Traffic Management

The intent of System Layers is to define in further detail recommendations that would serve toward the goals of how ADOT should be operating and managing their network. This System Layer Plan is focused on:

- **Traffic Management** – Traffic management of freeways and highways including infrastructure, daily and near/long-term operations, and agency coordination.

Context of Existing Capabilities

ADOT has in place a robust network of traffic management infrastructure throughout the state that is more advanced the more urbanized the area is. This includes signal systems, vehicle detection, visual monitoring systems, ramp metering, and feedback provided to the traveling public in the form of travel times for their day-to-day travel. Higher numbers of traffic management infrastructure are often found in more developed urban or suburban environments and are also likely found in highly traveled recreational destinations. There is some use within the state of third party data to supplement for where there is no visual or detection available, although not all parties that could use this data have access to or utilize it for their daily traffic management requirements.

While there is a solid foundation of Traffic Management infrastructure and processes in place, there are challenges and gaps in the deployment, maintenance, and sustainability of Traffic Management capabilities that drive the recommendations outlined in this System Layer Plan.

Current Issues

Through a variety of meetings, workshops, and review of existing conditions and applications utilized by the state, current issues were uncovered that provide insight into the direction that ADOT should focus on addressing. The following are some of the current issues identified as related to Traffic Management:

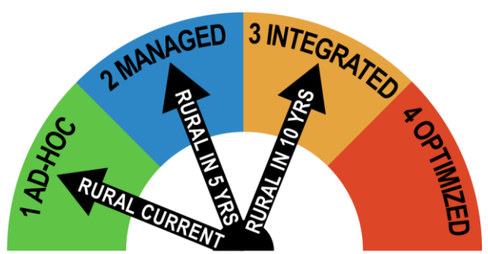
- Challenged with monitoring and proactively managing of day-to-day operations.
- Seeking real-time information on traffic conditions.
- Limited TOC/maintenance staffing.
- Need a better understanding of inventory, lifecycle and status of field devices to shorten maintenance timeframes.
- Funding sources are not readily available for lifecycle/replacement, capital new, maintenance, or piloting/innovation.

Future Direction

The project team conducted a series of individual workshops with ADOT for each System Layer Plan to identify the perceived existing readiness and future direction within the functional areas. The workshops included an interactive, online (JamBoard) activity in which ADOT staff provided specific feedback following a similar structure to the TSMO Capability Maturity Model (CMM) Framework. For Traffic Management, the workshop was held on March 23, 2022.

CMM levels for consideration of ADOT staff for their current capabilities, where they see progress in the next 5 years, and where there is desire to move toward in the next 10 years.

- **Level 1 – Ad-Hoc** – Activities are ad-hoc, informal, champion-driven
- **Level 2 – Managed** – Basic strategy application is understood with limited internal accountability or coordination
- **Level 3 – Integrated** – Standardized strategy applications that are managed for performance and aligned
- **Level 4 – Optimized** – Full and sustainable program based on prioritized data-driven process of continuous improvement



A summary of the feedback for rural (left) and urban (right) areas of the state is shown in the graphics to the left.

ADOT has in place a robust network of traffic management infrastructure throughout the state. Areas of the state that are considered urbanized have increased amounts of advanced infrastructure with the trend decreasing as the area becomes rural. Traffic management operations rely heavily upon accurate, timely, and quality data feeds to the TOC that enable decision-making for traffic flow.

ADOT should focus on getting to an integrated capability where urban and rural infrastructure alike are connected, updated on a regular basis to be optimized for day-to-day traffic mobility, and well maintained to support functional use. Funding should be commensurate and support operational needs for the various regions of the state.

Recommendations

This section provides a summary of important steps that be used as building blocks for achieving the ultimate vision that extends to the five- to 10-year horizon. Because ADOT is looking at the three- to five-year horizon for implementation, these recommendations will focus on investments that are foundational technologies needed to support ADOT's future. The remaining gaps between what ADOT has today and where ADOT needs to be in the future becomes the recommended changes/additions that are needed.

ADOT desires to look at potential recommendations in the following areas:

- Signal systems
- Visual/Monitoring system/Artificial Intelligence (AI) based monitoring system
- Vehicle Detection (traffic sensors, probe data, crowdsource data, capability and Integration)
- Travel times
- Ramp Metering
- Speed feedback – this particular category is captured in the Safety Applications System Layer Plan to account for the safety need for speed feedback signage

Table 1 provides recommendations that can assist ADOT in improving their current readiness level to move toward Level 3 capabilities for Traffic Management on a statewide basis, not just in the urban areas. While many of the recommendations are independent and can be accomplished in a short timeframe, ADOT should focus on a few key recommended activities (denoted in bold) to ensure adequate resources are available and generate the greatest benefits in progressing their readiness level.

