th	8:00 AM – 5:00 PM M-Th	Via remote access to manage and monitor traffic as needed
Peoria TMC	7:00 AM – 6:00 PM M-Th	7:00 AM – 7:00 PM M-Th (but checking emails/ phone calls every day)	Via remote access to manage and monitor traffic as needed
Phoenix Public Transit	24x7x365	Covered by Valley Metro Customer Service	24x7x365
Phoenix TMC	5:00 AM – 9:00 PM M-F	8:00 AM – 5:00 PM M-F	TMC staff and maintenance on-call
Scottsdale TMC	6:00 AM – 6:00 PM M-F	8:00 AM – 5:00 PM M-F	Via remote access to manage and monitor traffic as needed for TMC staff and through maintenance on-call
SRPMIC	8:00 -AM – 5:00 PM M-F	6:00 AM – 4:00 PM M-F	Roads and Maintenance on-call
Tempe TMC	6:00 AM – 4:30 PM M-F	8:00 AM – 5:00 PM M-F	Via remote access to manage and monitor traffic as needed
Valley Metro	24x7x365 (covered by Phoenix Transit Operations Control Center [OCC])	6:00 AM – 8:00 PM M-F 7:00 AM – 7:00 PM Sat	24x7x365

Agency/Department	TMC Business Hours	Public Information Office (PIO) Hours	After-Hours
		8:00 AM – 5:00 PM Sun and select holidays	

3.3.2 LOOP 101 CORRIDOR TRANSPORTATION SYSTEMS AND APPLICATIONS

Table 3 and the lists below identify the existing agency and regional systems and applications that support transportation operations and management and traveler information dissemination.

Table 3 – Agency Traffic Management Systems along Loop 101 Corridor

Agency	Traffic Signal Control System				Adaptive Signal Control		
	TransSuite	KITS	Centracs	MaxView	Kadence	InSync	TransCore ACDSS
ADOT				X		X	
Chandler	X						
Glendale		X				X	
MCDOT		X				X	
Mesa			X		X		
Peoria		X				X	
Phoenix	X						
Scottsdale	X						X
Tempe	X	X					

Traffic Incident Management:

- ADOT Motorola Flex CAD system – TOC dispatchers input information related to freeway incidents (when notified by Arizona DPS) and dispatch of IRU. Data is currently not available to others.
- Arizona DPS Computer Aided Dispatch (CAD) system – data from DPS CAD is not available to other agencies at the time this document was developed.
- Chandler Police CAD – data is currently not available to others.
- Glendale Police CAD – data is currently not available to others.
- Mesa Police CAD – currently integrated into RADS, and available to all partners through RADS and ARIS alerts.
- Mesa Fire CAD – currently integrated into RADS, and available to all partners through RADS and ARIS alerts.
- Peoria Police CAD – data is not currently available to others.
- Phoenix Fire CAD – incident data currently integrated into the Regional Archived Data System (RADS), and available to all partners through RADS and AZTech Regional Information System (ARIS) alerts.
- Phoenix Police CAD – data is currently not available to others.
- Scottsdale Police CAD – data is currently not available to others.
- SRPMIC Police CAD – data currently not available to others.

- SRPMIC Police and Fire – currently coordinating with City of Scottsdale Police, Arizona DPS, and ADOT.
- Tempe Police CAD – data is currently not available to others but in the future will be available through RADS and ARIS alerts.

Traveler Information:

- Regional Lane Restriction/Closure System – lane restrictions and closure reporting of planned/permitted construction activity for all agencies has been integrated into RADS and AZ511 website
- ADOT 511 phone and az511.gov web system (including MyAZ511). Information is obtained from ADOT's Event Reporting System (ERS) as well as non-ADOT sources.
- Valleymetro.org and Valley Metro mobile app.
- Information displays at Phoenix Transit and Valley Metro Park and Rides.
- Phoenix Public Transit Road Supervisors who rove within the City of Phoenix and assist riders whose route was detoured or re-routed.
- Travel time estimates and roadway condition information on freeway and arterial dynamic message signs.
- Social media notifications by PIOs at ADOT, Arizona DPS, MCDOT, Valley Metro, and local agencies.
- News media alerts and notifications via radio and television broadcasts and social media tools.
- Third-party mobile apps, some of which use regional data provided through RADS.

Transit Management:

- Clever Transit Vehicle Management System.
- Transit operations/customer service centers.
- Bus and transit center information systems/kiosks, including those at park and ride facilities.

Connected Vehicles:

- MCDOT SMART*Drive* Program^{SM} connected vehicle test bed in Anthem, AZ involving traffic signal priority applications for transit and incident response vehicles.

Data Management

- AZTech Regional Archive Data System (RADS) – regional warehouse of real-time and historical ITS data including traffic, construction, and incident impacts and serves as the database serving many other software systems that provide information to the public.
- ADOT Event Reporting System (ERS) – database of freeway incidents and closures, planned work zone and maintenance impacts, and other events resulting in restrictions. The ERS populates the ADOT 511 public information system and provides a record of events and ADOT actions that are taken with respect to freeway operations.
- AZTech Regional Information System (ARIS) – automated notification system with the capability to alert all agency subscribers of incidents in their designated areas and provide access to camera images and traffic detection for real-time conditions.
- Traffic Information for Road Closures (TIRC) – System to collect and share lane and road closure data along arterial roadways from local agencies for integration with regional tools like AZ511.

- MAG Regional Community Network (RCN) – regional shared fiber network that provides agencies with direct access to one another to share CCTV video feeds and other traffic data streams and serves as a backup communications network for regional public safety systems.
- Automated Traffic Signal Performance Measures (ATSPM) – Agency-owned real-time, high resolution data from traffic signals collected every 1/10 of a second that feed a central AZTech RADS ATSPM server that supports enhanced traffic signal operations, maintenance, management and design to improve the safety, mobility and efficiency of signalized intersections for all users.
- INRIX data analytics package – ADOT has a statewide contract with INRIX to get real-time speed data, and any public transportation agency can request access to data through ADOT.

3.3.3 TRANSPORTATION OPERATIONS AND MANAGEMENT INFRASTRUCTURE

Each Loop 101 operating agency owns and operates field equipment within the Loop 101 corridor area that supports traffic and transit management and operations. Infrastructure is summarized in **Table 4.**

Table 4 – Agency Traffic Operations and Management Infrastructure to Support Loop 101 Operations

Agency	Infrastructure
ADOT	Freeway detectors, freeway CCTV, freeway DMS, ramp meters and adaptive ramp meter capabilities, traffic interchange signals with vehicle detection, U.S. 60 (Grand Avenue) traffic signals, fiber and wireless communications; IRU vehicles – includes portable message boards and traffic control equipment
Arizona DPS	Freeway Service Patrol vehicles that assist motorists who are stranded on freeways due to minor incidents and provides prompt clearance
City of Chandler	Traffic signals with vehicle detection, arterial CCTV, arterial DMS, ARID, fiber and wireless communications
City of Glendale	Traffic signals with vehicle detection, arterial CCTV, arterial dynamic message sign (DMS), lane control signals, ARID, fiber and wireless communications, transit vehicles
City of Peoria	Traffic signals with vehicle detection, arterial CCTV, ARID, fiber and wireless communications
City of Phoenix	Traffic signals with vehicle detection, arterial closed-circuit television (CCTV) cameras, anonymous re-identification device (ARID), fiber and wireless communications, transit vehicles, park and ride lots (Happy Valley/I-17; Bell/I-17 (Deer Valley); Metro Center; Bell/SR-51; Shea Blvd/SR-51 (Dreamy Draw))
Maricopa County	Traffic signals with vehicle detection, arterial CCTV, arterial DMS, ARID, fiber and wireless communications; REACT vehicles – includes portable message boards and traffic control equipment; some vehicles are equipped with connected vehicle on board units (OBU)
City of Mesa	Traffic signals with vehicle detection, arterial CCTV, ARID, fiber and wireless communications
City of Scottsdale	Traffic signals with vehicle detection, arterial CCTV, transit (trolley) vehicles, fiber and wireless communications
City of Tempe	Traffic signal with vehicle detection, arterial CCTV, ARID, fiber and wireless communications (per my comment above, add ATSPM and advanced detection systems)
Valley Metro	Transit vehicles, bus stops, park-and-ride lots, fiber and wireless communications

3.4 EXISTING POLICIES AND AGREEMENTS TO SUPPORT ICM OPERATIONS

There are some inter-agency agreements currently in place that can be leveraged to support transportation operations and management of this corridor and future ICM strategies.

- REACT Intergovernmental Agreement (IGA) – ICM-specific agreement with City of Scottsdale expired in June 2020. While in effect, the MCDOT REACT team was called out during closures of the Loop 101 freeway to support arterial detour routing. IGAs for general REACT services (not specific to ICM) are in place with the City of Glendale, the City of Peoria, and the City of Chandler for REACT teams to support traffic control during major arterial road incidents within the city when requested by Police or the TMC.
- ADOT Traffic Signal Interchange Operations Agreements – in place with Glendale, Scottsdale, Phoenix, Chandler and Tempe – identifies that the local agency will maintain and operate the interchange traffic signals in ADOT's right-of-way for Loop 101 interchanges, as shown in **Appendix A**.
- Master IGAs for traffic management and operations for ICM Operational Goals and Needs between MCDOT/ADOT and between MCDOT and the City of Phoenix.

3.5 NEEDS AND PRIORITIES TO BE ADDRESSED BY LOOP 101 MOBILITY ICM SYSTEM

3.5.1 POTENTIAL FOR ICM

There have been a number of major incidents and closures along Loop 101 which have caused significant delay and inconvenience. Historically, when such major events occur, motorists will take it upon themselves to re-route, with no direction or adjustment being made to the route they have chosen and no pre-trip or in-trip recommendations about when or where to travel as well as what might be the optimal mode choice given these conditions.

During freeway events that require or result in traffic diversion, a huge responsibility and burden is placed on local agencies to quickly react and manage the increased volume of traffic being dispersed to their arterial networks. Proactively defining ICM strategies can help these agencies leverage traffic management systems and tools, and enhanced coordination among partners, to improve freeway/arterial coordination during freeway closures. Some notable examples of events on Loop 101 that highlight the importance of a cohesive ICM strategy include:

- ***A fatality on northbound Loop 101 at Indian School Road in the East Valley on October 22, 2020*** resulted in a freeway closure that affected northbound lanes for several hours. A wrong-way driver in the early morning crashed heading south on Loop 101 near Chaparral Road. Northbound lanes were closed at Indian School, and travelers diverted to several routes, including Dobson Road between Indian School Road and Chaparral Road through the Salt River Pima-Maricopa Indian Community (SRPMIC). Dobson Road through SRPMIC does not have adequate capacity or traffic management infrastructure, which resulted in severe traffic congestion along Dobson Road through the community, especially at four-way-stop intersections. Additionally, there is no connection between Dobson Road and the Loop 101

freeway north of Chaparral Road, so traffic was forced to turn around when the road dead-ended at the Arizona Canal. The region initiated a detailed study and approach for incident management and traveler information systems for Loop 101 through the City of Scottsdale. A part of that study included the evaluation of notifications for major freeway and arterial incidents and management of those incidents by partner agencies. That study and resulting tools served as a proof of concept that there were ICM strategies that could be put into place to facilitate freeway-arterial coordination.
- ***A crash and homicide on Loop 101 in the West Valley on Friday, March 22, 2019 south of Thunderbird Road*** resulted in a long-term closure of the northbound freeway lanes at Peoria Avenue. The AZDPS and Peoria police were on scene for investigations. The freeway was closed from 7AM until 4PM. The Peoria Traffic Management Center (TMC) became aware of the incident from the Peoria Streets Department at approximately 8:00 AM and supported arterial management by monitoring cameras along routes that people were detouring on and making sure that traffic signal timing was efficiently moving traffic. Traffic signals on key routes were able to adjust to the increased arterial volumes, and TMC staff monitored traffic flows until the incident was cleared, and the freeway traffic was no longer diverting to Peoria arterials.
- **A major planned freeway work zone for the widening project along Loop 101 between I-17 and Pima Road** (through the City of Phoenix and City of Scottsdale) **and between Baseline Road and the Loop 202 Santan Freeway** (through the City of Mesa, City of Tempe, and City of Chandler) created a continuous need for coordination efforts across the freeway and arterials. There were ongoing ramp frontage road closures, ongoing lane restrictions, and occasional full freeway closures that needed to occur while a new general-purpose lane and auxiliary lanes were being added to Loop 101. There were varying levels of coordination with the local agency TMCs, depending on the location of construction. Construction began early in 2019 and was completed in 2022. Although information was being shared about planned closures between ADOT and the cities, not every agency TMC was always notified of restrictions.

It is these types of events, though they do not occur daily, that can cause tremendous strain on the entire transportation network when they do occur. Involvement from all parties to react to and monitor a restriction on the freeway is required.

3.5.2 CORRIDOR CHALLENGES AND DESIRED CHANGES

The ATCMTD grant application for the Loop 101 Mobility Project identified a set of corridor challenges that the project would look to address through ICM strategies and systems. These challenges help define the desired changes that will help identify and organize ICM concepts as part of this ICM system ConOps and the concept develop for other components of the Loop 101 Mobility project (adaptive ramp metering, adaptive traffic signals, connected vehicle applications for transit signal priority and traveler mobility application). Both the challenges and the desired changes are show in **Table 5**.

Table 5 – Corridor Challenges and Desired Changes to be Pursued by the Loop 101 Mobility Project

Corridor Challenge	Desired Change
Challenges Identified in the Loop 101 Mobility Project ATCMTD Grant Application	
Increase in congestion and delay	• Optimize use of existing infrastructure and data to enhance corridor mobility and reliability • Improve ability for agencies to inform or influence travel behavior
Increase in crashes	• Reduce likelihood of incidents occurring on the corridor • Improve corridor operators' ability to respond quickly to changes in corridor operations • Improve ability for agencies to inform or influence travel behavior
Reduction in transit schedule adherence	• Optimize use of existing infrastructure and data to enhance corridor mobility and reliability • Enhance multi-modal operations on the corridor
Lack of timely and coordinated response plans	• Elevate coordination between corridor operators during non-recurring operational conditions • Improve corridor operators' ability to respond quickly to changes in corridor operations
Underutilized arterial capacity	• Optimize use of existing infrastructure and data to enhance corridor mobility and reliability
Limited real-time performance monitoring	• Optimize use of existing infrastructure and data to enhance corridor mobility and reliability • Expand data availability to support corridor monitoring
Increase in large-scale events hosted near corridor	• Optimize use of existing infrastructure and data to enhance corridor mobility and reliability • Elevate coordination between corridor operators during non-recurring operational conditions • Improve ability for agencies to inform or influence travel behavior
Additional Challenges Identified During Loop 101 Mobility Project Efforts	
Independently owned and operated transportation systems at each agency	• Elevate coordination between corridor operators during non-recurring operational conditions • Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor
Inconsistent work zone coordination between ADOT and local traffic staff	• Elevate coordination between corridor operators during non-recurring operational conditions • Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor
Extent of the corridor (61 miles) and various operating environments (grid vs. non-grid network) and operating philosophies among agencies along the corridor	• Elevate coordination between corridor operators during non-recurring operational conditions • Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor • Provide an ICM environment and tools that advance operations in a way that is supported by agencies and provides a blueprint for scalability

Corridor Challenge	Desired Change
Stakeholder transitions and changing priorities at operating agencies	• Elevate coordination between corridor operators during non-recurring operational conditions • Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor • Provide an ICM environment and tools that advance operations in a way that is supported by agencies and provides a blueprint for scalability
Unfamiliarity and lack of trust with automation and ICM operational strategies	• Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor • Provide an ICM environment and tools that advance operations in a way that is supported by agencies and provides a blueprint for scalability

3.5.3 LOOP 101 ICM GOALS

As evident in **Table 5**, there are some desired changes that are relevant to multiple corridor challenges, resulting in nine unique desired changes. Because these desired changes are the drivers for developing the Loop 101 Mobility Project concepts, they were advanced as project goals, and include:

1. Optimize use of existing infrastructure and data to enhance corridor mobility and reliability
2. Improve ability for agencies to inform or influence travel behavior
3. Reduce likelihood of incidents occurring on the corridor arterials
4. Improve corridor operators' ability to respond quickly to changes in corridor operations
5. Enhance multi-modal operations on the corridor
6. Elevate multijurisdictional coordination between corridor operators during non-recurring operational conditions
7. Expand data availability to support corridor monitoring and traveler information
8. Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor
9. Provide an ICM environment and tools that advance operations in a way that is supported by agencies and provides a blueprint for scalability for future ICM projects

In addition to these project goals, a set of specific metrics targets for the Loop 101 Mobility Project were included as part of the original grant application and will be reported to FHWA throughout the duration of the Loop 101 Mobility Project grant-funded activities. **Table 6** below summarizes the relationship between the goals that were derived from the corridor challenges and the specific metrics that were identified; these goals will be reported to FHWA to track progress toward the project goals and the overall goals of the USDOT's ATCMTD program. The goals and metrics are categorized into four Focus Areas:

- Safety
- Mobility and Cost Savings
- Traveler Information
- Institutional

Table 6 – Project Goals and Key Reporting Metrics

Focus Areas**	Project Goals	Proposed FHWA-Reported Metrics**
Safety	• Reduce likelihood of incidents on the corridor • Improve corridor operators' ability to respond quickly to changes in corridor operations	• Reduce traffic incident management response time on Loop 101 corridor • Reduce number of secondary crashes on Loop 101 and identified parallel arterials
Mobility and Cost Savings	• Optimize use of existing infrastructure and data to enhance corridor mobility and reliability • Improve corridor operators' ability to respond quickly to changes in corridor operations • Enhance multi-modal operations • Elevate coordination between corridor operators during non-recurring conditions • Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor	• Reduce egress time for mega events (50,000+ attendees) • Increase transit on-time arrival within the corridor • Provide cost savings to travelers through reduction in travel times and reduction in fuel use
Traveler Information	• Improve ability for agencies to inform or influence travel behavior • Expand data availability to support corridor monitoring and traveler information • Provide an ICM environment and tools that advances operations in a way that is supported by agencies and provides a blueprint for scalability	• Increase public awareness of ICM through dissemination of information on all agencies' websites and publications • Increase public trust in alternate routing and alternate mode information by providing reliable and consistent information
Institutional	• Elevate coordination between corridor operators during non-recurring operational conditions • Expand data availability to support corridor monitoring and traveler information • Support interoperability between processes, systems, and data sources to bridge system and process inconsistencies along the corridor • Provide an ICM environment and tools that advances operations in a way that is supported by all agencies and provides a blueprint for scalability	• Create an operational system that is transferable to other corridors within the Phoenix metropolitan area • Formalize public-private partnerships with companies who are innovating and manufacturing connected or autonomous vehicles and associated equipment to create a mutually beneficial collaborative environment for next generation technology development

***Identified in Loop 101 ATCMTD grant application for Quantifiable System Performance Improvements*

The ICM strategies outlined in this ConOps will be modeled at a high level to help set realistic targets for each of the reported metrics that the Loop 101 Mobility stakeholders agree are in line with their vision of ICM and are achievable. The metrics and targets identified will help demonstrate the quantifiable, future benefits of the ICM concept from the perspectives of agency operations staff, agency leadership, and the traveling public.

3.5.4 CORRIDOR OPPORTUNITIES AND RESOURCES

While the ICM concept articulated in the ConOps identifies strategies and tools to address gaps or challenges to operations along the corridor, there is also an opportunity to leverage and build upon existing investments and resources along the corridor to address these challenges:

- Core data systems, including the ADOT Event Reporting System (ERS) and the Regional Archived Data System (RADS) serve as the data engines that support 511, az511.gov, social media alerts, ARIS alerts, and data sharing with public and private partners.
  - ERS includes statewide closures, restrictions, planned events, incidents and weather sensor data to provide status for the statewide highway network.
  - RADS collects and stores traffic data from agencies across the region including data from the ADOT FMS, local agencies, third-party sources and public safety/emergency response dispatch (CAD) systems. RADS processes travel times for the region’s travel time program for freeways and arterials.
  - ARIS is integrated with RADS and automatically disseminates information to agencies to support operations decision-making when incidents impact the network. ARIS provides timely notifications to the affected traffic operations centers and provides continuous updates on traffic impacts throughout the incident duration.
- The connected vehicle components of this project will leverage the technology advancements and lessons learned of the Arizona Connected Vehicles Initiative and MCDOT SMART*Drive*SM program - a partnership between MCDOT, ADOT, FHWA and the University of Arizona that develops and demonstrates advanced ITS applications, including the Multi-Modal Intelligent Traffic Signal System (MMITSS) technologies, evaluate benefits, and provide a model for future connected vehicle applications. The partners have collaborated to develop the Anthem Test Bed to evaluate and test these advanced technologies.
- The Regional Community Network (RCN) is a high-speed fiber-optic communications system designed to share video, data, and other information among regional agencies. The RCN is the region’s communication backbone that supports interagency congestion mitigation activities, links member agencies via a wide area network, and reduces duplicative costs by providing fiber communications for shared use.
- AZTech is a regional traffic management partnership in the Phoenix Metropolitan area that guides the application of Intelligent Transportation System (ITS) technologies for managing regional traffic. The AZTech Partnership and organizational structure has been in place for more than 25 years and provides a strong foundational of multi-agency collaboration and consensus building around operations and strategy implementation.
- MAG Systems Management and Operations (SM&O) Plan – Driven by the MAG ITS Committee, a regional SM&O Plan was developed in 2018 outline the vision and set of strategies and investment areas for ITS and TSMO within the MAG region. This plan was used to inform the TSMO components and recommended investments in the Regional Transportation Plan and future considerations as the region looked to pursue an extension of

the Prop 400 regional sales tax. The SM&O Plan was organized around four investment 'buckets', with the first being ICM. The investments and projects in the ICM bucket are consistent with and supportive of the ICM investments envisioned for the Loop 101 Mobility Project and provides significant regional momentum and policy support for ICM in the region.

