



U.S. Department of Transportation  
Federal Highway Administration

# CASE STUDY



## Connecting Transportation Operations and Safety in Arizona



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## Introduction

The Arizona Department of Transportation's (ADOT's) vision is for the State "to become the most reliable transportation system in the Nation."<sup>1</sup> In support of its vision, ADOT's first strategic priority is to implement effective safety countermeasures to promote safe road user behaviors and reduce roadway crashes in high-risk areas.<sup>2</sup> ADOT has a strong focus on operations and engineering improvements that will result in greater road safety and travel time reliability. Recognizing the connection between safety and operations, ADOT has placed its safety and operations functions within its Transportation System Management and Operations (TSMO) Division. The TSMO Division furthers the goals of safety and operations by ensuring the safety and mobility objectives are prioritized in all the TSMO Division units, including traffic management, intelligent transportation systems (ITS), advanced technology, traffic operations, and safety. ADOT uses its organizational structure, data, plans, project development, and the implementation of operations strategies to coordinate safety and operations. ADOT also maintains a strong working relationship with the metropolitan planning organization for the Phoenix metropolitan area, the Maricopa Association of Governments (MAG). MAG has developed its own safety and operations plans and connects those disciplines through planning and project selection. MAG member agencies bring together operations and safety with their transportation solutions.

### ***ADOT: At a Glance***

Arizona covers a total area of 113,998 square miles (295,253 km), making it the sixth largest State.

With an operating budget of more than \$470 million, ADOT is responsible for almost 67,000 centerline miles of roadway that support nearly 180 million vehicle miles traveled daily.

ADOT has six divisions, including a TSMO Division that incorporates safety, operations, and other areas.

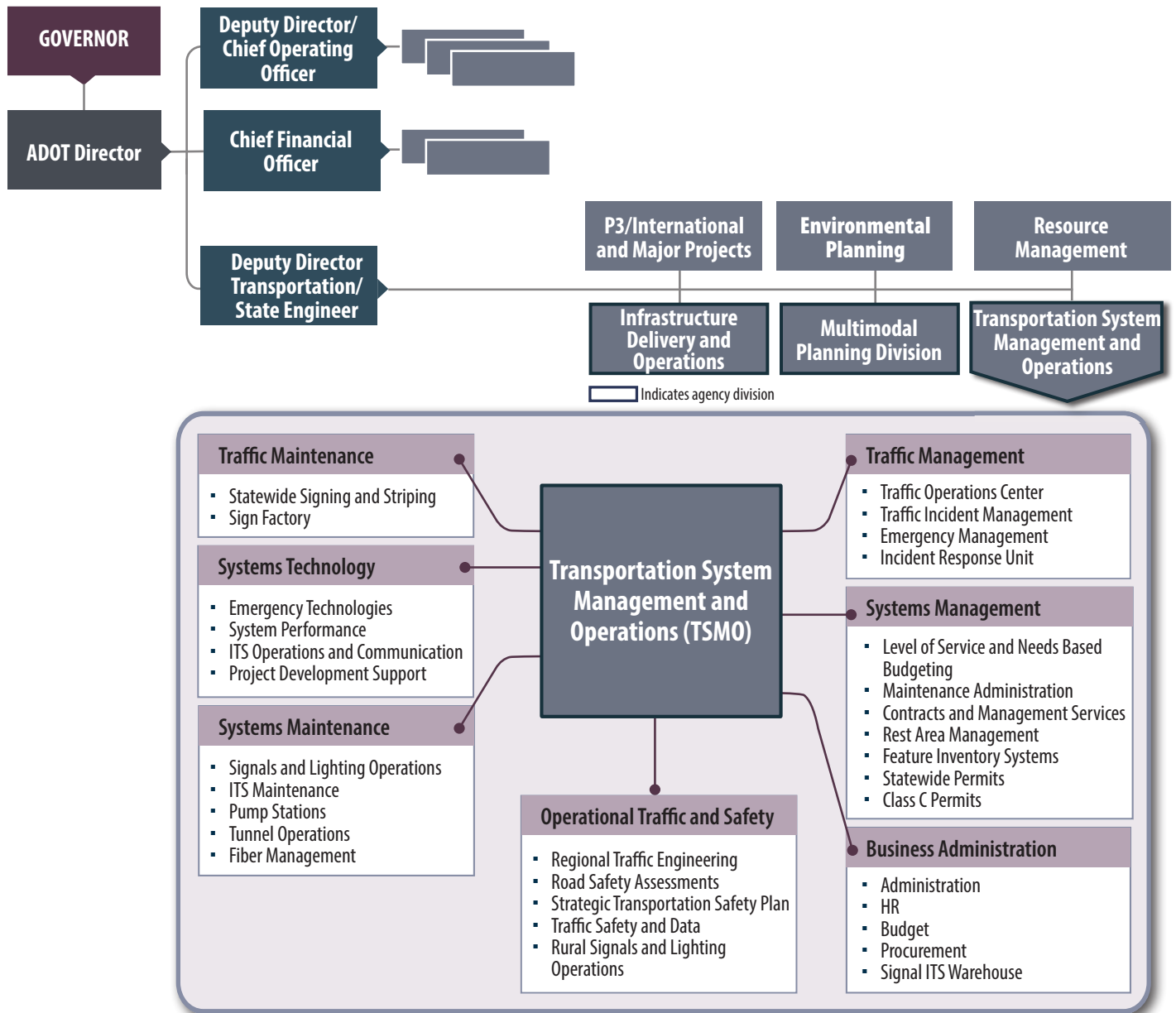
## Connecting Operations and Safety Through Institutional Arrangements