Table 1 – Traffic Management System Layer Plan Recommendation Summary (STIP level information)

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
DATA MANAGEMENT								
Institute a GIS-Based Asset and Work Order Management System	Each device would have information logged to track information such as make, model, location, date installed, and repair/work order history. This system would require updated and collected status of ITS inventory, operations, maintenance, and performance available statewide. This system would need to be user-friendly and remotely accessible for real-time queries and data updates. System access and training would need to be provided to staff, as this would become a regular resource utilized by field technicians as well as management. This system should be able to support work order management and enable work log/diary to be remotely accessible.	**Steps:** Continue ADOT committee work to establish scope of what functions a software should capture across ADOT divisions. Perform alternatives analysis to evaluate if existing software can be updated and integrated to achieve functions required. Complete inventory collection statewide to update databases. This should include all ITS devices and communications across all ADOT Divisions (including TSMO, Broadband Office, and MPD). Identify funding in TIP for vendor selection. Develop RFQ for new software or scope for updating existing software to support additional functionality. Get vendor under contract. Manage development and integration of data and processes into software. Integrate asset management tools into day-to-day processes to keep information up-to-date and accessible. **Outcomes:** Acquire and implement new software or update existing software.	ADOT TSMO staff have indicated that this need to be a priority because of the disparate systems used today. FIS (which is GIS based) and PeCos (which is not map-based) currently do not work together. ITS technologies across the state are managed by the TSMO and MPD Divisions – a unique complexity in ITS Program management not typical for state DOTs and decentralizes operations and management of investments. A centralized and comprehensive maintenance management system is needed statewide. ADOT does not have any current nor accurate accounting of the field infrastructure that it is required to operate and maintain, which means there is no feasible way to determine funding programming and resources needed over time. The ITS asset information does not exist in a lat/long or device verified format. ADOT is underway in developing this scope of work through the ADOT committee. Once this updated system is in place, information such as lifecycle costs could be gleaned from the work history as related to asset management to support future planning and programming efforts.	Assistant State Engineer TSMO as business owner champion as this is broader than TSMO	Information Technology, TSMO RTEs, District Maintenance, MPD (as related to ITS devices under MPD management), IDO (as needed), Assistant State Engineer, Maintenance Permits Service Manager, TSMO Systems Maintenance Engineering Manager	System: $500K - $1M Inventory to create linear reference accurate database: $1M	System: $50K - $250K range depending on vendor	System: Out-source to vendor Inventory: Could be in-house completing work (such as District staff) or be out-sourced

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
DATA MANAGEMENT								
Update AZ511 to Include Freight Information	Integrate height restriction locations such as low bridge, DMS, etc. and freight friendly routes into AZ511 for freight operators and permit providers to enable easy identification of safe route choices.	**Steps:** Collect any height restrictions across the state including low bridge locations, DMS locations, and other height restriction areas along freight friendly routes including locations that have low bridge detection existing. Provide that information to AZ511 vendor or to ADOT personnel in charge of mapping for AZ511 to incorporate that information. Work with updater to identify labels/layers that can be selected to show this information. Backcheck data is accessible in AZ511. **Outcomes:** Updated layers of information accessible in AZ511.	Information important for safe and efficient freight movement is not available in a readily accessible manner. The freight mover is required to collect this information today, although it is not readily available. The feature to collect DMS height and which lanes are impacted has been added to the FIS system, although there is no method in FIS today to collect DMS height. Data may already be available on AZ511, but it needs to be easily accessible and updated regularly. Freight uses AZ511's across the country as their primary information provider, will close that gap of information accessibility to freight when they need the information most.	Maintenance Permits Service Manager or ADOT representative in charge of AZ511 data	GIS Group, TSMO Systems Technology Manager, MPD and OHOW permitting	-	No funding required – inventory needs to be collected by the state to be accurate this information should be updated and verified annually for accuracy	In-house
Develop ITS Upgrade / Maintenance Plan	Collect updated physical traffic count information available statewide including intersection TMCs in a standardized format to build repository. Utilize that information to support a regular frequency of traffic operations analysis to ensure that the traffic signal timing is adjusted often enough to accurately reflect increase in traffic volumes and growth.	**Steps:** Solicit private sector data provider for physical data collection for collecting updated traffic count information for 1/3 of state-operated signals prior to completing signal timing updates, completed annually. Assess which signals require this data collection as not all signals are owned/operated by the state or have detection to capture this information already. Utilize ATSPM data where appropriate. **Outcomes:** Traffic count data by private sector data collector or provider.	ADOT has some existing detection that can capture this information. Signal timing is challenging to update throughout the state without updated turning movement counts.	Operational Traffic & Safety Manager, TSMO RTEs	TSMO Systems Maintenance Engineering Manager, Districts	1/3 of state signals (total of ~618 signals new plus existing) at $1.5K per intersection = $920K total	$900K per year just on signal maintenance	Out-source to private sector data collector or provider