4 OPERATING AND SYSTEM NEEDS

This section summarizes the needs from the operations side (people perspective) and system side (both from the user of the system perspective as well as from the underlying system functionality perspective). These perspectives are separate but related categories and are used as an entire collection of operating and system needs, as shown in **Figure 4**, to drive the concept development.

Figure 4 – Operating and System Needs

4.1 OPERATIONAL USER NEEDS

The operational user needs focus on the operational aspects of ICM in terms of people and processes and are based on the goals and objectives for ICM. These were developed in the Operations Plan.

The Loop 101 stakeholders want the proposed DSS to identify when ICM-related actions are needed and for the DSS to recommend appropriate response actions. However, one of the core operating principles for this Loop 101 Mobility Project is that each agency will retain control of its systems and, initially the implementation of traffic signal control strategies for the ICM response will continue to be manually processed; as agencies gain trust in the ICM concept over time, agencies may consider advancing to more fully automated implementation. There are some automated functions currently in place that would remain in place. These include automated data transfers between local agency systems and CAD systems and RADS, and automated notifications distributed by ARIS. This means that some level of manual processes will be required for decision-making and strategy implementation (i.e., changing signal timing, coordinating with another responder, monitoring a system or device).

Understanding the importance of the people and process-driven operations for ICM for the Loop 101 corridor, **Table 7** identifies the Loop 101 ICM Operational User Needs that were developed as part of the Loop 101 Mobility Project Operations Plan.[1]

Table 7 – Loop 101 ICM Operational User Needs

Operational User Need	Description
1. Need for all potential ICM responders to be informed of an ICM event	When an ICM event occurs all responders (traffic, transit, law enforcement) from any impacted agency (freeway, arterial, transit) needs to receive a timely notification.
2. Need a process to support making quick and timely	There needs to be a decision-making process in place to support ADOT and arterial traffic and transit responders in determining when they

[1] Loop 101 Mobility Project Operations Plan v1, Table 4, page 14, April 2021

Operational User Need	Description
decisions on when an ICM response strategy is warranted	need to enact an ICM-related response, and this will need to be done with minimal latency. Identifying a data-driven threshold may be a function of the DSS in the future, but an interim manual process and/or threshold is needed.
3. Need to discourage travelers from detouring on undesirable or non-viable arterial routes during ICM	When travelers are being diverted from the freeway onto adjacent arterials, strategies need to be available to deter people from using undesirable or non-viable roadways, such as those with limited capacity, those without necessary operational capabilities, or those that would have negative impacts to adjacent land uses (i.e., hospitals or schools).
4. Need cross-jurisdictional coordination when implementing and managing ICM strategies	Traffic, transit, and communications staff in adjacent agencies need to coordinate when implementing operational strategies or disseminating traveler information to avoid uncoordinated or conflicting operations or inconsistent information.
5. Need to be able to implement ICM strategies 24/7/365, when warranted	Agencies who may be responsible for implementing ICM strategies need to have plans in place to provide after-hours coverage and the ability to access agency traffic management systems to implement ICM strategies or monitor conditions.
6. Need to visually monitor the ICM network in real-time during ICM	Agency traffic management staff always need to be able to visually monitor arterial and freeway facilities within an ICM area to support situational awareness.
7. Need real-time arterial restriction information for the ICM network to be centrally available to all responding agencies	Accurate, real-time arterial restriction information such as planned construction, planned special events, or information about other nearby incidents needs to be consistently available to all Loop 101 Mobility stakeholders. This information is necessary to support decision-making for ICM responses, to help traffic, transit, and emergency responders avoid arterial routes that are operationally restricted.
8. Need to be able to update and adapt ICM responses and processes	The Loop 101 Mobility stakeholders need to have a process in place to review ICM strategies and processes, such as signal timing plans, coordination processes, or traveler information strategies, and identify changes and adjustments that are needed to improve their effectiveness.
9. Need to define traffic management roles and responsibilities during different ICM conditions	The role of staff who will support traffic management during ICM events with varying conditions (time of day, severity, location), including but not limited to TMC staff and local law enforcement.
10. Need operating plans to allow agencies to respond without latency when ICM events detour traffic to arterials	Pre-determined response strategies are needed to be able to quickly formulate traffic and transit responses when an ICM event is initiated and a response is warranted. These could include signal timing plans for preferred arterials, transit alternate routing strategies, arterial diversion plans, and internal agency processes for monitoring and responding to events impacting arterials

4.2 SYSTEM USER NEEDS

As part of the ICM ConOps, there are additional User Needs that are identified in **Table 8** below to reflect additional system and tool-specific user needs for DSS operations and functionality. These system user needs were informed by the Operational User Needs, stakeholder responses to a User Needs

Survey, and input from stakeholder discussions. System User Needs are grouped into the following system function categories:

- Operations Data Collection and Processing
- User Interface
- Decision Support
- Collaboration
- Public Information Dissemination
- System Management

Each System User Need is mapped back to an Operational User Need to demonstrate traceability.

The needs identified in **Table 8** will help direct the future software development of the DSS. There are additional needs for operating, maintaining and modifying the system once it is successfully developed and integrated. A discussion of options and maintenance needs, many of which are more people and process related, are found in Section 7.2 – Systems Operations and Maintenance. A discussion about modifying and revising the system is found in Section 7.3 – Change Management.

Table 8 – Loop 101 ICM System User Needs

System Function	System User Need	Related Operational User Need
Operations Data Collection and Processing	1. Continuously access data from existing agency transportation and transit systems along the ICM corridor and arterial alternate routes	5, 6, 7
	2. Leverage (not duplicate) existing regional databases and sources of operational data	2, 4, 7
	3. Support 'real-time' identification of traffic events occurring on the Loop 101 freeway that may impact arterial and transit operations	2, 7
	4. Aggregate and store historical data (traffic, transit, event, incident) and response actions during ICM events and system documentation (configuration management, testing reports, installation plans, etc..) and make them retrievable for post-incident review and analysis	8
	5. Synthesize disparate data sources from multiple agencies that might be in different formats without unnecessary duplication.	4, 7
User Interface	6. Support dissemination of real-time notifications to system users based on user customization preferences and ICM operational needs.	1
	7. Provide operating agencies with a user-friendly platform to support 24/7 real-time situational awareness of operational conditions of transportation facilities within the Loop 101 corridor	4, 5, 7
	8. Display data in formats that are easy to view and understand by system users	2
	9. Support user-driven customization of graphical user interfaces	
Decision Support	10. Generate and disseminate recommended operational actions to take that are specific to each impacted operating agency based on pre-defined response strategies and real-time conditions	2, 10

System Function	System User Need	Related Operational User Need
	11. Generate and disseminate recommended operational actions to take based on changing conditions	8, 10
	12. Adapt and improve decision making algorithms over time based on historical trends and conditions during previously completed ICM events	8
Collaboration	13. Support real-time, inter-agency coordination and collaboration for multimodal corridor operations	4, 9
Public Information Dissemination	14. Disseminate accurate and real-time multimodal traveler information to travelers on the corridor and travelers destined for the corridor	3
	15. Support agencies in disseminating information to travelers about desired traveler behavior in response to corridor conditions	3
System Management	16. Support manual input and adjustments of pre-approved response strategies	8, 10
	17. Support management of system user accounts	
	18. Provide system security	
	19. Track and generate reports on decision support performance, system performance, usage, and user activities	
	20. Support continuous program monitoring and multiple operating modes	

The operational concept for the Loop 101 ICM will be made up of various strategies that address the Operational User Needs from the Operations Plan and of system components that address the System User Needs.

5 ICM SYSTEMS OVERVIEW

This section provides an overview of the proposed Loop 101 ICM system, including a description of the specific capabilities or functions of the proposed DSS, the sub-systems required for those functions, and the roles and responsibilities of the Loop 101 stakeholders both related to the DSS and the overall ICM process.

5.1 PURPOSE OF THE PROPOSED ICM SYSTEMS

With trends toward increasing delay, an increase in the number of crashes, an increase in the number of large-scale events hosted near the Loop 101 corridor, and other conditions on the Loop 101 corridor, it is becoming increasingly important to organize the operations of the corridor through a collaborative freeway and arterial network response to incidents, work zones, events, or other conditions that can significantly impact traffic in a matter of minutes.

ICM will facilitate improved real-time freeway-arterial coordination when incidents impact Loop 101 and divert traffic onto adjacent local streets. The proposed ICM systems are envisioned to include a DSS, which will be the main analytics engine for ingesting and processing data related to the Loop 101. There are other supporting components and interfaces that may feed data to the DSS or receive DSS outputs to ultimately support agency situational awareness and their ability to respond to unplanned events, coordinate, and share information among operating agencies and the public. These systems will leverage and elevate existing data, systems, and processes for traffic management and traveler information to provide an operational environment where corridor-wide responses to freeway events can occur faster, be more coordinated between agencies, and optimize the use of freeway, arterial, and transit capacity to safely move people along the corridor.

The fundamental strategy to employing ICM in response to a freeway restriction is to safely divert freeway traffic off the freeway at exit points prior to the restriction, actively detour traffic along a parallel route (or routes) around the freeway restriction and re-route traffic back onto the freeway at a location downstream of the restriction. While this Loop 101 ICM concept is focused on non-recurring congestion events on the Loop 101, the ICM lifecycle and operational approaches outlined in this ConOps may be applied to ICM events due to recurring congestion if that is a direction that the Loop 101 Mobility stakeholders choose to pursue in the future.

5.2 L101 ICM OPERATIONAL CONCEPT

The Loop 101 ICM will rely on capabilities of a DSS and supporting components, in tandem with manual processes and coordination, to support each stage of the ICM Lifecycle. The proposed ICM Lifecycle, shown in **Figure 5**, considers the stages of an ICM event from a broader corridor context considering impacts to the freeway, arterials, and transit routes. It depicts the sequence of steps or conditions of an ICM event that will occur regardless of the type of ICM event (planned/unplanned, full closure/partial closure).

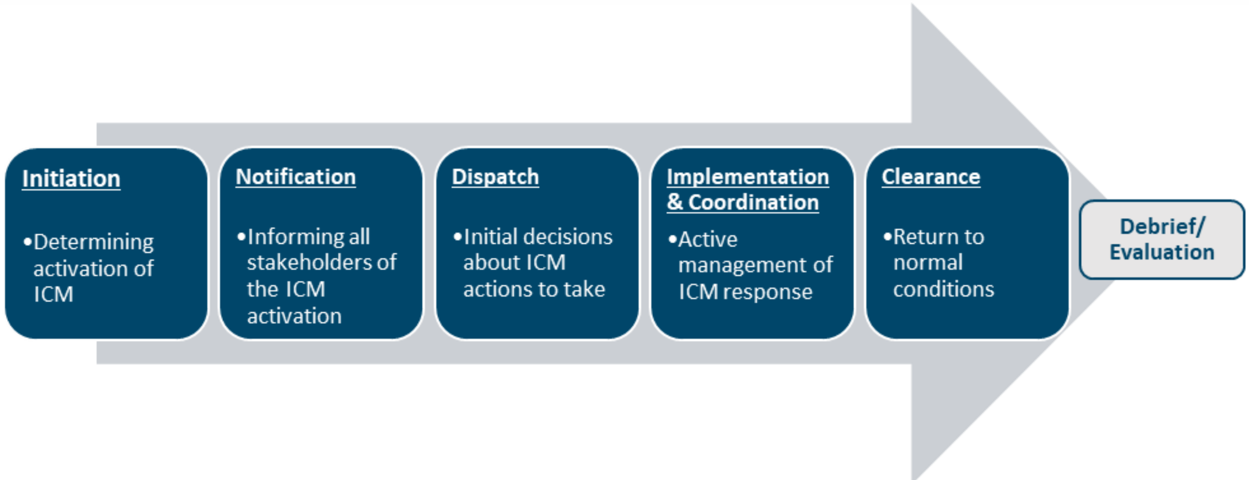


Figure 5 – Loop 101 ICM Lifecycle

Figure 6 outlines the existing ICM processes for the Loop 101 operating environment. This diagram highlights some of the needs and gaps related to consistency of processes on the arterial side, especially for notifications of potential ICM events, and implementing response activities in response to an ICM event. The ICM systems will look to address these gaps to elevate ICM processes for the corridor.

There is desire from the project stakeholders to consider a phased implementation of DSS capabilities to allow for implementation of quicker, near-term improvements as well as the opportunity to gain trust and understanding with a new system before moving towards an ultimate buildout. It is also recognized that not all DSS capabilities outlined in this Loop 101 Concept of Operations may be feasible as part of an initial phase, and partners recognize that full DSS capabilities will likely be implemented in phases over time. As such, **Figure 7** outlines an initial or 'Phase 1' condition to put into place some initial high priority DSS capabilities, as well as some process improvements to improve consistency of coordination processes to elevate ICM in the near-term. In Phase 1, it is envisioned that the DSS will be developed, initial DSS algorithms and logic will be built and processes will be developed to support ICM steps for determining an ICM event, distributing notifications and updating status. An initial user interface also will be established in this phase. Data connections to the DSS, including from ADOT data sources and RADS will be established. MCDOT will work with local agencies to establish connections from local agencies to RADS so there is one data feed providing local agency data and transit data to the Loop 101 DSS. MCDOT will establish an ICM Coordination role to support communications and coordination with local agencies during this initial phase. This role is described in more detail in 5.2.2 and 5.2.3.

Finally, **Figure 8** outlines opportunities for future buildout phases of the DSS that could look to automate additional processes to further elevate and standardize the ICM process. With initial capabilities established, the future DSS may include more automated functions and enhancements to the user interface. Future data sources may also be explored, such as agency data types and sources or additional third-party data not currently available or not currently being used to support ICM.

Components of each of these process diagrams are explained in greater detail later in this section.

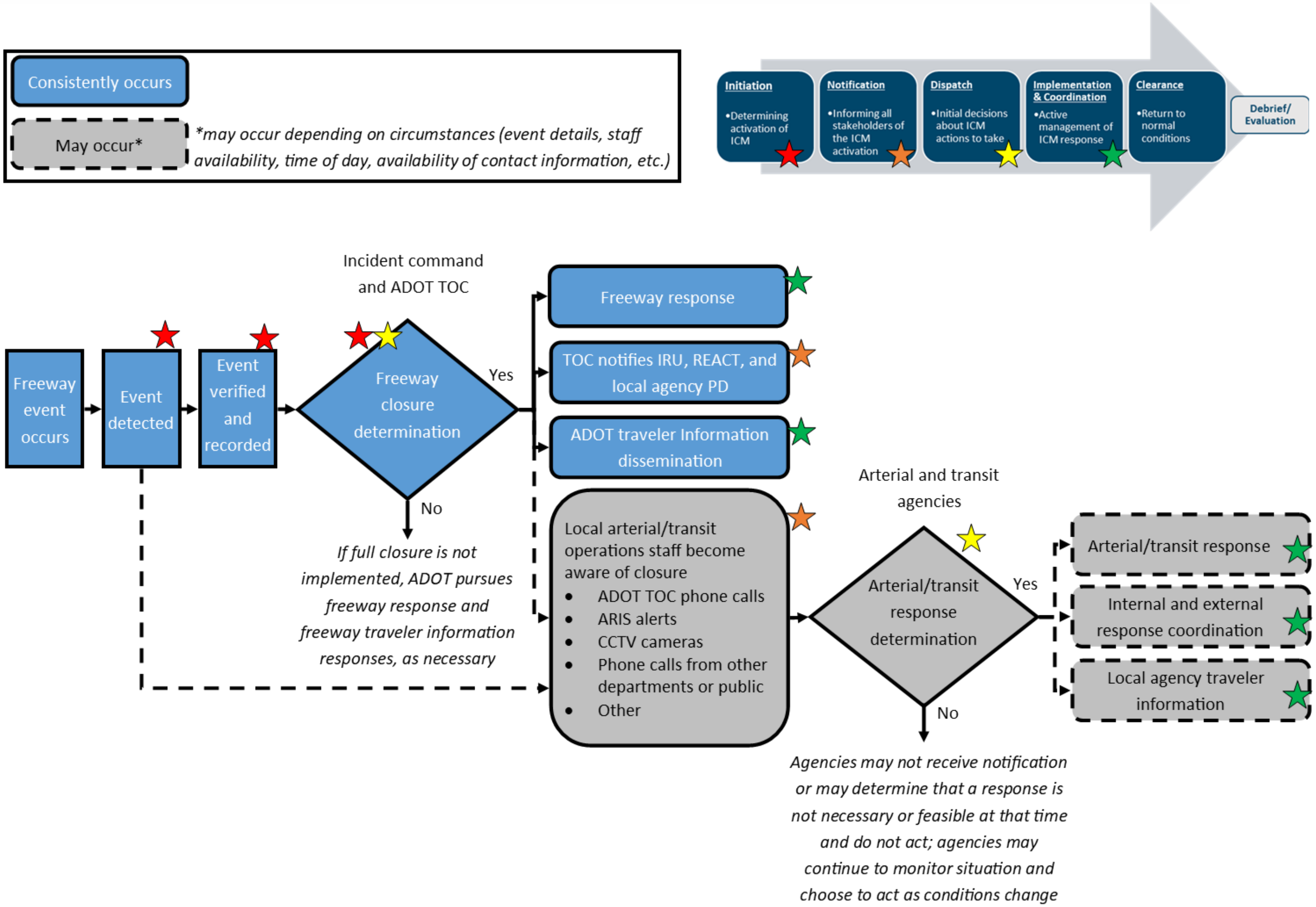


Figure 6 – Current Processes

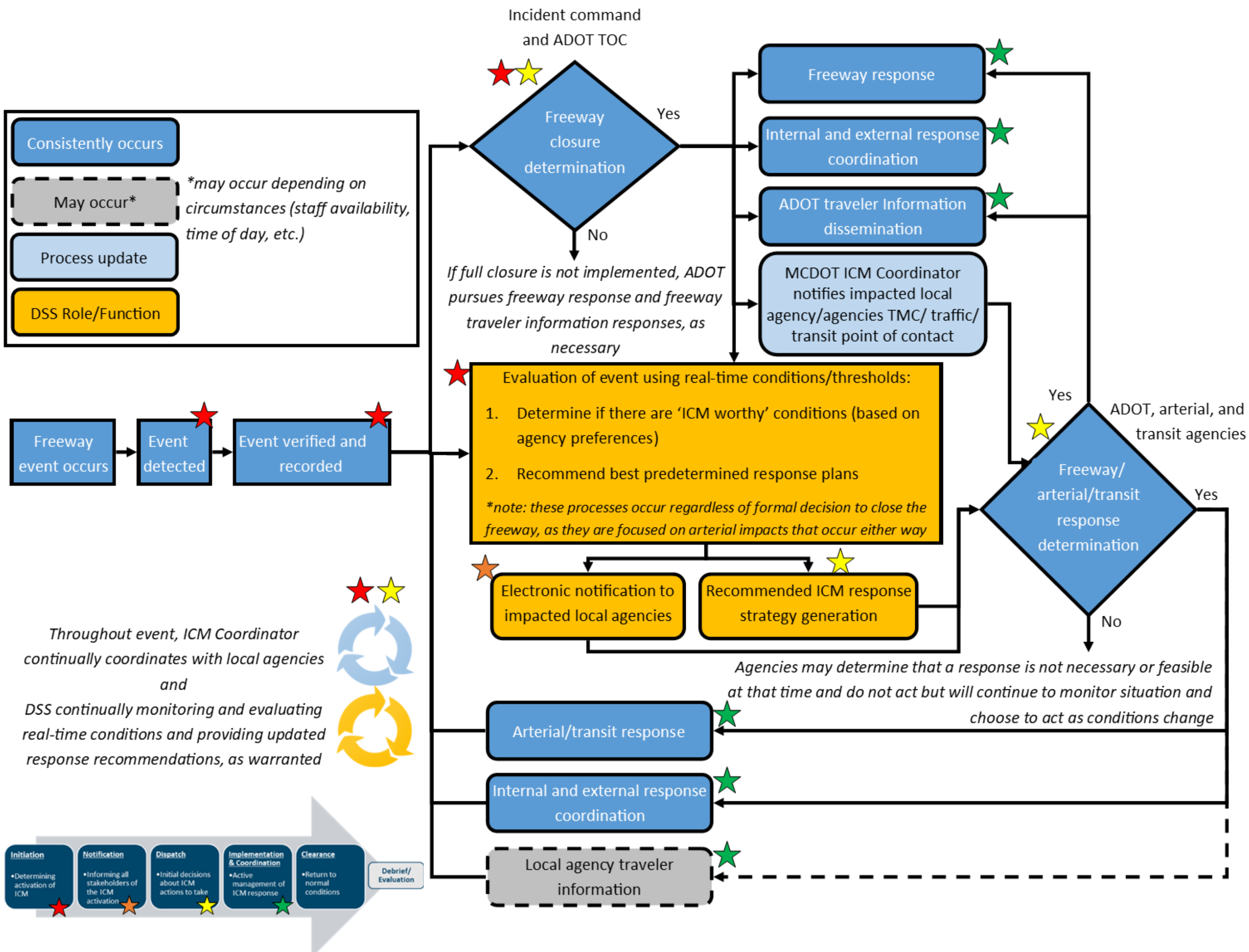


Figure 7 – Envisioned Initial Process Improvements and DSS Functions

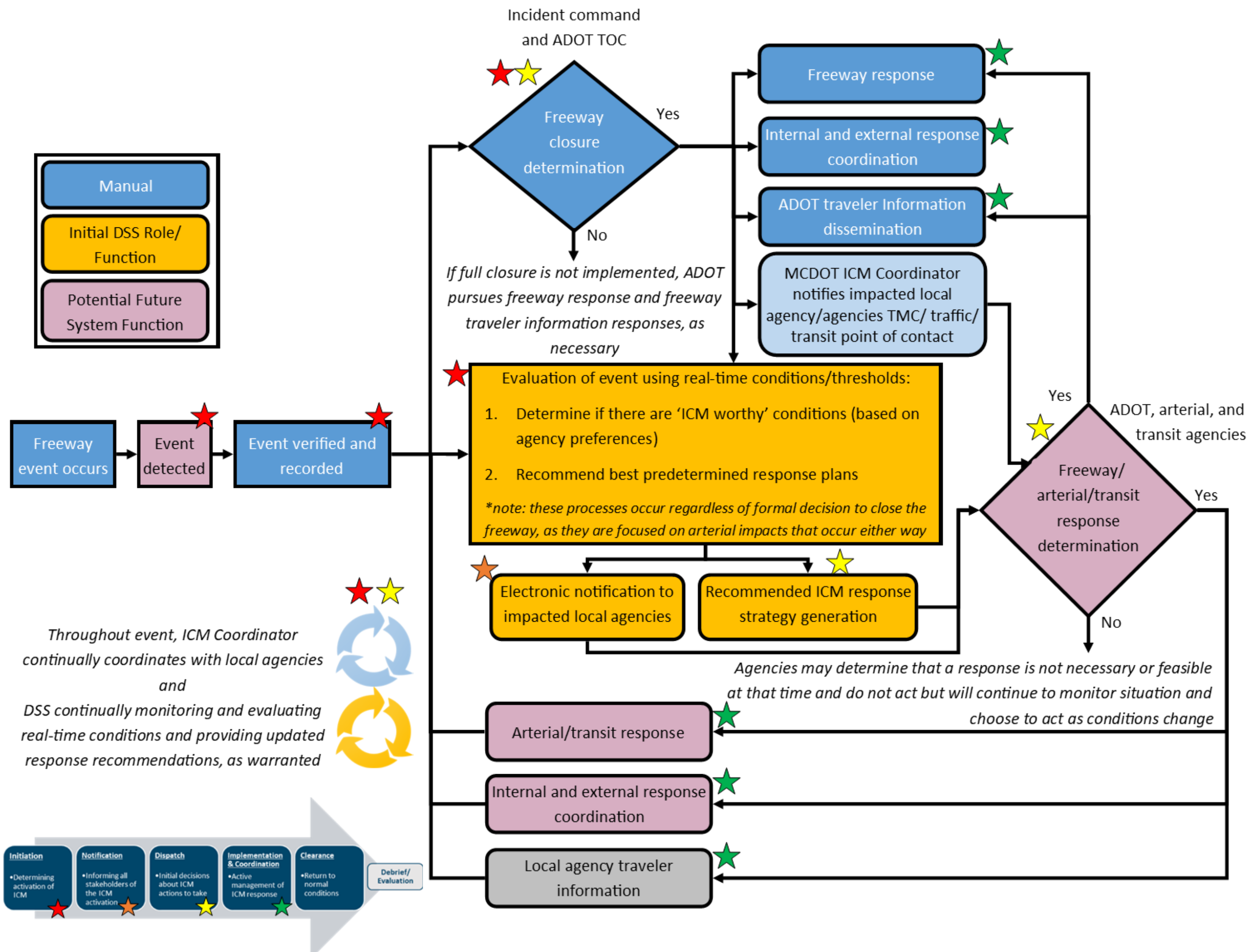


Figure 8 – Future Processes and DSS Functions

In support of the above graphics, the specific capabilities or functions that an ultimate buildout of ICM systems could provide within each lifecycle step, along with necessary manual activities or processes, are described below.