In 2015, ADOT reorganized and formed a new high-level TSMO Division, which contains both operations and safety functions. According to ADOT, this was partly motivated by the innovative technologies and business approaches that emerged from the Second Strategic Highway Research Program (SHRP2). The other driver for this change was the conviction of ADOT leadership that safety should be at the forefront of ADOT's day-to-day operations to support the State's Toward Zero Deaths vision. A strategic pivot away from highway expansion projects toward operations improvements was also part of this safety-first focus. The TSMO Division brought together existing traffic engineering, operations, safety, and traffic maintenance groups under one unit that reports directly to the State engineer.

1 ADOT. 2022. "Inside ADOT, Mission and Vision" (webpage). <https://azdot.gov/about/inside-azdot>, last accessed August 14, 2022.

2 ADOT. 2021. "Fiscal Year 2022 Strategic Plan 2-pager" (webpage). <https://azdot.gov/sites/default/files/media/2021/09/FY22-ADOT-Strategic-Plan.pdf>, last accessed August 2, 2022.

The Operational Traffic and Safety section provides subject matter expertise in traffic engineering services, road safety assessments, traffic safety and data programs, and the State's strategic transportation safety planning function. The Traffic Management section, also housed within the TSMO Division, manages the incident and weather-response programs, the joint goal of which is to improve mobility and safety. ADOT's overall focus on safety and operational efficiency has given the TSMO Division an influential role within the agency (figure 1).



Note: P3 = public-private partnerships, HR = human resources, ITS = intelligent transportation systems.

Source: Adapted from ADOT.

**Figure 1. Graph. Arizona Department of Transportation organizational chart with TSMO groups.**

The TSMO unit directors meet weekly. The meeting is guided by the Arizona Management System, a continuous improvement process that incorporates Lean and Six Sigma techniques throughout the division's daily processes.<sup>3</sup> The integrated organizational structure and the Arizona Management System encourage mutual problem solving between safety and operations. The result is that all ADOT's TSMO projects are designed with safety as a top priority. Arizona's Planning to Programming (P2P) process, which is the step between identifying projects in a planning study and getting projects into a 5-year plan, includes safety as a primary scoring criterion.<sup>4</sup> With the exception of pavement and bridge preservation projects, all planned projects, whether modernization or expansion, must include a safety score.

## Connecting Operations and Safety Through Data

ADOT connects archived operations and safety data to gain a broader view of safety and mobility issues on roads and to help prioritize improvements. These data include crash data, traffic volumes, lane volumes, speed, incident data, and construction data. To help ADOT better understand the safety issues in high-incident areas, ADOT uses lane volumes and traffic flow data to identify hotspots for sideswipes, ramp backups, or other causes of crash-related delay. Likewise, crash data paint a more complete picture of bottleneck hotspots by including the safety context, leading to identification of priority segments. By overlaying high congestion locations, such as bottlenecks, with high crash locations, ADOT can better identify priority areas for road safety assessments, a key element in the agency's project planning and prioritization process. ADOT has also applied real-time data to deploy and adjust operations and safety strategies, such as adaptive ramp meters, dust detection systems, and wrong-way driver systems.