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
PERFORMANCE MEASURES								
Develop ATSPM Dashboard	Develop a performance measure platform (i.e., ATSPM) across all TSMO elements that includes dashboards to easily communicate TSMO performance. Include the evaluation of VSL operations and compliance with DPS.	*Steps and Outcomes have been incorporated in the **Develop and Utilize TSMO Performance Measure Platform** action item in the **Data and Performance Management System Layer Plan***	ADOT is doing some performance reporting today at an executive level. However, much of the reporting does not trickle down to staff and is not granular in nature to determine needs for remedy or confirmation of successes. Many System Layer Plans are calling for this to be a priority for TSMO. It will be important to re-assess the program of reporting on performance metrics based on the definitions in the ITS Master Plan including what level of aggregation, what audience, and what frequency as well as reassess how best to communicate results/data. Automating the data collection, viewing, and reporting processes through a single platform that all TSMO groups can utilize will provide more successful and accurate centralized management of how ADOT is performing and where to put resources to remedy issues or invest further into developing. Traffic signals today are challenging to report on. A single platform would offer the ability to incorporate other types of data such as pump stations, tunnels, etc.	ADOT TSMO Director and Operational Traffic & Safety Manager	ADOT ITG to assist in database/software development, all TSMO Group managers to contribute	$400K for developing platform and dashboarding with the various groups that will utilize the platform	$50K per year of maintenance (if any is needed once it is initially established)	Out-source – either RFP or TSMO On-Call

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
PERFORMANCE MEASURES								
Automation to Assess Detector Health	Automation of currently manual processes to visualize loop detector health in real time.	**Steps:** 1. Identify the manual repetitive tasks involved in retrieving the loop health data. 2. Determine the level of visualization based on goals. 3. Examine the availability of RITIS data retrieval tools or APIs to serve the purpose. 4. Determine the ETL process that will be used to process the data. 5. Identify in-house resources for writing code for data connections, APIs, and the available visualization tool. 6. Prepare for rollout. 7. Run the automation and analyze the results. **Outcomes:** More complete and real-time understanding of detector issues.	Loop detection is used in real-time operations of ramp meters as well providing lane by lane speed, occupancy, and volume data for performance and planning purposes. However, in July 2023, at least 55% of locations had data quality issues. The manual process of identifying locations is cumbersome, time-consuming, and costly. Due to the temporal nature in failure of detectors, an automatic process is required to measure and visualize the detector health more frequently in order to better identify problems and make appropriate decisions.	TSMO System Technology Group Manager	Systems Maintenance, MAG, MPD	$0	$0	In-House

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
STAFFING STRUCTURE								
Evaluate Traffic Management Staffing & Workforce	Assess staffing at the TOC to support traffic management activities statewide as well as dedicated team to support signal timing statewide. This would include appropriate staff that have the skillsets and training required to support traffic management strategies, process/standard implementations, and serve as a secondary point of contact for traffic management needs.	**Steps:** Identify, allocate, and train new staff positions at the TOC and to support signal timing to serve as an extension of staff for traffic management purposes. The staff augmentation may be one person dedicated or a selected firm with a team of staff dedicated to a portion of their time during the year to provide a capped contractual number of resources. Real-time TOC traffic management and signal timing may require an Engineering license depending on ADOT requirements. Technology/automation should reduce the requirements of traffic management staffing. Evaluation will need to be done after beginning traffic management functions at the ADOT TOC to verify FTE required statewide as well as evaluate traffic signal timing needs statewide for day-to-day time-of-day plans, support weekend closures, and supporting full closures due to incidents. Consider best practice evaluation of other states that are well staffed at their TOCs for traffic management. **Outcomes:** Dedicated staff to support traffic management activities statewide.	There is limited capacity and a high number of systems that rely on manual decisions at the ADOT TOC. Automation of systems will relieve some, but not all, processes required for statewide real-time traffic management which is a significant gap that nearly all state TOCs in the country currently serve. To support these new initiatives, ADOT should allocate additional funding to bring on board additional staff specifically to facilitate coordination of traffic management needs statewide. Currently there is only one FTE position allocated to supporting traffic management statewide and there is a significant need to support traffic management from the ADOT TOC. With the desire for additional data and traffic management processes to be established and supported statewide, there is a need to identify additional staff to support adoption and integration into all Districts and Region processes.	Traffic Management Group Manager	ADOT Dispatch Manager, IRU Program Manager, AZDPS personnel	$300K per year for one FTE staff position in a staff augmentation contract	$300K per year for one FTE staff position in a staff augmentation contract	Out-source – either RFP or TSMO On-Call assignment for traffic management dedicated staff aug. for 100% of one FTE staff position to serve as liaison to complete System Layer Plan needs