The following terms are used in this description and are defined as follows:

- All Users – describes all agency staff who directly interact with the ICM systems and associated modules/components.
- All Agencies – describes all L101 stakeholder agencies, regardless of whether they are interacting with the ICM systems or not.
- All Impact Agencies – describes the agencies who are impacted by a specific ICM event and are thus receiving notifications/alerts from the ICM systems.

5.2.1 INITIATION

The *Initiation* step identifies the need for ICM activation when a threshold has been met that indicates ICM-worthy conditions.

ICM SYSTEM CAPABILITIES

The ICM systems will be capable of monitoring real-time operations data from a variety of agency-owned or operated sources and associate current conditions with historical data and system logic to detect user-defined "ICM-worthy" conditions.

Examples of ICM-worthy conditions may include, but are not limited to:

- When a specific number of lanes are restricted on a freeway.
- When a specific percentage of total capacity is restricted on a freeway.
- When AZ DPS and ADOT verify "full closure" conditions.
- When there is a fatal incident on the freeway.

The DSS logic will not be based on a specific threshold or set of conditions but will instead allow for user-defined preferences as to when users would like to acknowledge the potential need for ICM. This will provide opportunities for individual agency users to establish different thresholds based on factors such as time-of-day, incident location, or relationship to other traffic conditions (roadwork, special event, weather, etc.).

AGENCY ACTIVITIES AND PROCESSES

The following agency or user specific activities and processes were initially identified in the Loop 101 Operations Plan for the Initiation step and continue to be necessary even with the functions provided by the DSS:

- All users to provide preferences for 'ICM worthy-conditions' in the DSS platform.
- All agencies to maintain existing devices and software systems that feed into the ICM systems that can support incident and ICM threshold identification. Device/system outages should be monitored and reviewed by the owning/operating local agency to ensure these issues are resolved in a timely fashion.

- All agencies to have information that can be provided by the system and other agency partners of any planned work zone or special restrictions within the Loop 101 Corridor.
- Law enforcement agencies to enter incident information into their CAD systems (at present, there are few direct data feeds from local law enforcement CAD into transportation agency systems, but this is a future desired data sharing relationship).
- ADOT to receive incident notifications and closure decisions from DPS.
- ADOT to verify full closure or capacity restriction based on DPS or other incident notification and enter information about ICM event into FlexCAD and ERS. FlexCAD and ERS will both feed the DSS with freeway incident information entered by the ADOT TOC.

5.2.2 NOTIFICATION

The *Notification* step initiates processes to let other corridor partners know that ICM-worthy conditions have been confirmed and that ICM will be activated for a segment of the corridor.

ICM SYSTEM CAPABILITIES

The ICM system notifies all impacted agencies of the ICM event based on user-defined inputs. For this step, user-defined inputs to be built into the DSS logic will be related to notification thresholds (what conditions must be met to trigger notification for different users), and the agency's preferred notification format (email, text, call).

For notification thresholds, DSS logic will not be based on one threshold or set of conditions but will allow for user-defined preferences as to when and who would like to be notified of a potential ICM event. This will provide opportunities for agency users to establish different thresholds based on factors such as time-of-day, incident location, incident severity, or relationship to other traffic conditions (roadwork, special event, weather, etc.).

Examples of ICM notification thresholds may include, but are not limited to:

- Any time there is a verified full closure of the freeway in a certain location.
- When there is a verified full closure of the freeway during specified business hours.
- When there is an incident on the freeway at the same time as an arterial roadway closure within the designated detour footprint of the incident location.
- When arterial detour routes experience a level of congestion (to be set by each agency) that indicates that the agency should take a response action.

The ICM notification will include information that allows agency users to quickly identify the severity of the conditions of the event on their jurisdiction, or the potential impacts that could evolve. This could include incident details that are available from the DSS, including the initial FlexCAD or ERS entry (location, severity, direction of travel, lane or ramp closures), snapshots of camera feeds within the vicinity of the incident (freeway, ramp, frontage road), and congestion/speed data for the freeway, ramps, and adjacent arterials in a map-based format.

The ICM systems should leverage the AZTech ARIS as the foundation for notifications for ICM. ARIS is planned to be upgraded in coordination with RADS enhancements during the DSS design and development . Enhancements to ARIS to support this concept will include, at a minimum:

1. Improved filtering capabilities to be able to calculate and isolate conditions that meet the various notification thresholds and preferences identified by agencies in the system;
2. An enhanced notification format so they can be more easily distinguished from non-ICM alerts; and
3. Expanded information in the notification to provide agencies with the data necessary to make an informed decision about their response actions.

The DSS will also provide a feedback loop that looks to provide acknowledgment or confirmation from each agency that the alert was received. While the decision to take action in response to the notification will be with each individual agency, there is a need to establish a process to confirm that impacted agencies are aware that there is an event that may impact traffic operations. If the DSS does not get confirmation that an agency received an alert (through a read receipt), it may re-send or escalate the notification, potentially sending the notification to a larger group within each agency (based on user-defined preferences) until confirmation is received. Additionally, the new MCDOT role to support ICM coordination, described more in the activities and processes section below, may provide some redundancy for this confirmation function of the DSS.

Recommended response strategies are addressed in the ‘Dispatch’ section.

AGENCY ACTIVITIES AND PROCESSES

In addition to envisioned system capabilities for notifications, a new function – ICM Coordinator – will be established to support situational awareness and coordination during ICM events focused on the arterial network. This coordination role will be supported by staff at MCDOT, which could include a combination of MCDOT TMC staff (during business hours) and MCDOT REACT staff (after hours). There will not be a designed ICM Coordinator role, but the function will be fulfilled with a combination of MCDOT staff. In the Notification stage, the goal of the ICM coordination role is to monitor notifications to arterial and transit operating agencies and monitor acknowledgements of ICM events. This process is envisioned to provide redundancy specifically for TMC/traffic operations staff, where current processes result in inconsistencies as to whether traffic operations staff are notified of an event, mainly because local TMCs are not 24/7 (while local police dispatch are). The ICM coordination role will be further defined by MCDOT in coordination with Loop 101 stakeholders. Furthermore, processes for after-hours monitoring and coordination also will be defined as these will be covered by MCDOT REACT staff; depending on the time of day and impacts, there may be limited coordination needed.

The following agency or user-specific activities and processes were identified in the Operations Plan for the Notification step and continue to be necessary even with the functions provided by the ICM system:

- All users to identify notification preferences (thresholds for notification, notification format and escalation steps) in the ICM system platform.
- All notified agencies to provide active confirmation that they received the notification through the ICM system.
- ADOT TOC to directly notify ADOT IRU, ADOT PIOs, MCDOT REACT/ICM Coordinator, and local agency PD Dispatch, via a phone call, for any verified full freeway closure event; the local agency TMC may also be contacted by phone by the ICM Coordinator.

- If a REACT Agreement is in place, the REACT TMC support staff to notify and begin coordination with local agency traffic/TMC staff of an ICM event and support traveler information dissemination.
- ADOT TOC to monitor freeway and update ERS and FlexCAD with ICM activation status and freeway response.
- All agencies to receive automated ARIS notification and automated ADOT My511 notification of ICM event.

5.2.3 DISPATCH

The *Dispatch* step is where initial decisions about ICM response actions are decided, coordinated, and executed. Dispatch actions prepare for the implementation of ICM along the Loop 101 corridor and may include, but are not limited to:

- Identifying preferred arterial detour routing for cars, trucks, and transit (based on pre-approved routes and routing plans) and recommending dispatch of REACT to support traffic management along the route.
- Identifying recommended signal timing strategies along arterial detour routes. This may include recommended updates to adaptive signal system parameters if agreed-upon by adjacent jurisdictions along an adaptive corridor.
- Monitor adaptive ramp metering response plans based on location of the ramp meters in relation to the closure.
    - Downstream ramps – deactivate metering if it has not already been turned off because of lack of congestion.
    - Near Upstream (several ramps upstream of closure) – no changes to ramp metering to allow queueing on the ramps to encourage people to divert.
    - Further Upstream – monitor ramp meter operations. The intended operations are peer-to-peer communication from first controller upstream of the closure to the upstream ramp to indicate limited capacity on the mainline so metering rates are reduced.
- Recommending traveler information messages to be displayed on DMS and through other traveler information outlets, including 511 agency social media.
- Recommendations for communicating/coordinating between agencies.

ICM SYSTEM CAPABILITIES

For this step, the DSS will be capable of formulating and recommending ICM response actions to be executed by impacted agencies based on real-time conditions and historical learning from past ICM responses. The type of data that the DSS will consider when formulating recommended response actions may include, but are not limited to:

- Known, planned restrictions on freeways or arterials such as work zone activity, lane restrictions or special events.
- Current vehicle queues on the freeway, arterial intersections, or freeway ramps within the impacted area of the corridor.
- Current vehicle speeds and travel times within the impacted area of the corridor.
- Volume of freight vehicles on any roadway within the impacted area of the corridor.

- Number of transit vehicles and transit schedule adherence on routes along any roadway within the impacted area of the corridor.

After analyzing the real-time situational awareness data, the DSS will factor in network-level considerations to formulate a set of ranked recommendations; network-level and predictive considerations may include:

- Likely impacts of proposed actions on traffic flow within the impacted area of the corridor.
- Likely impacts of proposed actions on transit performance within the impacted area of the corridor.
- Likely impact of proposed actions on pedestrian or bicyclist movement within the impacted area of the corridor.

The recommended response actions for each agency will be disseminated to the operating agencies via their preferred notification method, which might include a web-based ICM interface in addition to text, email, or phone call formats.

AGENCY ACTIVITIES AND PROCESSES

The Dispatch step is another step where the ICM Coordinator role will support situational awareness, particularly among arterial agencies, in addition to the DSS recommendations being transmitted. One role of the ICM Coordinator may to communicate with TMC/traffic/transit operations staff at impacted local agencies to make sure that they receive a recommended response plan and that they are monitoring the situation on their arterials and considering taking action. It will not be the role of the ICM Coordinator to influence or confirm a response activity or make decisions about a response activity, but the Coordination role will help make sure that arterial and transit agencies are engaged in the event and can help keep a network-level view of the event response, while local traffic staff remain more focused on managing traffic in their jurisdiction.

The following agency or user specific activities and processes were identified in the Operations Plan for the Dispatch step and continue to be necessary even with the functions provided by the DSS:

- All users to provide pre-approved ICM strategies for their jurisdiction into the ICM system.
- ADOT to configure ICM-specific ramp metering commands and algorithm adjustments based on ramp proximity to a closure.
- All agencies to maintain existing devices and software systems that feed into the ICM System that can support incident and recommended response strategy development
- Impacted agencies to receive ICM strategy action recommendations from DSS, confirm receipt and evaluate if a response action will be taken at that time, based on current conditions.
    - Verify alternate arterial route options, either remotely through cameras or physically by agency staff) or by requesting REACT assistance.
    - If necessary, notify adaptive system vendor (after getting agreement with neighboring agencies) to make changes to adaptive signal system parameters based on DSS recommendation.
- Impacted local agencies to coordinate with ICM Coordinator, as needed, on response activities (or decision to not take an action at that time).

- Impacted agencies to notify their respective Local PD, Local Maintenance, Local Transit, and Local PIO to notify them of the ICM event, and if response actions are required.
    - Impacted agencies to prepare range of staff (law enforcement, traffic control, transit, PIO) and equipment to mobilize for response if deemed necessary.
- ADOT to continually implement and manage appropriate freeway incident response strategies and document them in FlexCAD and ERS; this includes any updates to freeway response status.
- ADOT coordinating with IRU for updates on incident scene and impacts, and information from incident comment in the field (provided to ADOT via IRU).
- ADOT coordinating with AZDPS at the TOC for updates during initial mobilization of resources.
- REACT to coordinate with local agency traffic/TMC staff if a REACT response is recommended.

5.2.4 IMPLEMENTATION AND COORDINATION

The *Implementation and Coordination* step evaluates and implements actions taken to respond to the ICM event and provides an ongoing feedback loop to continually monitor and manage freeway, arterial and transit operations through the duration of the event.

ICM SYSTEM CAPABILITIES

There are three modes of operation that the ICM systems will support during the *Implementation and Coordination* step:

- **Initial Implementation**: Evaluating and taking initial actions taken by various operating agencies based on initial recommendations from the Dispatch step.
- **Ongoing Monitoring**: Continuously monitoring real-time corridor conditions (freeway, arterial, and transit) and referencing/learning from historical ICM activities to generate and disseminate updated recommended response actions for each impacted agency, if necessary, as conditions change. This might include recommending response plans for additional agencies that may not have been previously considered 'impacted' but are now impacted based on current conditions.
- **Ongoing Response and Coordination**: Ongoing response actions taken by various operating agencies based on monitoring or from updated recommendations generated based on changing corridor operational conditions.

INITIAL IMPLEMENTATION

To support the *Initial Implementation* mode, the ICM systems will monitor data related to real-time conditions within the networks of impacted agencies to identify and indicate changes in operating conditions (signal timing plans, traveler information messages, etc.) that might be a result of implementing the DSS-recommended response actions. The ICM system will also have a feedback mechanism to promote two-way information transfer between the system and the operating agencies so that agencies are able to acknowledge that they are engaged with the event. The DSS will be able to leverage this information as it updates response recommendations.

As part of DSS-recommended ICM response actions, the DSS will identify the most appropriate pre-approved signal timing plans for traffic signals along the recommended arterial detour route.

There is not envisioned to be a formal 'accept' or 'reject' process for DSS-generated recommendations. A core operating principle for the Loop 101 ICM is that local agencies will maintain full control and authority over their response activities and may choose to not immediately implement a response plan at the onset of an ICM event. Further, agencies may determine that an alternate strategy may work best, and may implement traffic management strategies that differ from the DSS recommendation. However, there is an expectation of all operating agencies that someone will be monitoring conditions and be available to coordinate and take an action if conditions warrant. As such, the DSS is envisioned to have a mechanism to confirm and indicate to others that an agency is engaged with the event, regardless of whether specific actions are being taken.

ONGOING MONITORING

The DSS will be continually monitoring real-time condition information, including changes to operating conditions resulting from implementation of recommended ICM strategies or other response actions put in place by operating agencies. The data and logic that will feed the DSS during the *Ongoing Monitoring* mode will be the same as that defined for the Dispatch step. The system will continually process the real-time condition information and any changes to infrastructure operations (such as signal timing plan changes) to identify conditions where new or modified recommended response actions might be warranted for one or more agencies to provide the best ICM response at that time. As systems such as ERS and FlexCAD are updated by TOC dispatchers, this information also will be ingested by the DSS, which will determine any updates to recommended response strategies. As noted above, this might include expanding the ICM-impact area to another jurisdiction and thus providing initial recommended response actions to a previously uninvolved operating agency. The system will also be programmed to learn from previous ICM events so that it gets 'smarter' over time and better able to adapt to local circumstances.

ONGOING RESPONSE AND COORDINATION

One major component of this mode is providing a user-interface to visualize and interact with the data and inter-agency activities related to the ICM event. An ICM dashboard platform will allow users to access, through both desktop and mobile interfaces, a variety of real-time and static information that can help indicate where actions have been taken and track ICM activities, view roadway/corridor condition information, and create opportunities for elevated inter-agency coordination.

An ultimate vision for a DSS-related user interface would generally provide the following types of information:

- ICM response activities
  - Indication of agency engagement in ICM event
  - DSS-generated recommended ICM response actions
  - Actions completed by other agencies in response to an ICM event
  - Traveler information messages disseminated for an ICM event (via ADOT DMS or social media alerts)
- Real-time roadway conditions
  - Freeway, arterial, and ramp speeds

    - Transit vehicle location and schedule adherence
    - Emergency response (IRU, REACT) vehicle location
    - Planned work zones or special event restrictions
    - Updates to ADOT ERS or FlexCAD with updates as the incident response progresses
- Agency staff contact information
- ITS device information
    - Locations and ownership
    - Operational status where available (e.g. signal operating/in flash, camera on/off, etc.)
    - Camera snapshots
- User Preferences and User Manual
    - Notification preferences (format and parameters)
    - DSS User Manual

Any user interface will have the ability to be customized by individual users, so each user's display provides what is most relevant or meaningful to them.

Figures 9 through 11 provide a graphical mock-up of the ultimate vision for how information may be visually displayed via a user-interface. Actual interface design, including prioritization of elements to be implemented within initial phases versus future phases, will be completed during the system design phase.