ADOT states that safety is a top priority when it designs TSMO projects. Designs to improve mobility can sometimes have unintended safety impacts. ADOT uses safety and operations data to evaluate potential design modifications to ensure road safety.

## Connecting Operations and Safety Through Operations Strategies

In response to the State's adoption of the Toward Zero Deaths vision, ADOT's TSMO Division aims to optimize operations strategies for safety and mobility. The TSMO Division's Systems Technology group functions as a think tank for innovative ideas and technologies, such as connected and automated vehicles, that have the potential to make the traveling public safer and operations more efficient. As a result of this mindset, many operations projects have been, or are being, implemented to support safety objectives. Providing a safer traveling experience was a motivating factor for the Traffic Management unit's deployment of the Incident Response Unit, which assists with safe and efficient clearance of incidents. As highlighted in table 1, the strategies employed include adaptive ramp metering, dust detection systems, wrong way detection, and the Incident Response Unit.

3 American Society for Quality. 2022. "What is Six Sigma?" (webpage). <https://asq.org/quality-resources/six-sigma>, last accessed November 28, 2022.

4 ADOT. n.d.. "Planning to Programming" (webpage). <https://www.azdot.gov/planning/transportation-programming/planning-programming>, last accessed November 28, 2022.



Source: ADOT.

**Figure 2. Photograph. Installation of Arizona Department of Transportation dust detection instrument.**



Source: ADOT.

**Figure 3. Photograph. Arizona Department of Transportation's wrong-way driver alert message.**



Source: ADOT.

**Figure 4. Photograph. Arizona Department of Transportation's Incident Response Unit truck.**

Table 1. Examples of Arizona operations strategies used to improve safety.

Strategy	Strategy Description	How It Combines Safety and Operations	Who, Where, and When	Results
<b>Adaptive Ramp Metering</b>	Real-time traffic data are leveraged using a ramp metering algorithm that adjusts metering rates to better utilize freeway on-ramp storage based on upstream and downstream data. A companion element, the Ramp Metering Evaluation Tool, quantifies the benefits of the implemented algorithm using probe speed data, ramp meter phase data, and loop detector data.	Ramp metering regulates the volume of vehicles entering the freeway at a given time. It reduces the number and severity of freeway crashes while increasing freeway mainline throughput and overall travel delays. <sup>5</sup>	<ul style="list-style-type: none"> <li>ADOT and the University of Arizona</li> <li>Implemented a pilot along State Route 51 in the Phoenix metropolitan area in 2016</li> <li>After a successful pilot, ADOT continued to implement adaptive ramp metering throughout the Phoenix metro area.</li> </ul>	Pilot evaluation showed that traffic flow increased during the morning peak period by 152 vehicles per hour per lane on average. Speeds increased by an average of more than 4.8 mph, and the projected annual reduction in delay costs during the morning peak period will exceed \$1 million. <sup>6</sup>
<b>I-10 Dust Detection and Warning System</b>	Sensors, overhead message boards, variable speed limit signs, speed-feedback signs, and closed-circuit cameras were installed to create a first-of-its-kind dust detection and warning system over a 10-mile stretch of I-10 that is prone to sudden dust storms (figure 2). The variable speed limit signs are placed every 1,000 feet for the first mile in each direction and every 2 miles thereafter. When dust is blowing, the signs can change from 75 mph to as low as 35 mph.	Since 2000, dust has contributed to 1,207 collisions resulting in 40 fatalities and 1,136 injuries in Arizona. <sup>7</sup> The system is designed to promote safety during dust storms through dynamic operations strategies. The ADOT Traffic Operations Center monitor the system and road conditions.	<ul style="list-style-type: none"> <li>ADOT</li> <li>10 miles of I-10 between Phoenix and Tucson</li> <li>Implementation began in 2019, and became operational in 2020</li> </ul>	The primary objective is to enhance safety and driver awareness during blowing dust events. The system enables drivers to change their route or delay their journey based on severity of conditions. Launched in 2020, quantitative results are not available at this writing.

5 FHWA. 2014. "Ramp Metering: A Proven, Effective Strategy" (webpage). <https://ops.fhwa.dot.gov/publications/fhwahop14021/sec1.htm>, last accessed November 28, 2022.

6 ADOT and the University of Arizona. 2020. *Case Study: Arizona Department of Transportation SR-51 Adaptive Ramp Metering*. Washington, DC: National Operations Center of Excellence. <https://www.transportationops.org/case-studies/sr-51-adaptive-ramp-metering>, last accessed November 28, 2022.

7 Coventry, T., and K. Duby. 2021. "Confronting the Storm: Arizona's Innovative Dust Detection and Warning System." *Public Roads* 85, no 3. <https://highways.dot.gov/public-roads/autumn-2021/03>, last accessed November 28, 2022.

**Table 1. Examples of Arizona operations strategies used to improve safety (continuation).**

Strategy	Strategy Description	How It Combines Safety and Operations	Who, Where, and When	Results
<b>Wrong-Way Driver System</b>	The Wrong-Way Driver System incorporates over 300 thermal cameras and a warning system that notifies the ADOT Traffic Operations Center and Arizona State Police of a wrong-way vehicle (figure 3).	Developed and deployed through the ADOT TSMO Division, the system helps prevent crashes before they happen. It also provides TSMO staff with a video log of the wrong-way entries to help determine causes and patterns of wrong-way driving so that countermeasures can be developed to prevent recurrences. <sup>8</sup>	<ul style="list-style-type: none"> <li>ADOT and Arizona State Police</li> <li>Piloted 90 thermal cameras on a 15-mile stretch of I-17 between I-10 and Loop 101 in 2017</li> <li>Expanded system to more than 300 cameras throughout Phoenix metro area</li> <li>Plans to deploy at new sites as funding becomes available</li> </ul>	<p>Examples of results include:</p> <ul style="list-style-type: none"> <li>The system has mitigated several wrong-way driving incidents during the pilot period, including one in which law enforcement stopped a wrong-way driver 6 minutes after it had been alerted by the system.<sup>9</sup></li> <li>As of 2019, the system has detected more than 45 wrong-way vehicles. In these incidents, nearly all the drivers self-corrected and turned around, or they drove on the frontage road without entering the mainline lanes of I-17.<sup>10</sup></li> </ul>
<b>Advancing ITS Deployments</b>	The Loop 101 Mobility Project includes ITS that support integrated corridor management systems, public transportation, and other real-time information systems to advance adaptive traffic signals, ramp metering, a decision support system, an integrated traveler mobility application, and connected vehicle applications for transit and incident response vehicles.	Applies operations strategies for safety and mobility benefits	<ul style="list-style-type: none"> <li>Loop 101 Mobility Partnership of State and local agencies, the Federal Highway Administration (FHWA), and universities</li> <li>61-mile loop freeway corridor, State Route 101L in the Phoenix metropolitan area</li> <li>Secured funding in 2017 and has a projected end date of late 2026</li> </ul>	In addition to the goal of “Reduction in the number and severity of traffic crashes and an increase in driver, passenger, and pedestrian safety,” <sup>11</sup> this project will also “address the collective goals of reducing congestion, increasing reliability, and improving incident and event management on the Loop 101 freeway and adjacent arterials.” <sup>12</sup> Results are not available since the project is still under development.

8 ADOT. 2019. *Case Study: Thermal Imaging Wrong Way Vehicle Detection System*. National Operations Center of Excellence, Washington, DC. <https://www.transportationops.org/case-studies/thermal-imaging-wrong-way-vehicle-detection-system>, last accessed November 28, 2022.

9 PR Web. 2019. “New Wrong-Way Driver Detection Pilot Program Saves Lives.” [https://www.prweb.com/releases/new\\_wrong\\_way\\_driver\\_detection\\_pilot\\_program\\_saves\\_lives/prweb16124085.htm](https://www.prweb.com/releases/new_wrong_way_driver_detection_pilot_program_saves_lives/prweb16124085.htm), last accessed November 28, 2022.