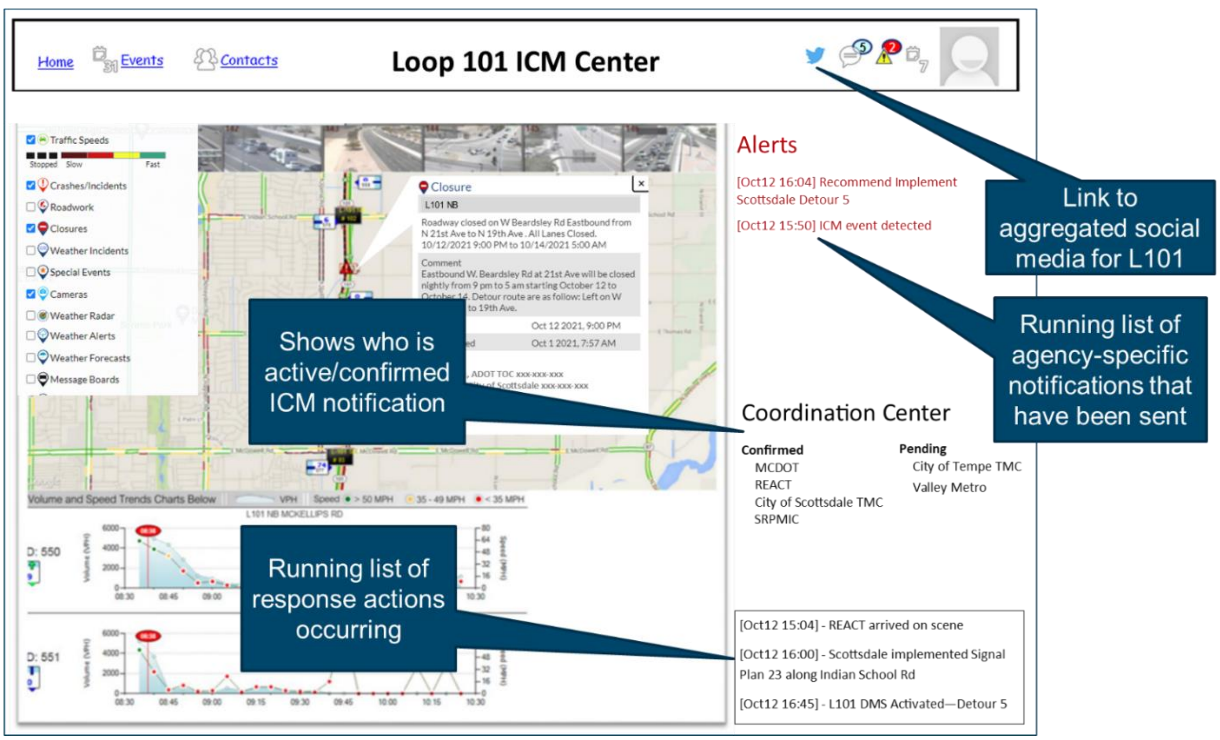


Figure 9– Proposed Features for ICM Response Tracking of ICM System Interface

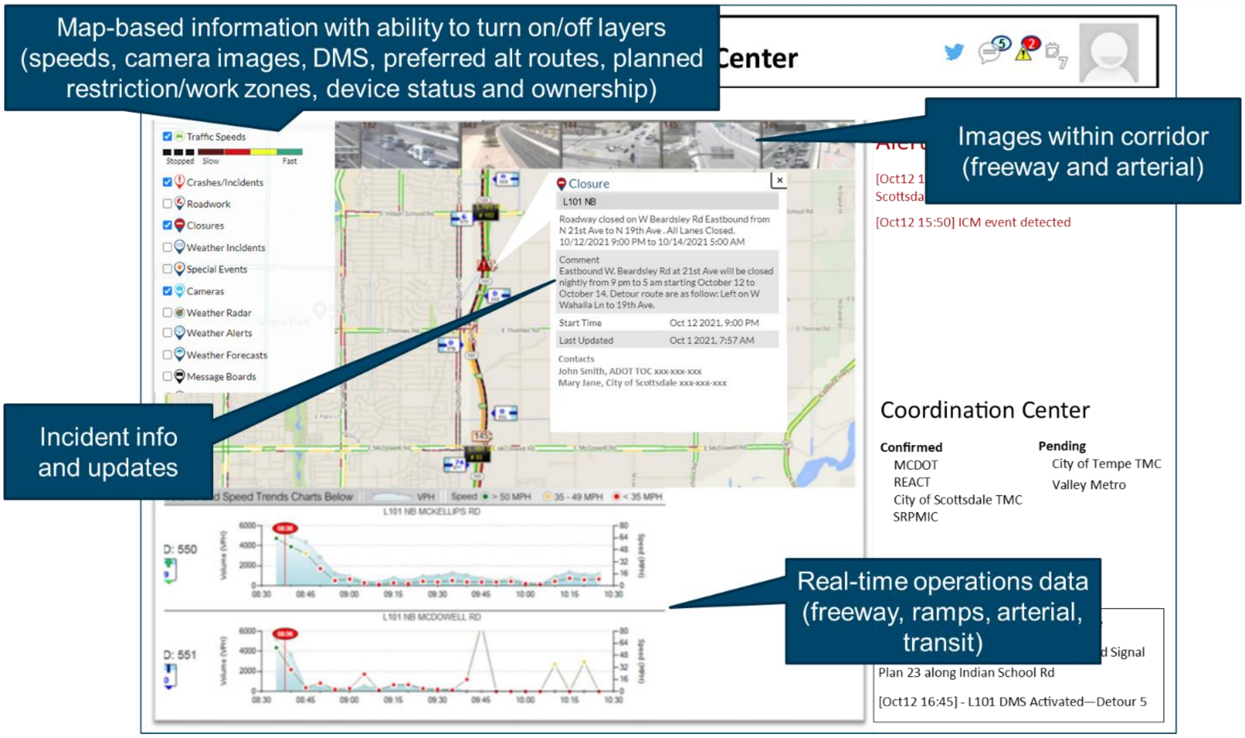


Figure 10 – Proposed Corridor Situational Awareness Features of ICM System Interface

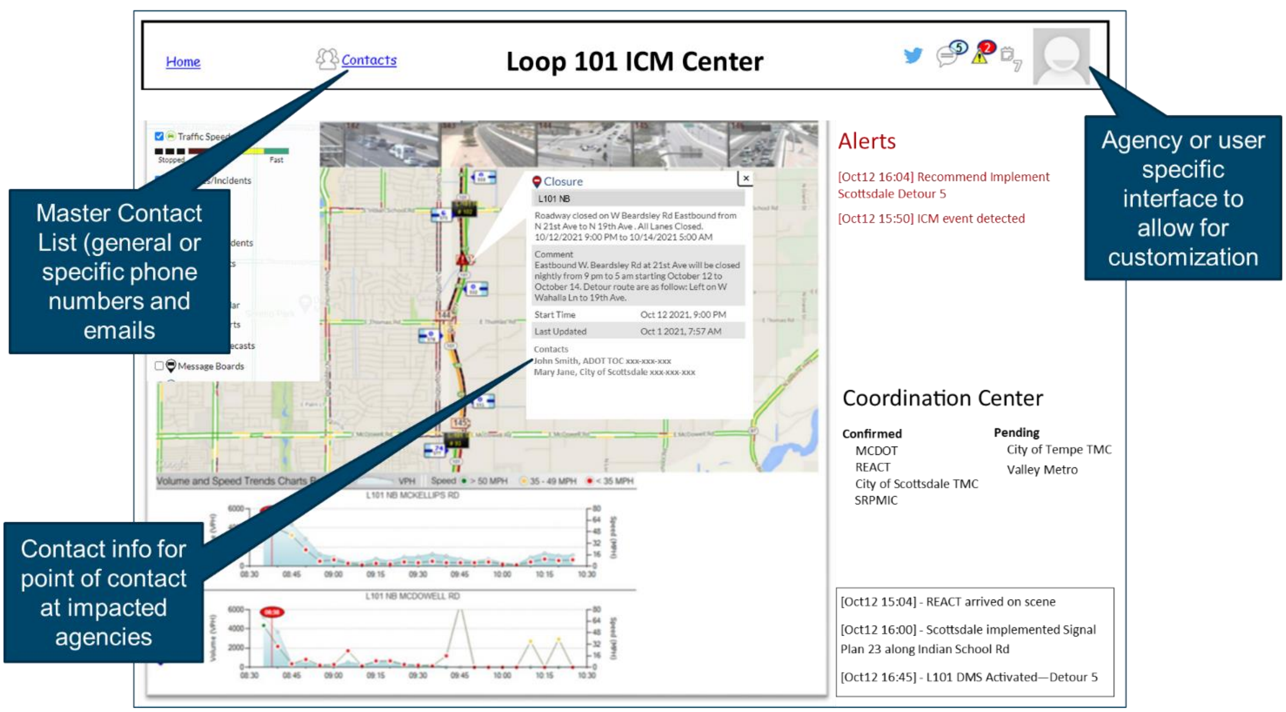


Figure 11 – Proposed Coordination Features of ICM System Interface

AGENCY ACTIVITIES AND PROCESSES

The following agency or user specific activities and processes were identified in the Operations Plan for the Implementation and Coordination step and continue to be necessary even with the functions provided by the DSS:

For DSS User Interface:

- All agencies to provide connections to data to support identified DSS user interface components.
- All users to set up and customize DSS user interface.

INITIAL IMPLEMENTATION

- All impacted agency users to access DSS interface when notified of an ICM event that will impact their jurisdiction/transit operations, this will indicate engagement with event (regardless of whether response actions are taken or not).
- Impacted agencies (freeway and arterial traffic management, transit operations) to evaluate and take response actions as needed, such as implementing an alternate route and/or updating a signal timing plan.
- Impacted agencies who are implementing response actions to notify other local partners (law enforcement, transit agencies, PIOs) of event status and local response actions.
- ADOT TOC to post messages on freeway DMS about incident and alternate routing (after confirmed by local agencies).

ONGOING MONITORING

- All traffic and transit operations staff to monitor roadway conditions in vicinity of closure and along alternate routes to identify if response strategies need to be modified or expanded.
- Coordination between local traffic/TMC, REACT, ICM Coordinator, local maintenance, and local law enforcement to manage traffic through a specified arterial detour (if necessary).

ONGOING RESPONSE AND COORDINATION

- All traffic and transit operations staff to adjust response strategies or implement new response strategies as warranted; this may be based on updated DSS recommendations/notification that are received.
  - Local traffic/TMC staff to adjust traffic signal timings along arterial detour if necessary, including interchange signals they manage.
  - ADOT TOC to inform ADOT Signal Operations staff if signal timing change at an ADOT-controlled interchange is warranted.
  - Coordination between IRU and the ADOT TOC, as well as between the ADOT TOC and AZDPS at the TOC for updates to incident response.
  - Coordinate between local traffic/TMC and local PD to identify and respond to any traffic incidents that might occur on active detour route.
  - Coordinate with REACT, local maintenance, local law enforcement, and local transit staff to adjust detour route if deemed necessary (such as if an arterial incident occurs on a detour route).
  - Transit Operations and Control Center (OCC) to monitor transit routes and implement any necessary route adjustments with drivers and communicate to Communications staff.

- All impacted agency traffic/TMC/transit staff to notify other local partners (law enforcement, PIOs, maintenance) of major changes in conditions or response actions.
- Public safety field officers coordinate through Incident Command for ICM event if Local PD involvement is necessary. IRU or AZDPS to coordinate any messages from Incident Command and the ADOT TOC.
- ADOT TOC to update incident response activities through FlexCAD and ERS, which will feed updates to the DSS.
- ADOT to update messages and notifications to travelers through DMS and social media.
- The DSS will document updates, traffic management strategy changes, changes in traffic conditions and other updates as the incident response progresses. This information and timeline are needed to support after action reviews.
- If within business hours, PIOs at impacted agencies to monitor ADOT social media feed and coordinate with local traffic/TMC and local law enforcement related to ICM event and provide and/or forward/relay messages to the public.
  - Coordinate with adjacent agency PIOs to ensure consistent messaging for event and response conditions.

5.2.5 CLEARANCE

The *Clearance* step marks the initiation of processes and coordination to conclude the ICM event and return to normal conditions. Because ICM considers operations of a multi-faceted corridor consisting of freeways, arterials, and transit routes, the definition of an 'all clear' condition will likely be different to different agencies; the conclusion of an ICM event will occur only when 'all clear conditions' are reached for all components of the corridor.

DSS CAPABILITIES

The DSS will support the Clearance step by:

- Monitoring conditions and gathering operating agency input to determine and notify agency operators of 'all clear' conditions for facilities as they are achieved.
- Determining when an ICM event is complete, meaning all clear conditions have been achieved for all operations along the corridor and received and acknowledged by all affected agencies.
- Automatically close out an ICM event when 'all clear' conditions have been met for all impacted agencies.

Similar to the evaluation of 'ICM worthy-conditions', the 'all clear' condition will not be based on a single, specific threshold or set of conditions but will instead allow for user-defined preferences as to when ICM can be deactivated. This will provide opportunities to establish different thresholds based on factors such as time-of-day, incident location, or relationship to other traffic conditions (roadwork, special event, weather, etc.). The ConOps recognizes that 'all clear' may have a specific definition in terms of an incident clearance, and that 'all clear' as it pertains to impacts on traffic will vary. The system logic factors to determine 'all clear' conditions will be the same as the suite of data used in the Initiation step.

AGENCY ACTIVITIES AND PROCESSES

The following agency or user specific activities and processes were identified in the Operations Plan for the Clearance step and continue to be necessary even with the functions provided by the DSS:

- All users to identify clearance preferences (thresholds for clearance notification) in DSS platform.
- All users to monitor DSS user interface to monitor real-time conditions and activities related to ICM event.
- ADOT to coordinate through Incident Command to identify and document in FlexCAD and ERS various clearance milestones – when some lanes are re-opened, when all lanes are re-opened, when the freeway is clear, when responders begin to leave the scene; etc.
    - ADOT to notify IRU, REACT, ADOT PIO and local law enforcement of incident clearance on the freeway.
- All impacted agency PIOs to provide traveler information messaging about various stages of clearance on both the freeway and arterials.
- ICM Coordinator monitors for 'all clear' and coordinates with local agencies (if needed) to be sure local agencies are getting the information that they can return arterials to normal conditions.
- Local TMCs may coordinate with local law enforcement, maintenance, PIO and neighboring TMCs as ICM conditions transition to normal conditions during event clearance. This may depend on the time of day (if outside of business hours, there may be limited coordination between neighboring TMCs)
- OCC/transit staff to receive DSS notifications related to 'all clear' for the freeway and subsequently the arterials and coordinate activities to return transit to normal service.
    - Inform transit drivers of clearance and request them to resume normal route.

5.2.6 AFTER-ACTION DEBRIEF/EVALUATION

Corridor stakeholders who participate in an ICM event will convene after the conclusion of the event to review the actions that each agency took, with a focus on the activities that worked well and resulted in successful outcomes, activities that did not work well and need to be adjusted, and any gaps or activities that did not occur during the event. Impacts to traffic, success of traffic diversion plans and other parameters will be addressed and documented as part of the after-action debrief. A key element of the after-action debrief is to understand how the DSS supported the different stages of the ICM event, including notifications, recommended strategies (and updates as the incident progresses), and overall situational awareness for involved agencies.

DSS CAPABILITIES

The DSS will support the after action-debrief and evaluation by:

- Archiving, generating, and making accessible data reports and action logs to help agencies reconstruct the event and evaluate key performance measures to determine what went well and what could be improved in the future to continue to elevate ICM and inter-agency coordination.
- System learning by archiving data and system response activities and using previous ICM scenarios to adapt and improve system functioning during future ICM events.

In addition to system-generated functions, the DSS will be configurable by agencies after the completion of an after-action debrief so that agencies can update parameters such as pre-approved detour route plans, signal timing plans, and traveler information messages that are used during DSS response recommendation analysis. Also, with the configurable user interface, agencies can change their preferences for notification thresholds, the user interface, and ‘all clear’ thresholds.

AGENCY ACTIVITIES AND PROCESSES

The following agency or user specific activities and processes comprise the After-Action/Evaluation step and will be supported by outputs from the DSS:

- ADOT and MCDOT to initiate after-action debrief within two weeks of conclusion of ICM event.
- Impacted agencies to attend after-action debrief and provide input to discussion.
- Impacted agencies to identify and make any desired changes, based on change management process (see section 7.3) to DSS-inputs (pre-approved strategies, user preferences on notification, thresholds, etc.).
- Impacted agencies to identify and document/update documentation for the various individual activities and coordination completed for ICM events.

5.3 PROPOSED SYSTEM GRAPHIC

The proposed system graphic, which provides an overview of the inputs, interactions, and outputs of the ICM System concept can be found in **Figure 12**. This graphic reflects agreed-upon user needs and corridor operating principles related to leveraging existing data and data management systems to provide data to the DSS.

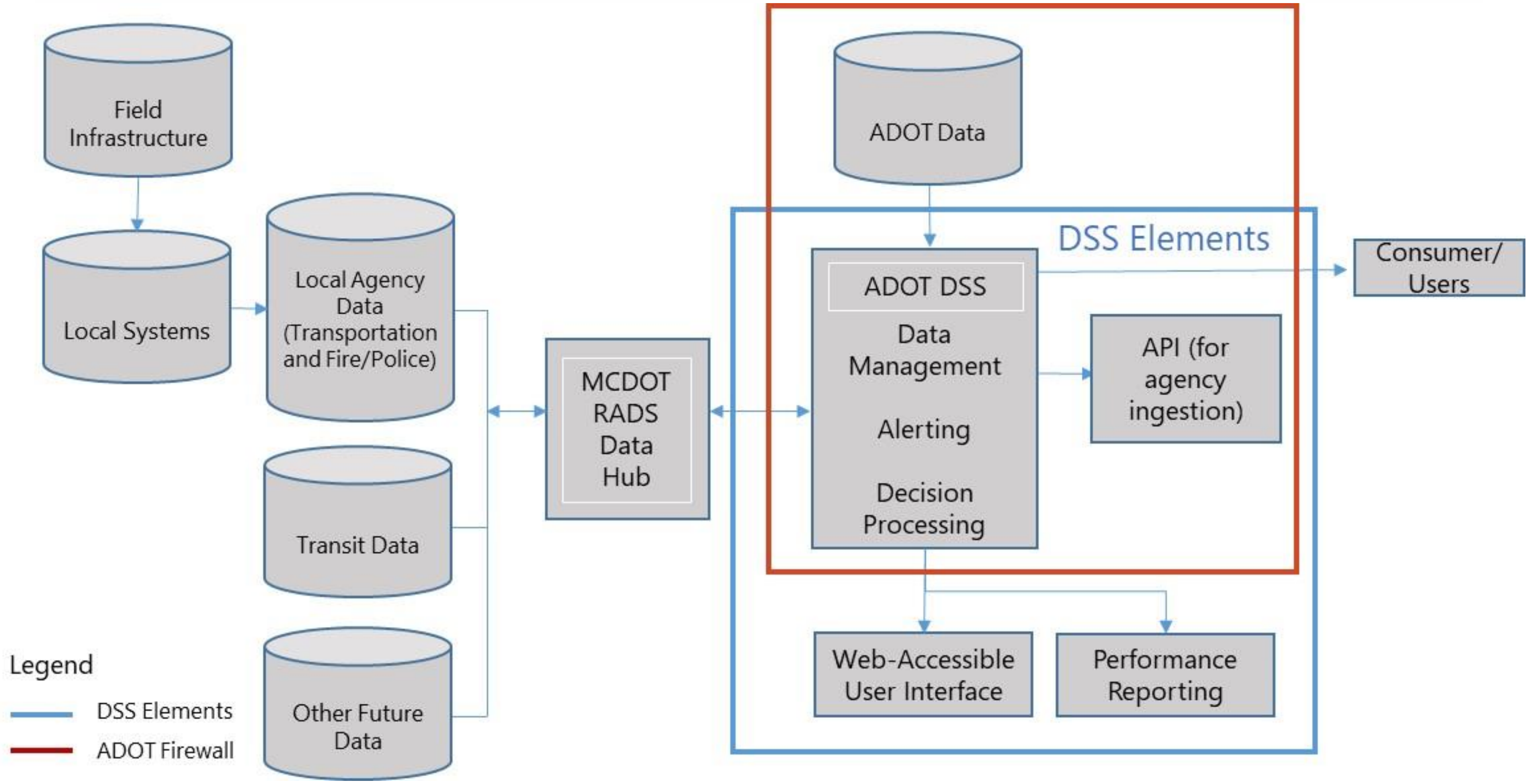


Figure 12 – Loop 101 ICM System High Level Architecture

5.4 KEY SUBSYSTEMS

As depicted in **Figure 12**, the ICM System is made up of a variety of elements, or subsystems, that independently operate but are also situated to interact in specific ways to address and provide system functionalities and capabilities. The subsystems for the Loop 101 ICM System include:

- Field infrastructure
- Local central management systems
- ADOT Data
- MCDOT/RADS Data Hub
- Decision Support System
- Consumers/Users
- Communication networks

Users of the ICM System include freeway, arterial, and transit management agencies, law enforcement and incident management responders, public information officers, and vehicular and transit travelers as end-user recipients of ICM System outputs.

ADOT Data includes all of the field and system data to be provided through existing ADOT systems and ADOT contracted systems. This includes:

- ADOT TOC FlexCAD data for incident details and updated incident information
- Event Reporting System, which is the statewide lane closure and restriction system that includes ADOT work zones, large scale planned events and feeds ADOT's 511 system
- ADOT field equipment, including CCTV, ramp meters, DMS, and detection systems. The DSS will access this data from ADOT's central systems, not directly from the field equipment.
- ADOT traffic and interchange signals
- Third-party probe data for speeds and travel times (freeways and arterials)

Field infrastructure collects data that contributes information to support ICM operations, as well as equipment and services that can be used to affect traffic and travel behavior within the corridor. The DSS will not have any interaction with specific field infrastructure but will rely on the data that will come through connections to central systems, including local agency ATMS connections to RADS. Key field devices supporting system operations include:

- Vehicle detectors providing information about traffic speeds, volumes, and flows, including devices for measuring travel time. Note, the DSS will access this data via existing data platforms such as RADS, ATSPM, and others that might be available at the time of DSS development and integration.
- Traffic signals used to control traffic movements at intersections and interchanges.
- Dynamic message signs installed along arterials.
- CCTV cameras to provide snapshots of freeway and arterial roadway conditions. The DSS will leverage the Luxriot system which already collects CCTV images from L101 agencies.
- Vehicle onboard devices to collect information about the location and status of incident response vehicles, maintenance vehicles and buses. This data will be sent from central AVL and vehicle management systems, not through a direct interface with individual vehicles.

While all of these devices or data may not currently be available, to achieve the desired system functionality, the DSS should be developed with the capability to include the data types and sources above.

Local central management and data systems provide centralized management of field devices and data at local agencies, including incident and road restriction data, that provide connections between the ICM system and the field elements and critical key data sets.

- Centralized management systems used by roadway operators to control the various devices and collect data generated by the systems they are operating. These include systems for traffic signals, CCTV cameras, ramp meters, and transit operations. As shown in Figure 12. local agencies will send this information to RADS, which will send data to the DSS.
- Traffic incident management systems used by law enforcement and incident response operators to support dispatching, management, and coordination for incident response. RADS currently includes CAD data from Phoenix and Mesa Fire, and Mesa PD, for arterial incidents, with Tempe PD added in the future.
- Road closure systems used by agencies to track road closures and restrictions from planned and unplanned events. These include local agency permitting systems and regional lane closure systems. RADS currently aggregates this data for multiple L101 agencies and makes this data available using the Work Zone Data Exchange (WZDx) format.

Communication networks that may be used to circulate information between system components housed at different locations.

- Each operating jurisdiction owns and maintains its own transportation communications network comprised of fiber and wireless communications.
- MAG RCN is a regional shared fiber network that provides agencies with direct access to one another to share information across agency systems/networks.

MCDOT/RADS data hub aggregates, centralizes, and archives transportation data from multiple sources to promote comprehensive data processing and sharing at a regional scale. The raw and processed data will be available as inputs to the ICM system.

- AZTech RADS provides a regional ITS data warehouse of real-time and historical operations data including traffic, construction, and incident impacts and serves as the database serving many other software systems that provide information to the public.
- Local agency data, including field equipment status, transit operations and local law enforcement/responder data will be shared with the DSS through the RADS data hub.
- MCDOT will establish connections to local transportation management agencies, transit management, and will maintain connections to Phoenix Fire and Mesa Fire for incident data.