10 Ibid.

11 ADOT. 2017. “Arizona Department of Transportation (ADOT) - Loop 101 Mobility Partnership” grant application. <https://ops.fhwa.dot.gov/fastact/atcmttd/2017/applications/azdot/project.htm>, last accessed November 28, 2022.

12 Ibid.



Table 1. Examples of Arizona operations strategies used to improve safety (continuation).

Strategy	Strategy Description	How It Combines Safety and Operations	Who, Where, and When	Results
<b>I-10 Corridor Coalition Truck Parking Availability System (TPAS)</b>	This strategy provides real-time truck parking availability information to truck drivers, dispatchers, and other stakeholders using dynamic parking availability signs, smartphone, and in-cab applications, and traveler information websites. <sup>13</sup>	The system uses real-time parking data and traveler information with the aim of reducing crashes caused by driver fatigue.	<ul style="list-style-type: none"> <li>▪ I-10 Corridor Coalition States of California, Arizona, New Mexico, and Texas</li> <li>▪ Along I-10 in the I-10 Corridor Coalition States</li> <li>▪ Began in 2019 with a planned completion date of 2023</li> </ul>	A main objective of the system is to improve safety by allowing drivers time to make alternate plans for their required hours of rest if their planned parking location is full, and by providing easy-to-find parking for truck drivers who need to rest. The system is still under development at the time of this writing.
<b>Incident Response Unit<sup>14</sup></b>	<p>Fourteen-member unit patrols are ready to assist State troopers and the public from 5 a.m. to 8 p.m. on weekdays (figure 4).</p> <p>The patrols respond to crashes, disabled vehicles, and debris, and support road closures.</p>	Improves both traffic flow and safety by faster incident response times, debris removal, and other Incident Response Unit activities	<ul style="list-style-type: none"> <li>▪ ADOT's Incident Response Unit within the TSMO Division</li> <li>▪ Sponsored by an insurance company</li> <li>▪ Phoenix-area freeways</li> <li>▪ Began in October 2019</li> </ul>	<p>Examples of the results include:</p> <ul style="list-style-type: none"> <li>▪ Responded to more than 10,400 crashes, disabled vehicles, and debris in first year</li> <li>▪ Improved incident response times</li> <li>▪ Reduces chances of primary and secondary incidents</li> <li>▪ Allows State troopers to focus on investigations and other public safety situations</li> <li>▪ Relieves road maintenance workers of incident response duties</li> </ul>

13 Arizona DOT, n.d. "Truck Parking and Availability System – Overview of TPAS." (webpage). <https://www.i10connects.com/node/4656>, last accessed November 28, 2022.

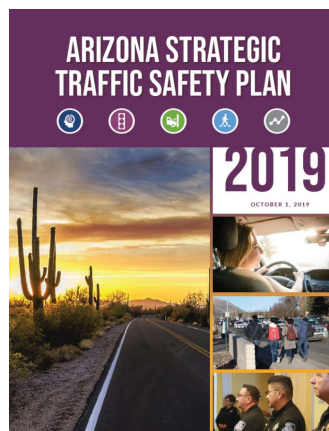
14 Arizona DOT. 2020. "ADOT's Incident Response Unit marks year of safety, keeping traffic moving." (website). <https://www.azdot.gov/adot-news/adot%E2%80%99s-incident-response-unit-marks-year-safety-keeping-traffic-moving>, last accessed November 28, 2022.

## Connecting Operations and Safety Through Plans and Policies

Operations and safety are also linked through ADOT's *Transportation Systems Management and Operations (TSM&O) Plan* and *Strategic Highway Safety Plan*. Completed in 2017, ADOT's TSM&O Plan features safety prominently and states that the "Safety of State roadways is the highest priority to ADOT."<sup>15</sup> The TSM&O Plan identifies a set of strategies to address critical gaps and opportunity areas for TSMO, including safety. The plan also has a section on safety and recommends strategies for improving safety data and identifying safety projects, including:

- Establishing a formal Safety Corridor program
- Analyzing routes with high crash rates and identifying low-cost countermeasures
- Finalizing Safety Analyst/Highway Safety Manual technology
- Updating crash reporting to implement enhanced GIS/web-based reporting and analysis
- Making data more accessible to ADOT Divisions and groups
- Working with TSMO leadership to develop a process for implementing and updating the 2014 Strategic Highway Safety Plan<sup>16</sup>