Decision Support System Elements includes modules implementing the intelligence of the ICM system and components operated by the ICM system.

- The ADOT DSS includes business rules used to identify conditions when response plans should be developed to address active incidents or events, and to develop appropriate responses to the identified incidents or events.
  - ICM event identification – Processes used to identify incidents and events, and to characterize their impacts on network operations.
  - Processes enabling stakeholders to review the suggestions made by the DSS and make decisions about taking action. This information will be shared through the web-accessible user interface.
- Security and administration processes to control who has access to the system and to ensure system security.

- Data management and warehouse holding information collected by the ICM system to characterize corridor operations and information generated by the ICM system itself during corridor evaluations and the development of response plans to incidents and events.
- Data from the DSS to support system and ICM performance reporting.
- The DSS should include an API that can be ingested by systems such as ADOT's 511, transit operations and other systems.

Web-Accessible User Interface enabling ICM system users to visualize the collected data and results of processing by the ICM system and facilitate inter-agency coordination between ICM system users. This will be the primary interaction between local agencies and outputs from the DSS. Interface modules include:

- Alerts and notifications about event status in multiple formats.
- Notifications of ICM strategy recommendations in multiple formats.
- Interface to monitor ICM response actions/conditions.
- Interface to document and monitor corridor and individual roadway conditions.
- Applications to coordinate with other responding agencies.

Consumers and users will consume outputs from the DSS through various traveler Information systems and outlets that are connected to/fed by the ICM system to provide information about real-time and upcoming roadway conditions and restrictions and providing recommended actions for travelers such as recommended routing or trip timing.

- AZ 511 statewide traveler information portal, including phone and az511.gov web system that provides real-time roadway condition and traveler information as well as notification, trip planning, and route guidance tools for travelers.
- Mobile applications owned and operated by state, regional, local, and transit agencies and by the private sector that provide traveler information.
- Social media outlets managed by PIOs at ADOT, AZDPS, MCDOT, Valley Metro, local agencies.
- News media alerts and notifications via radio/television broadcasts and social media tools.
- ARIS automated notification system to alert agency subscribers of incidents in their designated areas.

5.5 TRAVELER MOBILITY APPLICATION SYSTEM CONCEPT

While the proposed DSS is the backbone of the Loop 101 ICM System and will be the system that agency stakeholders interact with, there are ICM system user needs related to traveler information dissemination that can be supported by the DSS but will not be completely achieved by the DSS.

The following concepts for this ICM System may require a tool external to the DSS to fully achieve the functionality:

- Disseminating L101 ICM-specific alerts throughout the ICM lifecycle (initiation, implementation, clearance) to travelers preparing to travel or already traveling within the Loop 101 corridor.
- Disseminating information on specific alternate routing instructions that agencies choose to provide to support optimized arterial detouring routing.
- Disseminating to travelers travel information for specific trips using different routes and different modes to inform their decision making relative to the mode, routing and time they choose to travel.

As part of this L101 ICM System concept, a traveler mobility application is envisioned to support these functions as part of the larger L101 Mobility Project concept. The concept of the traveler mobility application is that it will interface with both the ICM DSS and the traveling public to provide timely and consistent information about ICM events along the Loop 101 corridor. The goal of the application is to provide travelers with information in a format that informs decision making so that traveler behaviors – such as a travelers mode choice, route choice, and time of trip – are consistent with operating agency goals of optimizing the use of corridor capacity during ICM conditions.

6 OPERATIONAL ENVIRONMENT

This section documents the existing corridor operating principles that will not be modified by this ICM concept, processes to be undertaken from both the people side and the system side to make full use of the concept that has been developed, and recognition of the permissions and agreements that need to be developed to support this operational environment.

6.1 OPERATIONAL OVERVIEW

This section describes the existing corridor operating principles and anticipated overarching guidelines for how this Loop 101 ICM concept will be used.

6.1.1 EXISTING CORRIDOR OPERATING PRINCIPLES

The goal of the Loop 101 ICM is to elevate operational capabilities while being respectful and cognizant of the desires and existing processes of the various agencies along the corridor. To accomplish this, a set of overarching Corridor Operating Principles were identified which represent operating conditions or processes that are currently in place and that will not change with the introduction of ICM strategies or a DSS.

The Loop 101 Corridor Operating Principles include:

- Each agency will continue being responsible for operating their own independent systems and infrastructure and determining any arterial diversion routes within their jurisdiction.
- Existing operational data exchanges will occur through RADS and the RCN.
- Operational Guidelines developed by AZTech for viewing/control sharing of CCTV and signal timing status data are in place and will continue to be reviewed annually.
- REACT can help to support ICM alternate routing for agencies that opt for an agreement with REACT for ICM*.
- ARIS and ADOT's My511 are existing systems that are available to agencies to receive notifications and information for user-defined areas of interest, including Loop 101. ARIS is available to agencies by requesting access from MCDOT, while My511 is publicly available through www.az511.gov.
- ADOT is the primary source of disseminating social media notifications to travelers about freeway events.

MCDOT REACT provides specialized traffic management support on arterial roadways during arterial incidents that requires traffic management for an extended period of time. REACT support services include confirming viability of detour routes, closing/restricting roads, supporting dissemination of detour information to travelers through portable message boards and traffic control equipment, and supporting inter-agency coordination, including coordination between traffic management staff at different agencies and coordinating with ADOT IRU for freeway ramp closures. A pilot program for REACT to support ICM was conducted in the City of Scottsdale and provided the initial framework for the full Loop 101 Mobility program. MCDOT has established agreements with some of the Loop 101 Mobility Partners for REACT to support ICM operations. The agreement is part of a MAG-funded project identified in the Systems Management and Operations Plan.* ***Local agency partnering with MCDOT for REACT support during ICM is optional but encouraged.*

6.1.2 LOOP 101 ICM OVERARCHING GUIDELINES

ICM Overarching Guidelines are conditions that must be true to support the ICM System Concept. They are a combination of general operational conditions that are either currently in place or that were agreed upon by Loop 101 Stakeholders as part of the development of the Loop 101 ICM Operation Plan and Loop 101 ICM ConOps and some agency-specific roles and responsibilities for ICM.

Overarching Operational Guidelines for ICM for Loop 101 corridor include:

- The DSS shall be owned, hosted and maintained by ADOT.
- Infrastructure data will be accessed from centralized systems, not direct field device access, in coordination with local agencies.
- The management of the DSS shall be conducted by ADOT with significant input from other partner agencies.
- The ICM Systems, including the DSS, shall be able to expand in concept to other corridors and other agencies in the future.
- ADOT ERS and MCDOT RADS shall ingest local agency construction information to support awareness of arterial restrictions that may impact ICM responses, primarily on arterial detour routes.
- ADOT TOC and MCDOT will have a list of up-to-date contact numbers for Local PD and Local Traffic/TMCs.
- ADOT ramp meters have adaptive capabilities that will automatically adjust to localized operating conditions.

6.2 EXISTING SYSTEM GAP ANALYSIS

A key concept of the ICM system is to leverage existing systems and data sources that are available to support the ICM concepts. The Loop 101 stakeholder agencies have put significant investments into local and regional systems that are instrumental to current operations of the Loop 101 corridor and the region as a whole, so it is both efficient and prudent that these systems are considered as part of the ICM solution; however, many of them will likely require upgrades or enhancements to address the ICM system concepts in this Concept of Operations.

Table 9 identifies the key existing systems that will likely play a role in achieving the ICM System concept and identifies the gaps or opportunities for improvements to allow them to best support the envisioned Loop 101 ICM operations.

Table 9 – L101 Existing System Gap Analysis

System	Description	Gaps for Supporting Loop 101 ICM
Regional Archived Data System (RADS)	Collects and stores traffic data from agencies across the region including data from the ADOT FMS, local agencies, third-party sources and public safety/emergency response dispatch (CAD) systems (Phoenix and Mesa Fire and Mesa PD). RADS processes travel times for the region's travel time program for freeways and arterials. Local agency, transit operations and public safety data will be aggregated by RADS and shared with the DSS systems.	• Does not currently include real-time transit data from Clever • Not used as a primary arterial data source for AZ511 (INRIX used instead) • Does not include robust detection data (limitation of agency data), especially advanced data such as turning movement counts and volumes
Event Reporting System (ERS)	Includes statewide closures, restrictions, planned events, incidents and weather sensor data, and combines with the ADOT freeway management system to provide real-time status for the statewide highway network.	• Is not currently integrated with DPS CAD, so all entries are manual by TOC dispatchers • Explore options for filtered data feed from ADOT FlexCAD system • Does not provide integration with RADS or other local agency data systems
Luxriot Video Management System	Regionally shared video management system where agencies can share CCTV camera images and PTZ control, if enabled, with other agencies throughout the valley. This is achieved through connection to the MAG Regional Community Network (RCN), which provides a regional communications backbone. Connection to the RCN allows agencies to share their video feeds and view the video feeds of other agencies as needed.	• Luxriot map interface is not user friendly
AZTech Regional Information System (ARIS)	Integrated with RADS and automatically disseminates information to agencies to support operational decision-making when incidents impact the network. ARIS provides timely notifications to the affected traffic/transit operations centers and provides continuous updates on traffic impacts throughout the incident duration.	• Event filtering process is not robust enough so too many notifications are sent • ARIS alerts do not currently provide all of the information for an incident desired by stakeholders, such as arterial camera images

System	Description	Gaps for Supporting Loop 101 ICM
Automated Traffic Signal Performance Measure (ATSPM) Database	Agency-owned real-time, high resolution data from traffic signals collected every 1/10 of a second that feed RADS ATSPM server.	• Not all agencies are participating • Some agencies that are collecting ATSPM data are not feeding the regional database • There is not a shared user interface/dashboard that is commonly used by agencies

6.3 AGENCY ROLES AND RESPONSIBILITIES

There is an expectation that a higher-level oversight of overall ICM processes will occur at multiple levels and across different stages of an ICM event. ICM is introducing an elevated level of operational response ownership among agencies in terms of "owning" processes for notifications, response activations, acknowledging alerts, and communicating response status to involved partners. The diversity of partner agencies and the number of independent systems involved in ICM responses means that oversight is also distributed yet needs to be coordinated. **Table 10** identifies stakeholders that have oversight of some portion of the overall ICM process; together, each of these oversight processes are needed to provide a cohesive ICM response.

Table 10 – L101 ICM System Roles and Responsibilities by Agency

Agency	Roles and Responsibilities during ICM Activation	Roles and Responsibilities for the ICM System
ADOT TOC	• Monitor and manage the freeway network (including DMS, traffic signals, ramp meters, vehicle detection) • Coordinate with DPS and incident command • Coordinate with IRU to support closures (and subsequent re-openings) • Coordinate with the on-site PIO for traveler information dissemination • Notify impacted agencies at the onset of an ICM response per standard procedures • Document freeway management response actions in ERS/FlexCAD • Participate in after-action debrief	• Own and manage the DSS including 24x7 use of the system, adequate staff to support the troubleshooting of the system, managing any licensing fees or maintenance contracts; and permissions control to manage the troubleshooting of the system • Define permissions and notification parameters for desired ADOT users or recipients of ICM System information in the DSS • Attend after-action debriefs after ICM activations • Host scenario workshops to update parameters and plans in ICM System • Host trainings for using the ICM System
MCDOT	• Oversee and coordinate arterial operations, including transit, during ICM events. This includes staffing for the ICM Coordination function. • Monitor and manage the arterial network in their jurisdiction • Document/communicate ICM response activities to ICM System throughout duration of ICM event • Coordinate with REACT to support alternate routes as needed • Coordinate directly with local departments and neighboring agencies during ICM activation • Lead and participate in after-action debrief	• • Lead RADS management and upkeep and support management and upkeep of other components of the ICM Systems relative to MCDOT • Lead coordination of after-action debriefs after ICM activations, which may leverage the AZTech Partnership • Establish pre-determined alternate routing and signal timing plans for MCDOT-owned facilities that would be ingested by DSS based on location and specific threshold • Define permissions and notification parameters for desired MCDOT users or recipients of ICM System information in the DSS • Participate in scenario workshops to update parameters and plans in the ICM System and

Agency	Roles and Responsibilities during ICM Activation	Roles and Responsibilities for the ICM System
		trainings for using the ICM System, which may leverage the AZTech Partnership
DPS	• Lead incident command for freeway activities • Field officers notify and coordinate with the ADOT TOC to support freeway traffic management during an ICM event • Participate in after-action debrief	• Define permissions and notification parameters for desired DPS users or recipients of ICM System information in the DSS • Participate in scenario workshops to update parameters and plans in ICM System and trainings for using the ICM System
Local Traffic/TMC	• Monitor and manage the arterial network in their jurisdiction • Document/communicate ICM response activities to ICM System throughout duration of ICM event • Coordinate with REACT to support alternate routes as needed • Coordinate directly with local departments and neighboring agencies during ICM activation • Participate in after-action debrief	• Establish pre-determined alternate routing and signal timing plans for local-agency owned facilities that would be ingested by DSS based on location and specific threshold • Define permissions and notification parameters for desired agency users or recipients of ICM System information in the DSS • Participate in scenario workshops to update parameters and plans in ICM System and trainings for using the ICM System
Transit	• Monitor and manage transit operations • Document/communicate ICM response activities to ICM System • Coordinate directly with local traffic/TMC during ICM activation • Identify and communicate to drivers any necessary detour routes or service changes • Support any ICM response activities where transit might be able to help play a role in continuing to move people along the corridor • Participate in after-action debrief	• Define permissions and notification parameters for desired agency users or recipients of ICM System information in the DSS • Participate in scenario workshops to update parameters and plans in ICM System and trainings for using the ICM System
Local Law Enforcement	• Coordinate with local traffic/TMC to call on REACT to support alternate routes as needed	• Define permissions and notification parameters for desired agency users or recipients of ICM System information in the DSS

Agency	Roles and Responsibilities during ICM Activation	Roles and Responsibilities for the ICM System
	• Coordinate directly with incident command and local TMC to facilitate emergency traffic detouring per pre-approved alternate route strategies • Participate in after-action debrief	• Participate in scenario workshops to update parameters and plans in ICM System and trainings for using the ICM System
Local Maintenance	• Coordinate directly with local TMC as needed • Support REACT to support alternate routes as needed • Participate in after-action debrief	• Define permissions and notification parameters for desired agency users or recipients of ICM System information • Participate in scenario workshops to update parameters and plans in ICM System and trainings for using the ICM System
REACT	• Provide traveler information message displayed on truck-mounted message boards • Coordinate directly with incident command and local TMC to verify alternate routes (where requested) and facilitate emergency traffic detouring per pre-approved alternate route strategies • Participate in after-action debrief	• Maintain agreements with local agencies to support arterial diversions from the freeway • Define permissions and notification parameters for desired REACT users or recipients of ICM System information • Participate in scenario workshops to update parameters and plans in ICM System and trainings for using the ICM System
PIO	• Provide or re-share traveler information messages on ICM event • Coordinate with other PIOs to ensure consistency of information • Coordinate directly with local TMC as needed • Participate in after-action debrief	• Define permissions and notification parameters for desired agency users or recipients of ICM System information • Participate in scenario workshops to update parameters and plans in ICM System and trainings for using the ICM System

6.3.1 PERMISSIONS TO SUPPORT ICM OPERATIONS

It will be necessary to define permission details for a variety of features and modules for the L101 ICM System. Examples and descriptions of important permission categories are provided below, although these will be further specified and defined during the system design phase:

- *Subscribed User/Subscriber* – Subscribed users who can only view and subscribe to notifications.
- *Agency User* – Can view notifications and full visual and data content for the corridor
- *Data Loader* – Users who can add or update system data and interface assets.
- *Site Administrators* – Can add/remove content for all users, manage users and view audit/event logs
- *Super Admin* – Can call other site related tasks such as sending alerts and import/export through the API

An Operating Principle of the Loop 101 ICM is that each agency will retain complete control of their systems and devices and that any strategies will need to be verified and implemented by an operator at that agency. However, there are some existing or potential conditions where an agency does have permission to interact with devices or systems that are owned by another agency. **Table 11** identifies a set of permissions that are given to other agencies for the use of ITS infrastructure/systems in support of ICM.

Table 11 – Non-Automated Device and System Permissions to Support ICM Operations

Permissions	Agencies
Camera Sharing	• All agencies connected to the RCN can see CCTV cameras in other jurisdictions. • Some local TMCs give their local PD and MCDOT TMC permission to utilize the PTZ functions on the cameras under specific circumstances. Most provide partner agency TMCs view-only permissions. • DSS will receive snapshots for camera images (ADOT and local agencies)
Center-to Center	• There have been discussions about implementing C2C control so that another local agency could have the ability to implement pre-approved signal timing changes on Phoenix traffic signals during ICM.
Traffic Signal Operations	• Chandler, Mesa, Tempe, Scottsdale, and Phoenix have an agreement to integrate freeway interchange signals as part of the local agency traffic signal network. • Glendale has expressed interest in being able to operate ADOT signals at interchanges near the Glendale Stadium during special event ingress and egress, but this capability is not currently in place.

Additionally, the intention of a phased approach to implementing the DSS system is to implement initial DSS capabilities that address the highest priorities and current process gaps but still envision an ultimate system that has greater levels of automation to support ICM. This concept is shown in **Figure 8** from a previous section, where opportunities to automate additional processes within the ICM lifecycle are highlighted. In future conditions, greater automation may be put in place, including the potential to automate the implementation of response strategies like signal timing plans or traveler information message dissemination. At that time, agencies interested in automation would provide the DSS with permissions to connect directly to and make changes to agency systems such as their ATMS (if automated signal timing plan changes are desired), to an agency social media system (if automated social media posts are desired), or potentially other system permissions.

6.3.2 AGREEMENTS TO SUPPORT ICM OPERATIONS

The Operations Plan identifies a set of agreements to support inter-agency coordination and resource sharing that is needed to support Loop 101 ICM activities; many of these are identified in the ICM Overarching Guidelines or as part of required agency processes and activities for ICM within each lifecycle. The ICM elements to be captured in agreements should include:

- REACT Coordination (if applicable)
- Real-time Construction Restrictions (potentially through future WZDx interface)
- Traffic Signal Timing Coordination
- Arterial Detour Routing
- TMC General Number
- Documenting ICM Actions
- Consistent Traveler Information
- Ramp Meter Coordination
- Unified Command
- Local Agency Coordination
- Incident data sharing from AZDPS

Additional system-specific agreements to support the Loop 101 ICM

- **Data sharing agreement** – Agreements enabling participating agencies and/or entities to use data that has been collected and/or processed by other agencies. This includes exploring an agreement between ADOT and AZDPS for access to incident data from CAD.
- **Standard operation and maintenance procedures** – Agreements outlining the procedures that are to be followed by individual agencies in support of normal system operations. Such agreements may establish guidelines on how traffic signal coordination is to be promoted and implemented across jurisdictions, how transit routing is established during ICM events, how freeway ramp metering rates are to be established, who would be responsible for the maintenance of ICM field devices, etc.
- **Formal Operating Agreement** – All Loop 101 stakeholder agencies who have a role in ICM response for the corridor will enter into an Operations Agreement prior to any DSS development activities.

6.3.3 MODES OF OPERATION

The modes of operation that the ICM System will accommodate are outlined in **Table 12**.

Table 12 – ICM System Modes of Operation

Mode	Description
ICM Activation	When an ICM event is active, meaning that 'ICM-worthy' conditions have been identified and the system proceeds through the ICM lifecycle, as described in Section 5.2.
Monitoring	When there is no active ICM event. In this mode, the system is collecting and processing data that is available and scanning for ICM-worthy conditions, as defined by users. When conditions are met, the system transitions to ICM Activation mode.
Maintenance	When the system, its individual modules, or associated equipment (servers) are being updated or repaired. This mode will likely result in a temporary reduction in system functionality.
Training	Provides the experience of system functionalities but with representative or mock scenarios and interfaces so that any actions or data do not actually impact real-time field operations and systems.
Failure	The ICM system will be robust enough to operate in a state of partial failure; however, should a major failure be detected that prevents adequate system operation, the ICM system will then revert to Maintenance or be disabled completely.

In addition to Failure mode, periodic system checks will assess whether individual system components are operating as intended. These checks will also cover the health of input data feeds and quality of input data. Following the detection of an existing or potential problem, the system will inform the transportation system operators of the problem and try to continue its operation by compensating for the problem, to the extent that this may be possible.

7 SUPPORT ENVIRONMENT

The L101 ICM System will require cooperation between all agencies to successfully implement, use, and maintain it. Initially, there will need to be consensus on the requirements and functions, operational parameters, and roles and responsibilities for the development and roll-out of the system. After roll-out there will need to be continued collaboration and commitment to using the system and maintaining and updating data inputs, both those automatically assimilated and those manually indicated. All stakeholder agencies must have a certain level of investment in the ICM system to integrate it both physically/technologically and procedurally into their agency functions, such as training staff or ensuring that the ICM System is accommodated within existing agency systems.

7.1 ICM PROGRAM LEADERSHIP AND MANAGEMENT

L101 ICM Working Group – Currently, the Loop 101 Mobility Technical Task Teams, described in Table 1 and lead by ADOT and MCDOT, are responsible for overseeing the development of the L101 ICM concept and requirements. This stakeholder group will transition into the L101 ICM Working Group, which will be the body responsible for managing and overseeing the deployment of the ICM concept. The Working Group will meet regularly to discuss and coordinate on the deployment of the various strategies identified in the ICM concept, including the infrastructure, systems and process changes that are identified. As the ICM concept is deployed, this group will coordinate on ICM operations on a day-to-day basis, reviewing corridor performance, and participating in after-action debriefs when there are events on L101 that trigger implementation of ICM. Through the performance review and debriefs, this group will identify updates that are needed for ICM to work more effectively or efficiently, and the Working Group will be responsible for seeing that the updates or changes get implemented.

AZTech Partnership – The AZTech Partnership is a regional traffic management and operations partnership with participation from governmental transportation agencies in Maricopa County, public safety agencies, universities and several private technology and media companies. Through AZTech, there are existing and successful institutional arrangements that illustrate collaboration between planning and operations, and ways to support the implementation of operational strategies, including ICM. AZTech partners have collaborated through the AZTech Operations Committee, TIM Coalition, and TMC Operators Working Group to develop existing agreements and a framework for coordination during incidents. They also conduct multi-agency tabletop exercises and debriefs/lessons learned after incidents throughout the region. This experience can be leveraged by the L101 ICM Working Group to support the leadership and management activities of the L101 ICM.

MAG ITS Committee – The MAG ITS Committee is an existing technical committee at MAG that consists of representatives from FHWA, ADOT, DPS, Valley Metro, ASU, and sixteen MAG member agencies. The Committee provides oversight to the development of regional plans related to operations and ITS, such as the Systems Management and Operations Plan, and recommends ITS applications on the arterial and freeway systems through projects that are programmed in the regional TIP. The ITS Committee will have a role in promoting ICM to other committees at MAG with the goal of gaining widespread understanding and support from representatives at MAG member agencies. Finally, the ITS Committee helps gather and share lessons learned related to ICM deployments in the region, as well as nationally.

7.2 SYSTEM OPERATIONS AND MAINTENANCE

Partner agency operations staff (TOC, TMC and OCC staff) will have the highest level of interaction with the ICM system and will be expected to follow procedures related to using the system and acting upon the information provided by it. However, the system will also impact a variety of other users such as information technology staff, especially those at ADOT and MCDOT who will have responsibilities related to ongoing upkeep of the DSS. Maintenance staff, law enforcement officials, or public information officers also will be provided with corridor-wide information.

Agencies and agency systems may require procedural and system modifications to accommodate the L101 ICM System. Each agency will have to agree to integrate the systems and processes for ICM and make sure the system interface is available to staff that will interact with it. They also must incorporate the use of ICM system and processes into staff duties and responsibilities.

7.2.1 STAFF SKILL SETS AND TRAINING

Implementing the L101 ICM systems and concept will likely require changes to the number or type of staff or positions at the lead agencies (ADOT and MCDOT) but will likely not require changes to staffing at stakeholder agencies.

System Design, Development and Implementation

A qualified contractor will be procured to support the detailed design of the DSS and, subsequently, the development of the system. The Loop 101 technical stakeholder team, led by ADOT and MCDOT, will be responsible for oversight of the respective contractors to make sure that the system is designed and developed according to the details of this ConOps.

- ADOT staff will be responsible for working with the system designer/developer to design, develop, implement and test the system and its components to make sure that they properly integrate and operate on the ADOT network. ADOT staff will also be responsible for managing the developer contract, including design, development, implementation and operations.
- MCDOT staff will be responsible for working with the DSS developer to connect to RADS as a foundational database and data engine that the DSS will be based off.

System Maintenance

After system acceptance is achieved, the system developer will provide system maintenance and upgrades for a specified period of time, and after that time, because the DSS will reside behind the ADOT firewall, ADOT will be responsible for upgrading and maintaining the system.

- ADOT will need professionals with skills to perform or oversee regular maintenance and occasional system upgrades, and oversee and ensure cybersecurity of the system.

System Operation and Use

Capability needs for the daily operations of the ICM system after its launch includes:

- ADOT will need staff to manage the contract, oversee contractor operations of the system, lead future phases, and help to promote understanding and awareness of the DSS and ICM throughout ADOT's TSMO Division. ADOT will be responsible for updating operating procedures at the TOC for ongoing DSS operations, coordinating with ITG for technical and system security needs, and working with external vendors and contractors that support the various software and tools that comprise the ICM systems that provide data to the DSS.
- MCDOT will designate a staff person (or persons) to fulfill the ICM Coordinator role. Staff may be a combination of TMC staff and REACT staff with knowledge and awareness of general ICM principals and Loop 101 stakeholder agency contacts. gestions from the ICM System and who may be tasked with evaluating and implementing response actions on their respective networks.
- System users should be able to understand quickly what is being suggested and have the ability to make quick and timely control decisions when necessary. To do so, they must be familiar with how the corridor should operate at a given time of the day and, at a high level,

be informed on basic functions that other agencies perform and on how traffic is typically managed across the various jurisdictions.

A System User Manual will provide any user with clear instructions on various ways to interact with and navigate the system functions. The user manual will be updated periodically as updates or changes to the system are made, in accordance with the established change management process (see Section 7.3) for this project. The System User Manual will be made available electronically to all participating agencies, as well as be readily available from within the ICM dashboard, and it will be the responsibility of each agency to share it with new staff who may interact with the system.

Additionally, ICM tabletop exercises should be held periodically where stakeholders will come together to play out an ICM scenario for a portion of the corridor and make sure that all agency stakeholders understand their role and responsibilities as part of the ICM response. These tabletop exercises can be based off actual incidents and ICM events and will vary in location to provide coverage of the entire L101 system. Because of the extensive length of the Loop 101 corridor and the various existing operating environments, these tabletop exercises may be most effective at a corridor segment-level. Segment-specific tabletop exercises should occur annually, at a minimum, and include all transportation, transit, law enforcement, and public information/communications partners who may play a role in an ICM response.

7.2.2 DATA OWNERSHIP AND SHARING

While ADOT will be the 'host' for the DSS, every agency will be responsible for both the availability and accuracy of the data that is necessary to feed into the system. While the unique feature of the ICM system will be its ability to provide agency-specific recommendations for ICM response actions, at the core of the system is its ability to collect and process all relevant information that is available by stakeholder agencies to identify various conditions that trigger the different steps of the ICM lifecycle. Thus, both the usefulness and success of the system is based on the availability and accuracy of data.

Given this, the L101 ICM System will require the development and implementation of policies and procedures by partnering agencies to address key data sharing considerations, which might include:

- Types of data that will be collected.
- Types of data to be available by each agency.
- Data quality and frequency considerations.
- Data privacy and security.
- Information archiving and storage.

Each agency will make a commitment to work internally to both provide the agreed upon data and information and verify that both the technology- and organization-based operating environment is compatible with the use of the system. This acknowledgment of commitment might take the form of an IGA or other multi-agency agreement. Agency-specific policies and procedures will be developed and implemented to help govern information and data sharing as well as the physical operational needs of the system. This step will involve the inclusion of entities within each agency during the development and/or review of these policies to consider legal, information technology, operational, and managerial perspectives.

7.2.3 ONGOING OPERATIONS AND MANAGEMENT

There will be ongoing operations and maintenance considerations that will need definition prior to implementation. These include the following activities:

- Annual meeting of users or primary contacts for agencies that have users of the L101 ICM system to review functionality and plan for adjustments/upgrades based on need.
- Periodic administrator confirmation that elements are functioning properly within the system.
- Oversight and management of the system's operational security.
- Maintenance response to downtime or errors being received by users.
- Complete installation/upgrades of system, as warranted.
- Periodically and as necessary verifying contact information across all agencies that have jurisdiction over roadways.
- Periodic performance reporting and discussion between stakeholder agencies regarding use of system and applicability during actual incidents/events along L101.

7.3 CHANGE MANAGEMENT

It is the intent of this concept that the ICM System including the DSS, is modified and improved over time based on inputs from system users. It will be important to establish a process for identifying, requesting, and implementing changes to the ICM System.

The configuration control process consists of a sequence of steps to prevent unilateral decisions that could have negative or unforeseen consequences. A control process ensures the entire project team is aware of a change being implemented and that an evaluation is performed to understand the potential risks, costs and impacts of that action. **Figure 13** illustrates the steps in the process.

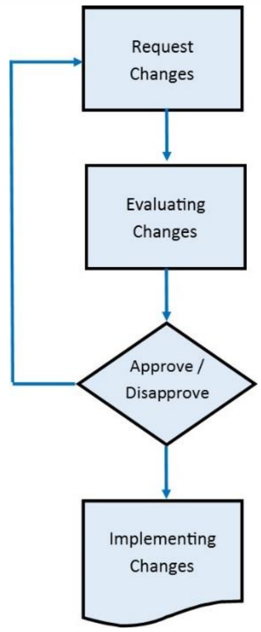


Figure 13 – Configuration/Change Control Process

All members of the L101 ICM Working Group will designate a representative to respond to each level of change control. All requests will be written when submitted and subsequently documented how they are addressed. A low-level priority may require only a verbal request/approval. Higher levels of change control that might have a critical impact on configuration items will require the review of a Change Management Board.

A Change Management Board will be designated by the L101 ICM Working Group as oversight and approval method for which all changes, updates, additions to the ICM System will be discussed and managed. The Change Management Board will have at least five representatives, with at least one representative from ADOT and one from MCDOT in addition to at last three other representatives. There will be a chairman/head of the Board that will rotate on an annual basis.

7.4 PERFORMANCE MEASURES AND TARGETS

This section identifies the performance measures and targets that will be used to evaluate the ICM operations in the region. Individual values are preliminary and are subject to revision. Institutional goals included within the overall goal list for the system as defined in Section 4 are only able to be measured in a qualitative manner. The goals along with associated quantifiable performance targets from which to measure long-term success and the associated methods for data collection and reporting are shown in **Table 13**.

Table 13 – ICM Performance Measures and Targets

Goals	Conditions	Performance Targets	Data Collection Methods	Reporting Methods
Safety Goals				
Reduce traffic incident management response time on Loop 101 corridor	ICM activation	By 25%	First notification or awareness at ADOT TOC – explore FlexCAD data feed	Per incident, aggregated in annual report
Reduce number of secondary crashes on Loop 101 and identified parallel arterials	ICM activation	By 30%	DPS crash form for freeway crashes; Local CAD feed timestamp of incident start time geofenced within an ICM event area	Annual report
Mobility Goals				
Reduce egress time for mega events (50,000+ attendees)	During special events in Glendale	By 10%	Glendale to provide	Per event
Increase transit on-time arrival within the Scottsdale CV corridor	All the time (not just during ICM activation)	By 5%	Clever AVL	Monthly report
Cost Savings Goals				
Cost savings to travelers related to travel time savings	ICM activation	$4 million after first year of deployment	Before/after study of travel times during an ICM event on the corridor	Annual report
Annual cost savings of fuel	ICM activation	$1 million related to fuel savings	Based on before/after study of travel time savings	Annual report

7.5 RELATIONSHIP OF NEW CONCEPTS TO NATIONAL AND REGIONAL ITS ARCHITECTURES

The ADOT ITS Architecture, updated in 2018, defines the physical elements in the field, explains the functions that are required of the elements, and documents the information flow that connects the functions and the systems together to create a complete integrated system.

The MAG ITS Architecture was updated in 2019 to reflect enhancements of the region's system that changed the functionality for some agencies. The update reflected the latest version (8.3 at the time) of ARC-IT. The MAG ITS Committee and a Technical Advisory subgroup provides oversight, review and guidance to the RIA development process. As one of the two regional architectures in the state, the

MAG ITS Architecture interacts with the Statewide Architecture, but the Statewide Architecture focuses on the ADOT-owned ITS elements and all other ITS elements outside of the regional architectures.

A high-level comparison of the MAG regional and ADOT statewide ITS architecture and the Loop 101 ICM DSS concept includes the following findings:

- The ADOT statewide ITS architecture reflects the management of FMS devices and software systems as well as highway patrol and other partner systems that will serve as inputs to the newly created ICM DSS system. ADOT use of the ICM DSS system is recommended to be reflected in an update to the ADOT statewide ITS architecture.
- Major focus areas of the MAG regional ITS architecture include real-time information sharing (data and video) between all agencies and providing a clearinghouse of real-time information covering all critical routes and modes within the region. The Loop 101 ICM DSS concept includes these same functions in an automated manner that would now be transferred through a DSS system rather than directly between agencies. The Loop 101 ICM DSS will represent the initial implementation of freeway/transit/arterial coordinated operations and the information sharing/storage capabilities in support of this functionality.
- The MAG regional ITS architecture provides a comprehensive review of ITS standards and how they apply to the MAG region's projects. For the Loop 101 ICM project system requirements development, specific standards must be selected and applied as part of the corridor system's engineering process.
- A major function of both the ADOT statewide ITS architecture and the MAG regional ITS architecture is regional coordination support between transportation agencies and public safety agencies during major incidents such as full closures, construction activities and special events. The Loop 101 ICM concept includes agency coordination during incident management and introduces the concept of a DSS system in the facilitation and updating process during incident management.
- The MAG regional ITS architecture, and the ADOT statewide ITS architecture with respect to ADOT functionality, recognizes that each organization in the region, and along the Loop 101 corridor, currently operates independently, maintaining control of all aspects of their respective systems. The Loop 101 ICM concept provides a new DSS system tool and an integrated traveler mobility application, while not inherently changing the independent system model, creates a shared platform and 'middle man' step in the process between independent systems and regional-level operations for incident management and traveler information functionality behind major closure or capacity restriction management.

The Loop 101 ICM DSS concept is consistent with the MAG regional ITS architecture and the ADOT statewide architecture. Although there are no conflicts with the architecture, the current architectures do not identify the proposed ICM System and the automation of the information flows that are currently manual. The ICM DSS concept includes significantly more information sharing (including command and control functions) and integrated operational capabilities than what is currently provided by the MAG regional ITS architecture. The primary addition that would be needed to the next update to the MAG regional ITS architecture is to reflect the new DSS system that will be utilized by a number of agencies around the Phoenix region.

It is recommended that the MAG regional ITS architecture and ADOT statewide architecture be modified to include the Loop 101 ICM DSS once it is completed and operational. Moreover, the Loop 101 ICM DSS will coordinate with the MAG ITS Committee and a Technical Advisory subgroup to ensure that the specific ITS standards identified for the Loop 101 corridor are consistent with regional use.

8 USE CASES AND OPERATIONAL SCENARIOS

This section provides an example scenario of how the DSS will be used once implemented from a variety of different user perspectives. The use cases and scenario perspectives are organized around the ICM lifecycle, which is shown again in **Figure 14**.

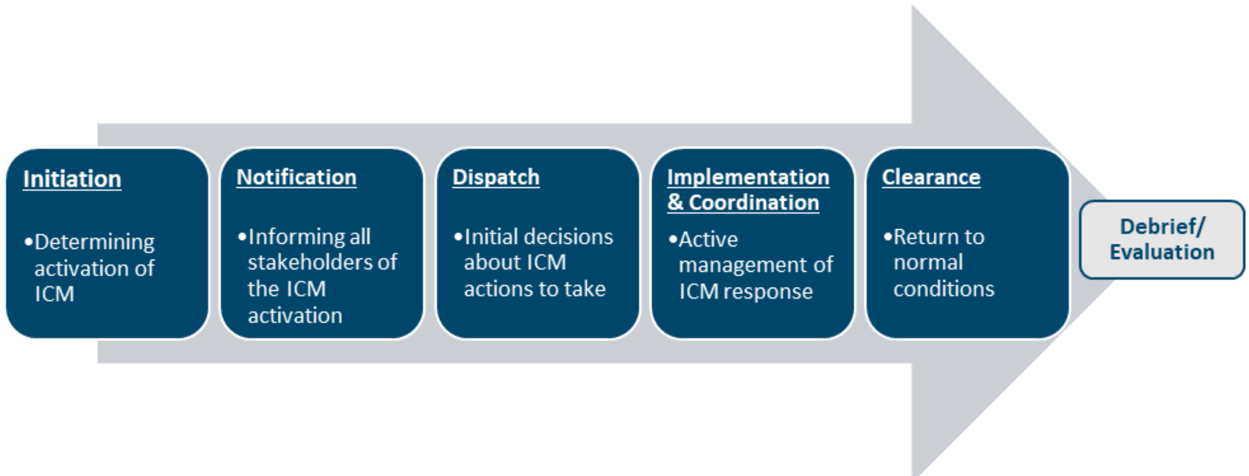


Figure 14 – Loop 101 ICM Lifecycle

8.1 FROM THE IMPACTED AGENCY PERSPECTIVE

The following scenario describes the DSS concepts from the perspective of TMC/TOC operators at agencies who are impacted by an ICM activation on L101:

At 4:30am on a Tuesday, dispatchers at the ADOT TOC are informed of a wrong-way driver crash on the Loop 101 heading northbound in the City of Glendale. The TOC dispatcher utilizes the nearest ADOT CCTV camera to the crash location to get a visual of the crash and notifies the TOC leadership of the event. The TOC is notified by AZDPS that they will be closing all northbound lanes at Camelback Road.

Initiation

Knowing that this event is now a verified full closure, the TOC dispatcher begins the process of notifying other ADOT staff and other agency stakeholders of the event. The TOC dispatcher calls ADOT IRU, MCDOT REACT, Glendale Police Dispatch, and the MCDOT ICM Coordinator. The dispatcher also notifies the ADOT PIO that is in the TOC and posts an initial alert on L101 DMS about the crash. The dispatcher inputs information into the ADOT ERS and FlexCAD systems, allowing the DSS to automatically ingest the information about the event and establish whether that information triggers any individual agency thresholds for activation of an ICM event. The City of Glendale has set up parameters where current conditions warrant an ICM activation.

Notification

The DSS sends out a notification to the City of Glendale users and other agencies whose parameters indicate this is an ICM event via the method that each user prescribed in the DSS; this includes the REACT point of contact who will support detouring through the City of Glendale. The DSS notification includes a link to the system platform for shared coordination and central situational awareness. The traveler mobility application begins to provide traveler alerts about the ICM activation to notify the travelers subscribed to the application.

The on-call traffic operator at Glendale receives the text message alert and email alert from the DSS. The MCDOT ICM Coordinator on-call, which is a member of the REACT team, also receives the alert from the DSS about the wrong-way driver. The Glendale operator remotely accesses the Glendale CCTV cameras directly through the Glendale ATMS system to see if there have been any traffic impacts yet. Because it is early enough, there have not been any impacts, so the operator continues to monitor the situation. In the meantime, the operator calls her supervisor as well as the Glendale PD dispatch to make sure they are aware of the event. Glendale police dispatch receives the call from the Glendale traffic operator and confirms that they had also been notified by the ADOT TOC and are monitoring the situation.

Dispatch

As time goes on and the freeway closure remains, the Glendale operator notices that traffic is beginning to back up on 91st Ave at Camelback as rush hour has begun and people are diverting from the freeway onto the arterial roadways. The DSS is ingesting freeway FMS detection data and the queueing of traffic automatically triggers the Glendale ICM threshold to warrant recommending a specific predefined detour route to the City of Glendale and other impacted agencies to utilize to minimize the congestion.

The Glendale operator receives the DSS dispatch message including a recommended arterial detour route, arterial signal timing plans to implement to facilitate travel along the route. The Glendale operator logs onto the DSS user interface to get more information about the impacts of the ICM event on the network and to see what other agencies are involved. At the same time:

- A Phoenix TMC operator receives the DSS dispatch message including a recommended arterial detour route and associated arterial signal timing plans to facilitate travel along the route.
- The MCDOT ICM Coordinator also receives an alert that an ICM even has been activated.
- The traveler mobility application continues to provide updates to travelers.
- The Phoenix Transit OCC receives a recommended transit response plan.

Each individual agency determines if the signal timing or transit routing recommendations are something they want to implement, and the City of Glendale decides to implement the timing plan. The DSS notifies the Phoenix TMC, ADOT TOC, MCDOT, Phoenix Transit OCC, Glendale PD, and any other agency that is triggered by the ICM event notification of the implemented detour route and timing plan.

The Glendale operator accepts the recommended detour route and signal timing plans directly in the DSS interface and makes the updates in the ATMS system. The operator also calls REACT, who was already notified of the City's decision to implement through the DSS, to coordinate directly to mobilize and provide assistance in supporting the detour route.

Signal timing changes through the City ATMS are noted by the DSS system, and the system notifies the Phoenix TMC to let the TMC operator know that the City of Glendale has made a timing change. The Phoenix TMC operator has been monitoring his local network and decides to also implement the DSS-recommended signal timing plan, since the Phoenix traffic signals along that corridor are within the traffic impacted area.

ADOT TOC dispatchers continue to monitor freeway traffic on L101 and on I-10 approaching L101 (both east and westbound). ADOT updates the DMS messages to reflect current restrictions and expands the L101 crash notifications to DMS on I-10 to warn travelers that might be heading for northbound L101 that there is an incident and the freeway is closed.

The DSS system has notified the ADOT TOC and Phoenix Transit OCC that both Glendale and Phoenix have implemented response actions and that REACT is supporting diversions on to the designated arterial routes. The Phoenix Transit OCC opens up the DSS user interface to learn of the implemented detour route and other agencies involved in the "ICM event".

Implementation and Coordination

The operator monitors the intersections as traffic continues to get heavier with the morning commute.

The Phoenix Transit OCC, after being notified of the event, had been monitoring the intersections using the DSS system to view Phoenix CCTV cameras and had also called Valley Metro Customer Service to inform them of the event and keep them on alert. They had also been coordinating with their drivers to continue their regular routes until otherwise notified. If traffic on the regular route becomes too delayed to operate normal service, they coordinate with their drivers to take the new recommended route. They inform Customer Service of the new route and enter the acceptance of the new transit route into the DSS system to let other agencies know of the new route. They also inform Customer Service that sends out an alert to the Valley Metro mobile app and on their website notifying riders of the event and the service impact.

The Glendale operator has implemented and is monitoring the detour route and associated traffic signal timing performance. She notices that traffic is trying to get back onto the freeway at Glendale Avenue. The Glendale operator adjusts the signal timing in the ATMS accordingly to support the natural progression of traffic back onto the freeway at Glendale Avenue, which automatically updates the DSS system status for this "ICM event" and notifies others with access to the DSS system of the updates. REACT field teams communicate with staff at the MCDOT TMC, and MCDOT TMC staff are also coordinating with the Glendale TMC. The Phoenix TMC, Phoenix Transit OCC, MCDOT, ADOT TOC, Glendale PD and others with access to the DSS system monitor the current status and conditions of the closure for changes until the incident is cleared out of the roadway.

Clearance

AZDPS clears the incident from the traveled lanes. AZDPS notifies the ADOT TOC operator of the incident removal who then updates ERS and FlexCAD with the new information. The DSS system is updated automatically using inputs from ERS and FlexCAD that the incident has been cleared, but that there is still backed up traffic impacting the freeway and arterial networks. The DSS system sends out a notification that the incident is no longer blocking lanes on the freeway; it sends subsequent notifications to impacted agencies when the incident is fully cleared and responders have left the scene.