Similarly, operations considerations are reflected in the *Arizona 2019 Strategic Traffic Safety Plan (STSP)*.<sup>17</sup> The Operational Traffic and Safety group within the TSMO Division spearheaded the development of Arizona's 2019 STSP, as shown in figure 5 (updated from the 2014 Strategic Highway Safety Plan). TSMO Division leadership and many of the Operational Traffic and Safety group's program leads were part of the executive committee that oversaw the development of the STSP.



Source: ADOT.

Figure 5. Image. Cover of the *Arizona Strategic Traffic Safety Plan* | 2019.

15 ADOT. 2017. *Transportation Systems Management and Operations (TSM&O) Plan*. <https://www.azdot.gov/sites/default/files/media/2020/02/ADOT-TSMO-strategic-plan.pdf>, last accessed August 2, 2022.

16 Ibid.

17 ADOT. 2019. *Arizona 2019 Strategic Traffic Safety Plan*. <https://azdot.gov/about/transportation-safety/arizona-strategic-traffic-safety-plan-stsp>, last accessed November 28, 2022.

## Connecting Operations and Safety Through Transportation Planning, Project Prioritization, and Funding

ADOT's P2P process connects ADOT's Long-Range Transportation Plan to the 5-Year Transportation Facilities Construction Program and State Transportation Improvement Program (STIP) through performance. After identifying projects in a planning study, ADOT uses the P2P process to move projects into a program for approval. The four overarching score categories for projects assessed during this process are as follows:

- **Technical Score:** Based on a prioritization from the respective ADOT Technical Groups, the project's original study, or the Multimodal Planning Division expansion project evaluation process
- **Policy Score:** Formed from planning-level criteria such as freight flow, corridor significance, and local funding contributions
- **Safety Score:** Based on the weighted level of safety service values identified in a statewide database
- **District Score:** Obtained from each ADOT District Engineer's prioritization of projects and supported by an evaluation of each project<sup>18</sup>

The TSMO Division creates its TSMO project list for the P2P process by reaching out to the regional traffic engineers, district engineers, and regional stakeholders. The P2P coordinators within the TSMO Division then work with safety staff to further identify projects that may be eligible for Highway Safety Improvement Program (HSIP) funding. To be eligible under HSIP, projects must be identified using a data-driven process, reduce fatal and serious injuries, and be consistent with the STSP. Therefore, TSMO projects that meet the aforementioned criterion may appear on the State's HSIP eligible list. Alternatively, safety projects with operational benefits that do not qualify for HSIP funding may appear on the TSMO list.

### Summary

Combining safety and operations functions within a single TSMO Division has enabled ADOT to connect processes and facilitate greater coordination between operations and safety. According to ADOT staff, this has resulted in greater safety, improved mobility, more efficient use of available resources, and more timely identification of, and responsiveness to, needs. Key projects are advanced more easily because of routine coordination, data-driven decisions, and better access to TSMO and safety funding programs.

<sup>18</sup> AECOM. 2020. *ADOT Planning to Programming Scoring Guidebook*. Phoenix, AZ: ADOT. [https://azdot.gov/sites/default/files/media/2020/09/FY20\\_P2P\\_Guidebook.pdf](https://azdot.gov/sites/default/files/media/2020/09/FY20_P2P_Guidebook.pdf), last accessed November 28, 2022.

## MAG and Cities of Peoria and Tempe

MAG underwent a reorganization in 2018 to emphasize certain programmatic areas, one of which was transportation safety. As a result, MAG created a separate Transportation Safety Program, which was part of an ITS program. The Safety program helped MAG increase its focus and ability to develop internal resources in the safety area. The TSMO and Safety programs are part of MAG's Transportation Technologies and Services Division, which helped to ensure the programs collaborate closely through joined activities, projects, and internal coordination. The new Transportation Safety Program also provided strong incentives and opportunities for incorporating technical innovations from other divisional programs into the safety and TSMO areas, such as innovative big data applications, emerging technology pilots, and performance management. MAG's *Strategic Transportation Safety Plan (2020–2030)*,

consistent with ADOT's *2019 Strategic Traffic Safety Plan*, incorporates numerous operations strategies. MAG's *Systems Management and Operations Plan (fiscal year (FY) 2021–2030)* integrates safety into the strategic and tactical elements of the plan. One of MAG's key planning documents, the *Regional Transportation Plan MOMENTUM 2050*, explicitly addresses and integrates both programmatic areas into regional planning efforts.<sup>19</sup>