The ADOT TOC returns the DMS message status, the ramp meter operations resume their normal operation, and other items are returned to normal conditions. The ADOT TOC also coordinates with the ADOT PIO to notify the traveling public via the traveler mobility application and other platforms the ADOT PIO uses. The Glendale TMC and the Phoenix TMC continue to use the DSS system to monitor the speeds, travel times, and other information that the DSS is ingesting on a real-time basis to determine when traffic has returned to normal conditions. REACT teams begin to demobilize and notify the MCDOT TMC that the teams will be removing their equipment from the arterials.

Using the parameters set by each agency, the DSS monitors conditions until real-time operations are at a place where Glendale TMC and Phoenix TMC consider them “normal conditions”; at this point, the DSS alerts users from both agencies and operators, upon receiving the alert, remove the ICM-specific detour signal timing plans and return signal timing to normal. That change in the individual agency ATMS systems will automatically update the DSS system and will activate a notification message for all agencies that arterials are back to normal and the “ICM event” is automatically closed in the system. The Phoenix Transit OCC receives the DSS system notification that the “ICM event” has been closed in the system and returns transit routing to normal conditions.

Evaluation/After-Action

Within two weeks of the conclusion of this particular “ICM event”, the Glendale TMC, Phoenix TMC, Phoenix Transit OCC, MCDOT, ADOT TOC, and any other impacted stakeholder agencies that participated in the “ICM event” convene to conduct an after-action debrief of the event. During this debrief, the partner agencies discuss the event and the actions that each agency took, with a focus on the activities that worked well and resulted in successful outcomes, activities that did not work well and need to be adjusted, and any gaps or activities that did not occur during the event. The DSS collected a log of all user activities conducted in the system as well as changes captured by automatic ingestion of other system data such as the Glendale ATMS signal timing updates and the FlexCAD incident updates.

The DSS reports from the “ICM event” provide valuable insights into the timing, coordination, information that supported actions taken, and a summary of performance of the corridor based on the FMS data of speeds, travel times, and other defined metrics to show the impacts on the transportation network from the incident.

During the after-action debrief, some agencies log into the DSS system to adjust the parameters used for triggers and notification preferences that would support a more streamlined or efficient “ICM event” management process the next time this kind of an incident occurs.

Based on the information collected during the "ICM event" by both real-time conditions and actions taken in response to the event, the DSS system will be able to make recommendations to agencies as to appropriate improvements to be made before the next ICM event occurs. These recommendations can include queuing detected by the event that could have been mitigated through the use of activation of signal timing plans in a timelier manner, or perhaps updated signal timing plans by use of after-action analysis to recommend to the agencies for updating. The DSS system is expected to learn over time of these recommendations for improvements to allow the agencies more information from machine learning that will improve the ICM response each time an "ICM event" triggers the system.

8.2 FROM THE TRAVELER PERSPECTIVE

The following scenario describes the DSS concepts from the perspective of the travelers of Loop 101 and the surrounding arterial networks that are directly impacted by the use of the system:

At 4:30am on a Tuesday, there has been a wrong-way driver crash on the Loop 101 heading northbound in the City of Glendale. A traveler plans to get on the road to travel the Loop 101 corridor toward work that morning. The traveler has downloaded the traveler mobility app for this Loop 101 corridor that they regularly use for commuting to work.

Notification

The traveler mobility application lets the traveler know in a direct message to the traveler based on their notification preferences that an "ICM event" has occurred along their predesignated route along Loop 101 to work. The message relays to the traveler that the situation is being monitored and no adjusted route is suggested at this time.

Dispatch

The traveler enters their vehicle to travel toward the Loop 101 corridor to work with the understanding that their route has not been impacted yet by this Loop 101 incident. The traveler mobility application sends the traveler an updated message status that a detour route has been recommended by the state freeway agency, ADOT, and routing information has been provided to the traveler on a route that will be more effective than their original planned route, including travel time to work taking their normal route versus taking the recommended detour route. The traveler heeds the warning message and begins to travel the detour route rather than enter onto the Loop 101 corridor.

The traffic is heavier than normal, but the traveler understands that this is a better situation than if they had no information and drove onto Loop 101 getting into major queuing. The traveler notices along the detour route that REACT vehicles have been positioned to support the detour routing from the freeway off to the arterials and back onto the freeway after the location of the closure.

A transit passenger also receives an alert of the ICM event and sees that their regular bus route is being impacted. The rider is able to see their bus is being re-routed and that there will be a slight service delay as a result. The mobility app provides the rider with a projected travel time to their destination using their regular, although slightly modified route, and the rider decides that the delay is not so severe that they will still plan to use the route and catch the bus at a slightly different stop than normal.

Implementation and Coordination

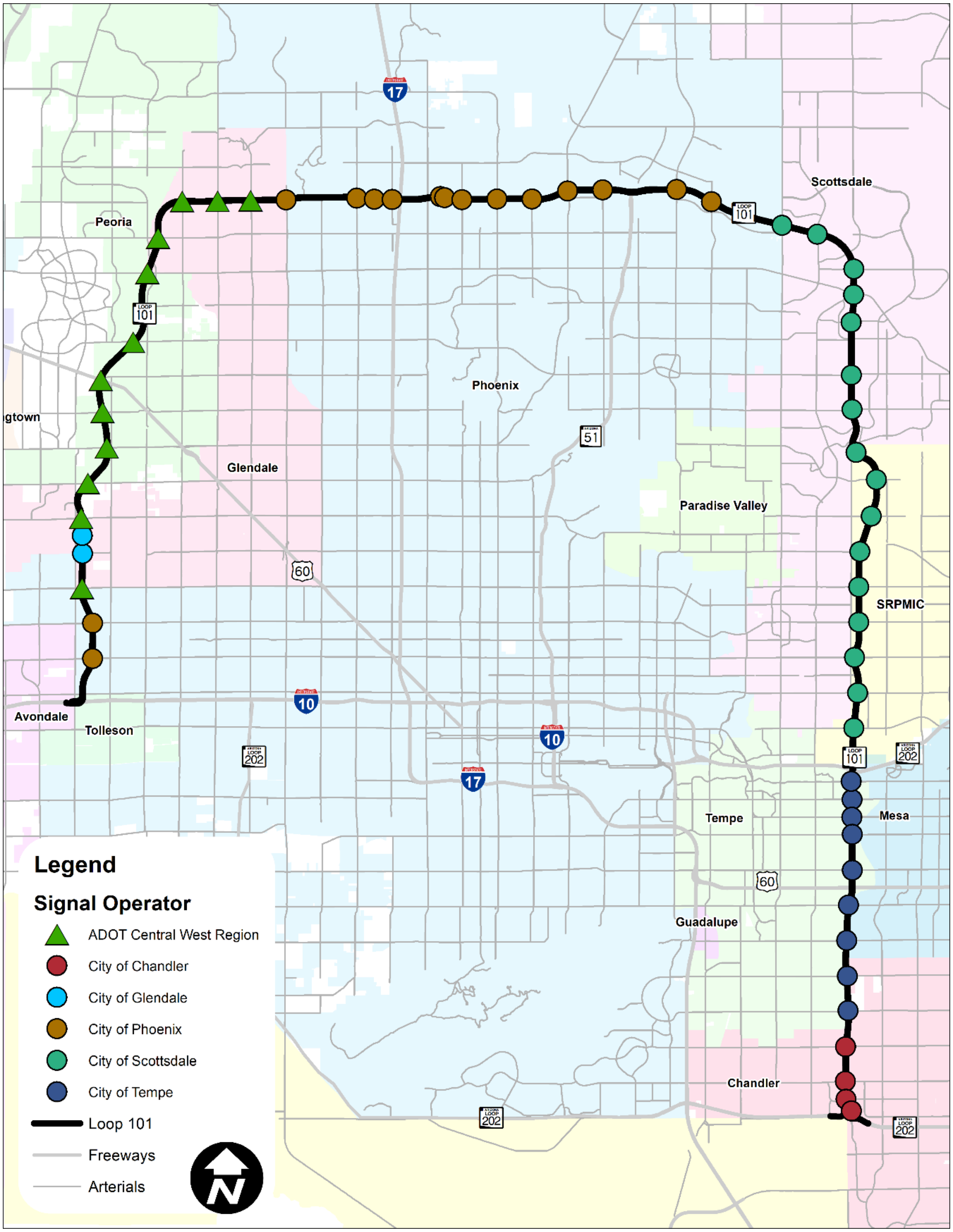
The traveler continues to follow the recommended detour route from the app and is further guided by portable DMS that are set up along the route indicating where to go. The driver notices that there seems to be very long green time at intersections along the route, which is helpful to move the heavy volumes of traffic that are using the route. The driver reaches their work a bit delayed from their normal commute experience, but thankful that they did not get stuck on Loop 101 while it was closed.

At the same time, the transit passenger has boarded their bus and is in route. In addition to getting alerts on their traveler app, they had also received alerts from Valley Metro about the service impacts from the ICM event. As the bus gets closer to the Loop 101, the rider can see REACT vehicles equipped with portable messages signs directing heavy volumes of car traffic along certain routes. The rider notices that the bus is actually being routed down a different roadway then all of the cars, which seems to be helping the bus move along. The transit rider reaches their stop and disembarks the bus.

Clearance

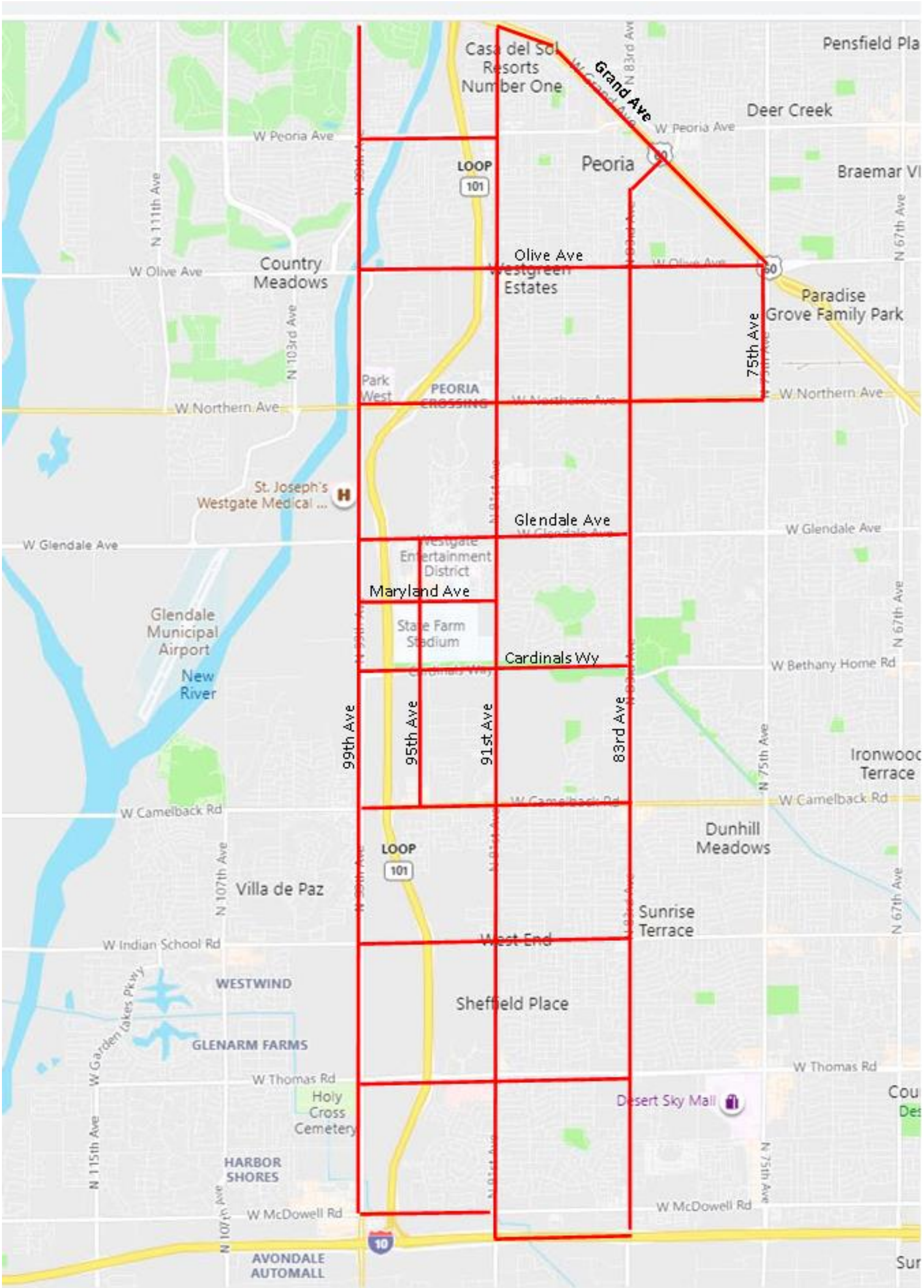
The traveler mobility application sends the traveler and transit rider updated status messages that the “ICM event” along the Loop 101 corridor has been cleared and there is no more detour route or service delay in place. Both travelers now know that everything has returned to normal conditions.

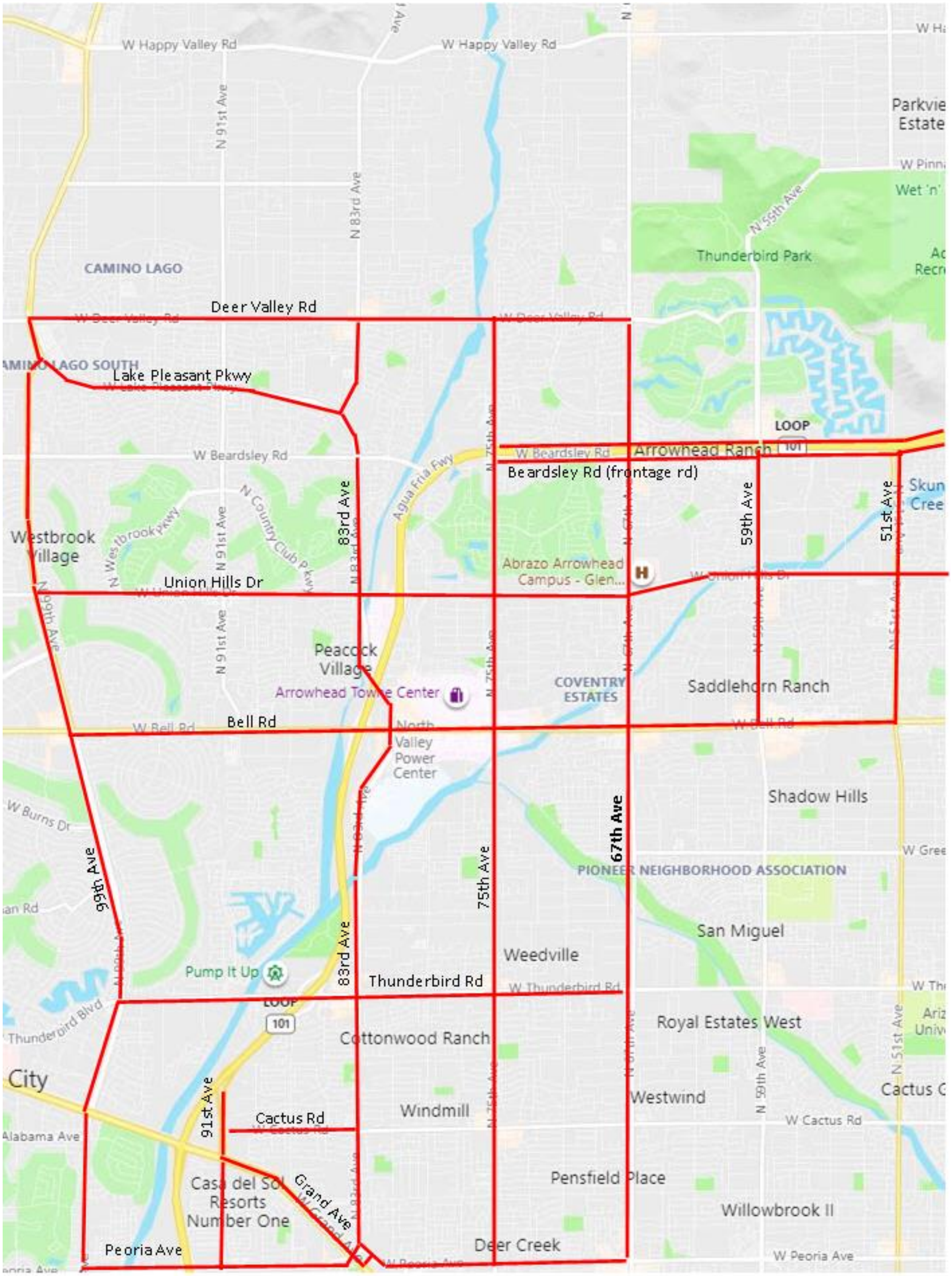
APPENDIX A - RESPONSIBILITY FOR OPERATIONS OF LOOP 101 TRAFFIC INTERCHANGE SIGNALS

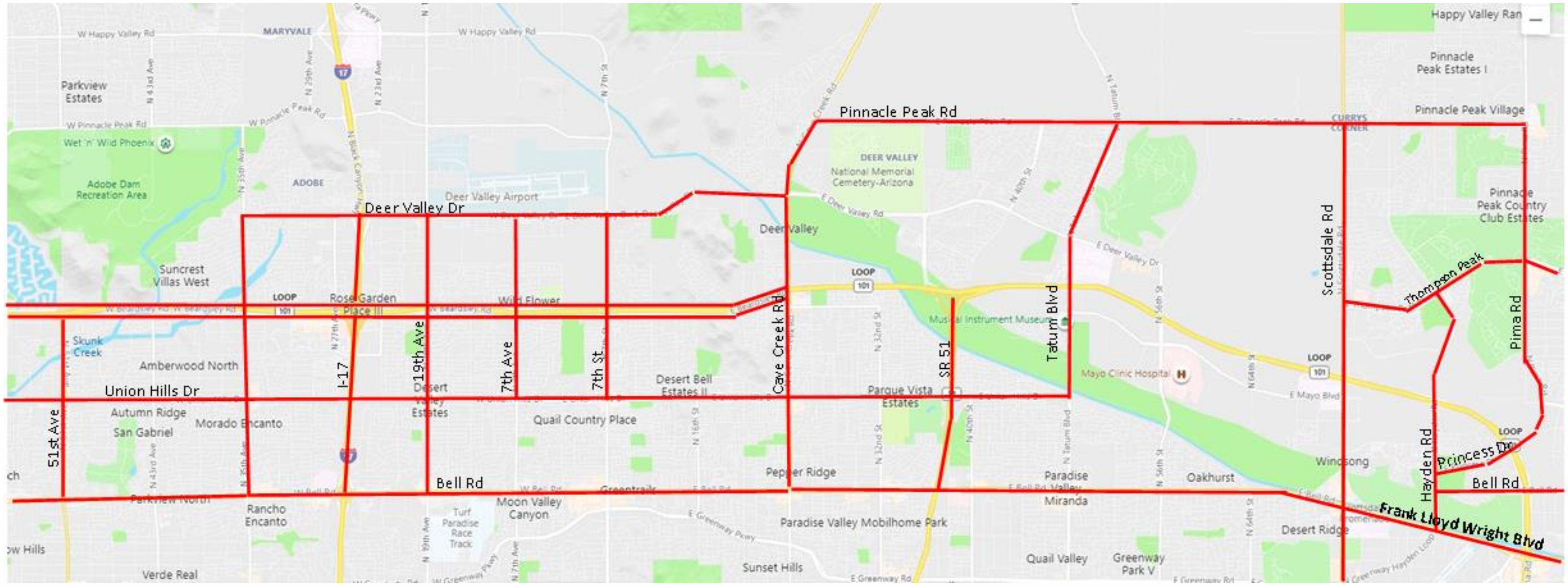


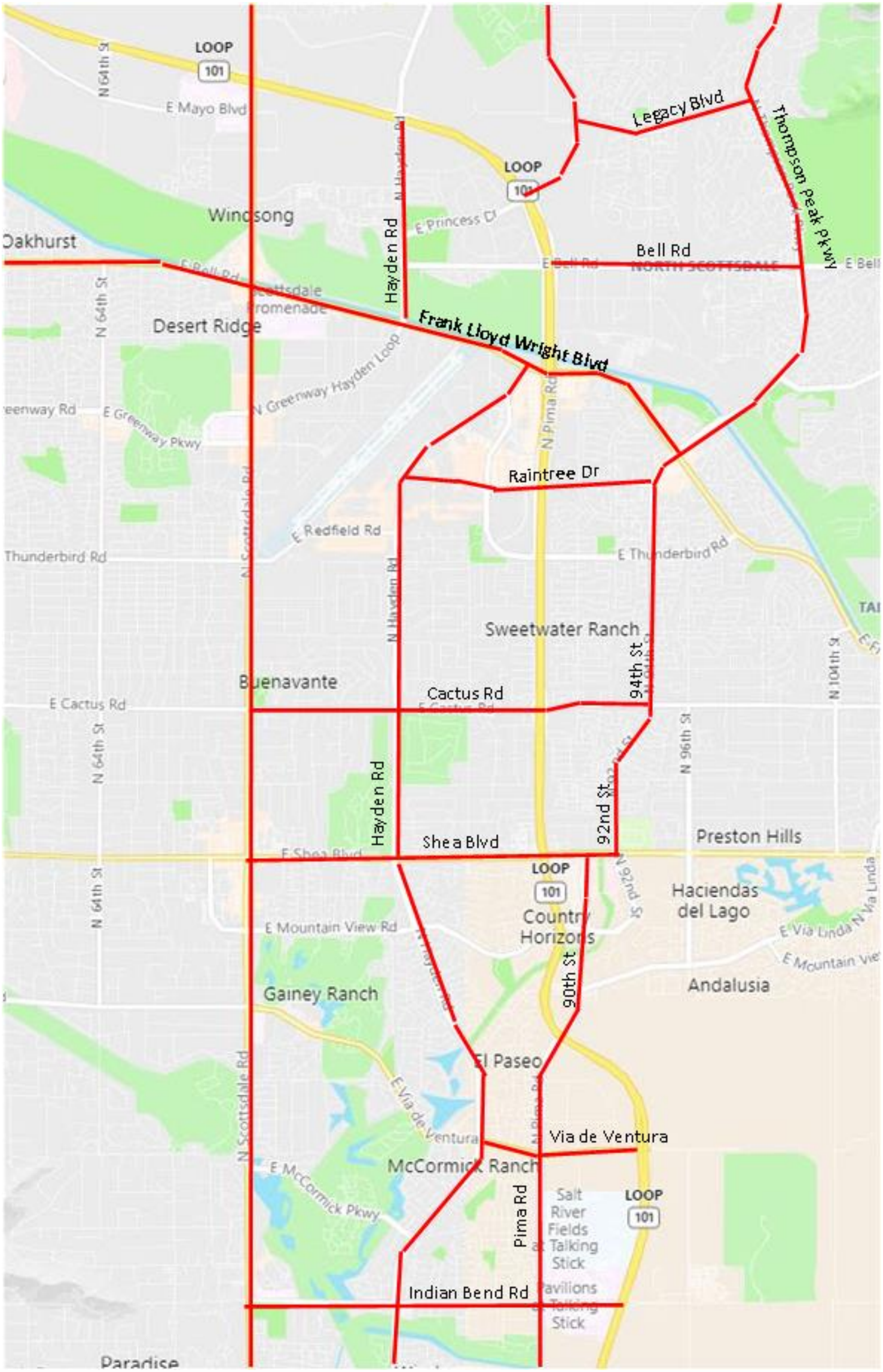
Source: ADOT TOC and Local Agency Input

APPENDIX B – PROPOSED LOOP 101 ALTERNATE ROUTE OPTIONS

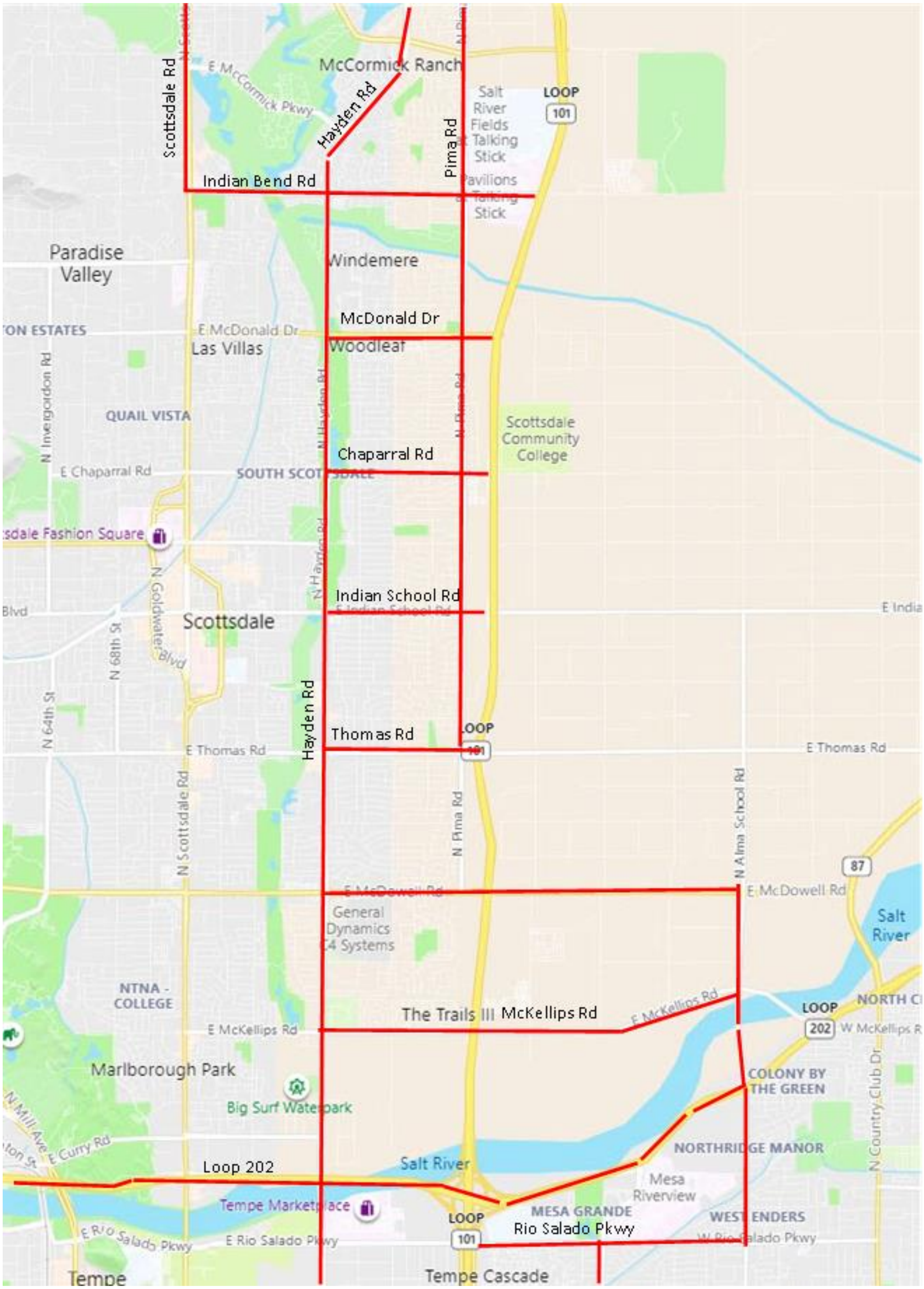

Olive Ave
Glendale Ave
Maryland Ave
Cardinals Wy
Grand Ave
75th Ave
99th Ave
95th Ave
91st Ave
83rd Ave
West End
Peoria
Casa del Sol Resorts Number One
Deer Creek
Braemar Vi
Pensfield Pla
Country Meadows
Westgreen Estates
Paradise Grove Family Park
Park West
PEORIA CROSSING
St. Joseph's Westgate Medical ...
Westgate Entertainment District
State Farm Stadium
Glendale Municipal Airport
New River
Ironwood Terrace
Dunhill Meadows
Villa de Paz
Sunrise Terrace
WESTWIND
GLENARM FARMS
Sheffield Place
Holy Cross Cemetery
Desert Sky Mall
HARBOR SHORES
AVONDALE AUTOMALL
W Peoria Ave
W Olive Ave
W Northern Ave
W Glendale Ave
W Bethany Home Rd
W Camelback Rd
W Indian School Rd
W Thomas Rd
W McDowell Rd
N 111th Ave
N 103rd Ave
N 107th Ave
N 115th Ave
N 67th Ave
N 75th Ave
W Garden Lakes Pkwy
LOOP 101
10

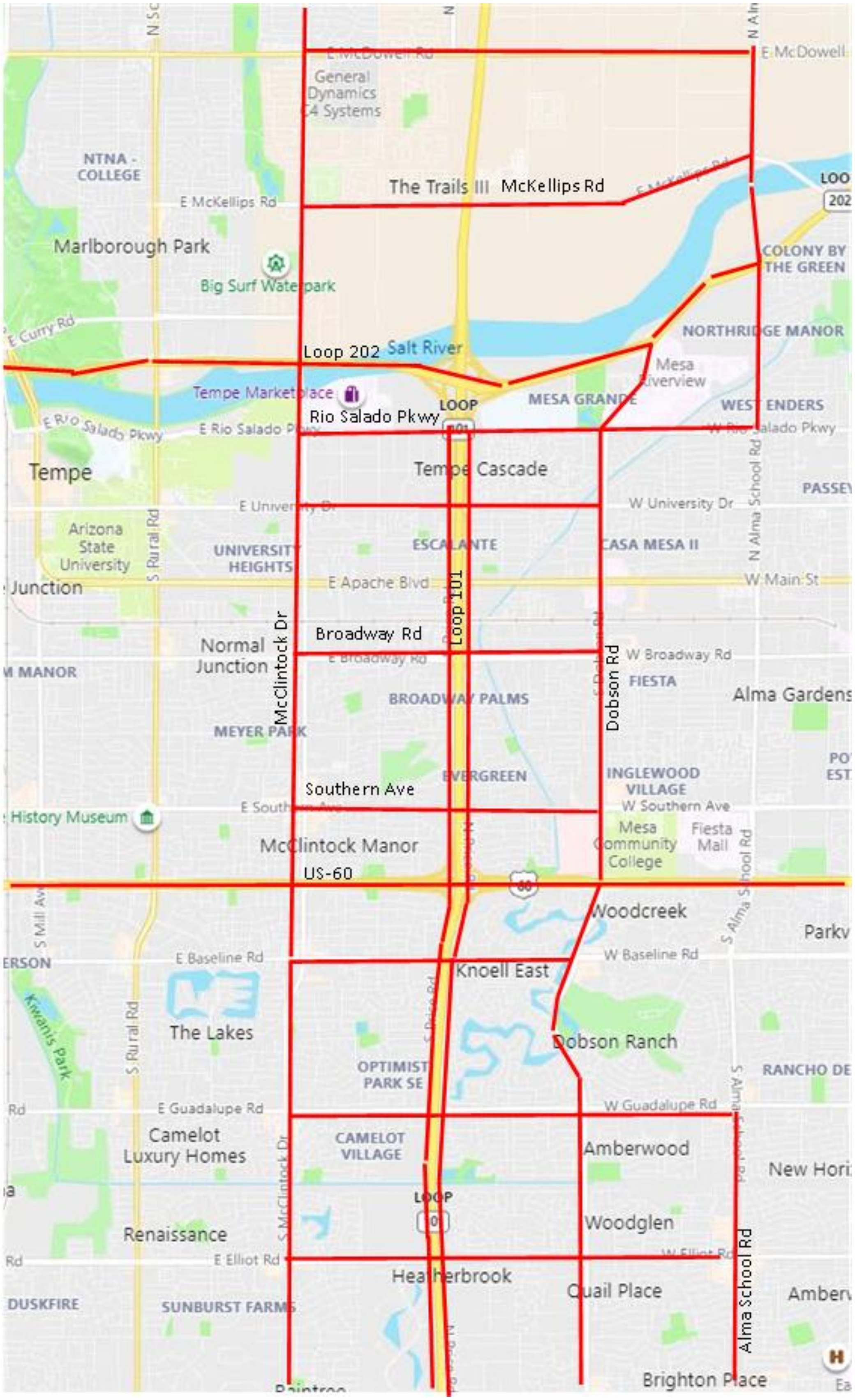

Deer Valley Rd
Lake Pleasant Pkwy
W Beardsley Rd
Beardsley Rd (frontage rd)
Arrowhead Ranch
83rd Ave
Union Hills Dr
Bell Rd
99th Ave
75th Ave
67th Ave
59th Ave
51st Ave
91st Ave
Thunderbird Rd
Cactus Rd
Grand Ave
Peoria Ave
W Happy Valley Rd
N 91st Ave
N 83rd Ave
CAMINO LAGO
Westbrook Village
Peacock Village
Arrowhead Towne Center
North Valley Power Center
Abrazo Arrowhead Campus - Glen...
COVENTRY ESTATES
Saddlehorn Ranch
Shadow Hills
PIONEER NEIGHBORHOOD ASSOCIATION
San Miguel
Weedville
Pump It Up
Cottonwood Ranch
Royal Estates West
Windmill
Westwind
Casa del Sol Resorts Number One
Pensfield Place
Willowbrook II
Deer Creek
Thunderbird Park
Agua Fria Fwy
W Cactus Rd
W Peoria Ave
W Burns Dr
Alabama Ave
City

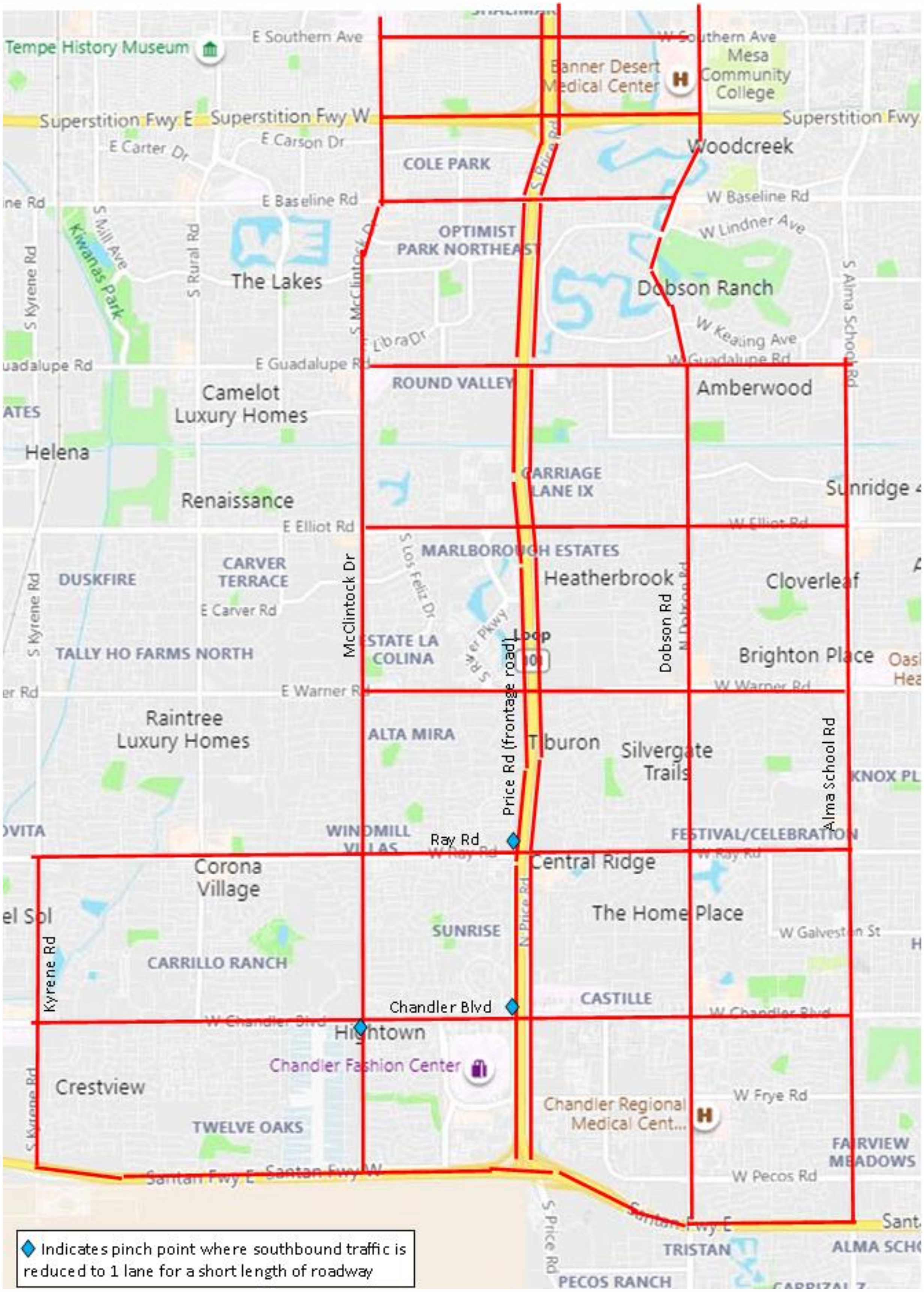

Pinnacle Peak Rd
Deer Valley Dr
Union Hills Dr
Bell Rd
51st Ave
I-17
19th Ave
7th Ave
7th St
Cave Creek Rd
SR 51
Tatum Blvd
Scottsdale Rd
Thompson Peak
Pima Rd
Hayden Rd
Princess Dr
Frank Lloyd Wright Blvd



Legacy Blvd
Thompson Peak Pkwy
Bell Rd
Hayden Rd
Frank Lloyd Wright Blvd
Raintree Dr
94th St
Cactus Rd
Hayden Rd
92nd St
Shea Blvd
90th St
Via de Ventura
Pima Rd
Indian Bend Rd
LOOP 101
Windsong
Oakhurst
Desert Ridge
Scottsdale Promenade
Sweetwater Ranch
Buenavante
Preston Hills
Haciendas del Lago
Country Horizons
Andalusia
Gainey Ranch
El Paseo
McCormick Ranch
Salt River Fields at Talking Stick
Pavilions at Talking Stick
Paradise
E Mayo Blvd
E Princess Dr
E Greenway Pkwy
N Greenway Hayden Loop
E Redfield Rd
Thunderbird Rd
E Thunderbird Rd
E Cactus Rd
E Shea Blvd
E Mountain View Rd
E Via de Ventura
E McCormick Pkwy
N Scottsdale Rd
N 64th St
N 96th St
N 104th St
N 92nd St
E Via Linda
N Pima Rd


Scottsdale Rd
McCormick Ranch
E McCormick Pkwy
Hayden Rd
Pima Rd
Salt River Fields at Talking Stick
LOOP 101
Indian Bend Rd
Pavilions at Talking Stick
Paradise Valley
Windemere
McDonald Dr
E McDonald Dr
Las Villas
Woodleaf
N Invergordon Rd
QUAIL VISTA
N Hayden Rd
N Pima Rd
Scottsdale Community College
Chaparral Rd
E Chaparral Rd
SOUTH SCOTTSDALE
Scottsdale Fashion Square
N Goldwater Blvd
Indian School Rd
E Indian School Rd
Scottsdale
N 68th St
N 64th St
Thomas Rd
E Thomas Rd
N Scottsdale Rd
N Alma School Rd
87
E McDowell Rd
General Dynamics C4 Systems
Salt River
NTNA - COLLEGE
The Trails III
McKellips Rd
E McKellips Rd
LOOP 202
W McKellips Rd
Marlborough Park
Big Surf Waterpark
COLONY BY THE GREEN
N Country Club Dr
NORTHRIDGE MANOR
E Curry Rd
Loop 202
Mesa Riverview
Tempe Marketplace
MESA GRANDE
WEST ENDERS
Rio Salado Pkwy
E Rio Salado Pkwy
W Rio Salado Pkwy
Tempe
Tempe Cascade


E McDowell Rd
E McDowell
General Dynamics C4 Systems
NTNA - COLLEGE
The Trails III
McKellips Rd
E McKellips Rd
Marlborough Park
Big Surf Waterpark
COLONY BY THE GREEN
E Curry Rd
NORTHRIDGE MANOR
Loop 202
Salt River
Mesa Riverview
Tempe Marketplace
LOOP
Rio Salado Pkwy
MESA GRANDE
WEST ENDERS
E Rio Salado Pkwy
W Rio Salado Pkwy
Tempe
Tempe Cascade
PASSEY
E University Dr
W University Dr
Arizona State University
UNIVERSITY HEIGHTS
ESCALANTE
CASA MESA II
N Alma School Rd
S Rural Rd
Junction
E Apache Blvd
W Main St
Loop 101
Broadway Rd
Normal Junction
McClintock Dr
E Broadway Rd
Dobson Rd
W Broadway Rd
FIESTA
MANOR
BROADWAY PALMS
Alma Gardens
MEYER PARK
INGLEWOOD VILLAGE
EVERGREEN
Southern Ave
E Southern Ave
W Southern Ave
History Museum
McClintock Manor
Mesa Community College
Fiesta Mall
US-60
Woodcreek
S Mill Ave
ERSON
E Baseline Rd
W Baseline Rd
Knoell East
Kiwanis Park
S Rural Rd
The Lakes
Dobson Ranch
OPTIMIST PARK SE
RANCHO DE
E Guadalupe Rd
W Guadalupe Rd
Camelot Luxury Homes
CAMELOT VILLAGE
Amberwood
S McClintock Dr
LOOP
Woodglen
Renaissance
E Elliot Rd
W Elliot Rd
Heatherbrook
Alma School Rd
DUSKFIRE
SUNBURST FARMS
Quail Place
Brighton Place
Raintree


Indicates pinch point where southbound traffic is reduced to 1 lane for a short length of roadway
Ray Rd
Chandler Blvd
Price Rd (frontage road)
McClintock Dr
Dobson Rd
Alma School Rd
Kyrene Rd
Tempe History Museum
E Southern Ave
W Southern Ave
Banner Desert Medical Center
Mesa Community College
Superstition Fwy E
Superstition Fwy W
Superstition Fwy
E Carter Dr
E Carson Dr
COLE PARK
Woodcreek
E Baseline Rd
W Baseline Rd
OPTIMIST PARK NORTHEAST
W Lindner Ave
The Lakes
Dobson Ranch
Kiwanis Park
S Mill Ave
S Rural Rd
S Kyrene Rd
S McClintock Dr
S Alma School Rd
S Price Rd
W Keating Ave
E Guadalupe Rd
W Guadalupe Rd
ROUND VALLEY
Amberwood
Camelot Luxury Homes
Helena
CARRIAGE LANE IX
Renaissance
Sunridge
E Elliot Rd
W Elliot Rd
MARLBOROUGH ESTATES
Heatherbrook
Cloverleaf
DUSKFIRE
CARVER TERRACE
E Carver Rd
S Los Feliz Dr
S River Pkwy
ESTATE LA COLINA
Loop 101
N Dobson Rd
Brighton Place
TALLY HO FARMS NORTH
E Warner Rd
W Warner Rd
Raintree Luxury Homes
ALTA MIRA
Tiburon
Silvergate Trails
KNOX PL
WINDMILL VILLAS
FESTIVAL/CELEBRATION
W Ray Rd
Central Ridge
Corona Village
The Home Place
N Price Rd
W Galveston St
SUNRISE
CARRILLO RANCH
CASTILLE
W Chandler Blvd
Hightown
Chandler Fashion Center
Crestview
W Frye Rd
Chandler Regional Medical Cent...
TWELVE OAKS
FAIRVIEW MEADOWS
Santan Fwy E
Santan Fwy W
W Pecos Rd
TRISTAN
PECOS RANCH