MAG conducts various calls for projects through the Transportation Safety and TSMO programs. The funding allocations and sources are specific to the programmatic areas, but selection processes are interconnected and consider both safety and mobility aspects. The project selection processes include overlapping criteria in which safety considerations are considered when prioritizing TSMO projects and operations considerations are assessed when prioritizing safety projects. MAG's Traffic Signal Optimization Program is an area in which the safety and TSMO teams have established strong connections.<sup>20</sup> Both groups review crash data and recommend improvements, such as additional signal heads, retroreflective backplates, and improved signal timing. MAG is also currently piloting video and artificial intelligence technology that analyzes near-misses at intersections to better understand operations and safety.

The MAG represents 27 cities and towns, three Native nations, Maricopa County, and portions of Pinal County. Members include representatives from the incorporated cities and towns in Maricopa County as well as the City of Maricopa, Town of Florence, Maricopa County, Pinal County, Gila River Indian Community, Salt River Pima-Maricopa Indian Community, Fort McDowell Yavapai Nation, and ADOT.

MAG serves a region that covers 10,600 square miles and over four million people.

Source: Maricopa Association of Governments. n.d. "Frequently Asked Questions and Answers" (web page). [https://azmag.gov/Portals/0/Documents/Communications/Frequently-Asked-Questions-and-Answers\\_v3.pdf](https://azmag.gov/Portals/0/Documents/Communications/Frequently-Asked-Questions-and-Answers_v3.pdf), last accessed November 28, 2022.

19 Maricopa Association of Governments. 2021. *Regional Transportation Plan MOMENTUM 2050*. <https://azmag.gov/Portals/0/Transportation/RTP/2022/RTP-Momentum-2050-v2.pdf>, last accessed November 28, 2022.

20 Maricopa Association of Governments. 2022. "Traffic Signal Optimization Program" (webpage). <https://www.azmag.gov/Programs/Transportation/TSMO-ITS/Traffic-Signal-Optimization-Program>, last accessed August 14, 2022.

Cities within the region that MAG covers have also found traffic video to be a useful tool for improving operations and safety. For example, the City of Peoria uses traffic camera footage for Silver and AMBER alerts, serious collisions, and collisions involving government vehicles. Archived traffic video has helped improve traffic engineering functions, such as determining the causes of collisions, observing traffic control device compliance, and monitoring school zone safety issues.

As part of the City of Tempe's Vision Zero Program, the city added turn lanes at intersections—one of FHWA's suite of Proven Safety Countermeasures<sup>21</sup>—to reduce congestion and improve safety. Tempe's Transportation Systems Management Group actively monitors congestion performance, travel-time delays, and speeds on roadways. As part of the development of the Vision Zero Tempe Action Plan of 2019, City of Tempe staff reviewed crash data and determined that strategies related to speeding would be important in reducing high-severity crashes.<sup>22</sup> The City of Tempe hosted a public meeting to discuss the need for speed reduction to save lives and addressed some of the common misconceptions that lowering speed limits increases congestion and travel time.<sup>23</sup>

These are some examples of how MAG and its member agencies connect safety and operations in their plans and transportation solutions for cross-disciplinary benefits.

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21 FHWA. n.d. "Proven Safety Countermeasures" (website). <https://highways.dot.gov/safety/proven-safety-countermeasures>, last accessed November 28, 2022.

22 City of Tempe. 2019. *Vision Zero Tempe Reducing Fatal and Serious Injury Crashes to Zero*. <https://www.tempe.gov/home/showdocument?id=74455>, last accessed November 28, 2022.

23 City of Tempe. "Vision Zero" (website). <https://www.tempe.gov/government/engineering-and-transportation/transportation/vision-zero>, last accessed November 28, 2022.





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