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
STAFFING STRUCTURE								
Develop and Conduct ITS Technologies and Software Training Plan and Program	Develop standard ITS technologies and software system trainings for all ADOT groups, subgroups, and districts. Developing and implementing new technologies to support ITS throughout ADOT's system inherently comes with new processes, standard work, and applications to support the technology. Training should span all users who interface with the devices or their programs and be kept up to date as new technologies are introduced.	**Steps:** TSMO Group Managers to identify the available training resources already in ADOT possession. Collect training resources that are required to have been provided as part of vendor contracts or software warranties. Create repository of training resources. Summarize training resources collected and already available. Provide repository on ADOT intranet to all ADOT TSMO, Region, and District staff for immediate use. Identify training that needs to be developed in sufficient detail to communicate who needs what type of training, who will be doing the training, and requirements as part of "standard work" documentation. Create training videos, slides, or summary sheets for new training. Provide new training resources in repository. Evaluate potential application of training as required annual performance of staff. This training program should include ITS equipment troubleshooting training for Region Technicians, tracking software use, and coordination protocols. This training should also include standard protocol use for software system entry, integration, and time requirements for data entry. Accountability should come with the training program. **Outcomes:** Training Plan and Program as well as a repository of tools and resources available on ADOT intranet and process put in place to update on training regularly.	A lot of training does happen at the state but moves and changes challenges the program. A comprehensive training program needs to be developed and implemented to ensure those utilizing these resources can use them to their full potential. This would also help ensure redundancy in staff's knowledge to combat potential for information loss from staff turnover. This applies to new initiatives as well as existing applications currently in ADOT's system. There needs to be a broader use of third-party data to be used by others within TSMO as well as other ADOT functions that could make use of the data. ADOT could model the Train the Trainer model in the incident management space creating subject matter experts over time.	TSMO Group Managers	TSMO RTEs, Regional Maintenance Personnel	-	No funding required – although this information should be updated and verified annually for accuracy	In-house (this can be out-sourced as well, although in-house staff should initiate the process)

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
PROCESS STRUCTURE								
Establish ITS Program Funding Pools	Establish funding pools that are right-sized specifically to dedicate to different activities such as lifecycle/replacement, capital new, maintenance, pilot/innovation. These funding pools will be used by Regions to apply to District needs as identified in this Plan as well as unidentified needs that arise over time. Costs for individual devices vary and include procurement, installation, and maintenance required over time.	**Steps:** Identify funding pools for each Region allocated to each District based on size of existing infrastructure and planned locations based on existing documents and communicated need. Including funding pools into TIP for each category as shown in the table to the left. The summary of recommended programmatic level costing for capital implementation and ongoing annual maintenance is shown below for each device type: - Autogate: $15K / $1.5K - Beacon: $400 / $40 - CCTV (and pole): $35K / $500 - Detection – Vehicle: $5K / $500 - Ramp Meter (signals): $16K /$1.5K - DMS: $400K / $2.5K - LCS: $150K / $1.5K - Radio/Cell: $4K / $400 - RWIS: $100K / $7K - SFS: $400 / $40 - Traffic Signal: $350K / $1.5K - VSL: $20K / $2K - WWD: $25K / $2.5K - Adaptive Traffic Signal Control: $30K / $3K Each RTE should be in charge of distribution of the funding pools and tracking of use. Reevaluate use of funding pools annually as part of regular reporting and review process. Each Region should forecast for five years out their anticipated “ask” of the funding pools recognizing the lifecycle inventory replacement needed based on a thorough inventory completed for the state. **Outcomes:** Continuous, year-after-year TIP funding pools that reevaluated for size and scope annually.	While ADOT has not been restricted in the ability to be reactive to urgent needs in lifecycle, maintenance, capital investment areas, there has not been a mechanism in place to allow for proactive and responsive addressing of needs and issues that occur around the state. Priority is typically placed on the Central District urbanized area at the detriment of every other area of the state. Apportioning out funding to allow for activities to happen throughout the state at the same time will move the needle on progress faster and more equitably. This ability for each Region to pull from a funding source that applies to their infrastructure creates a high focus on equal distribution of funding across the state rather than a large focus on the Central Region.	Assistant State Engineer TSMO	TSMO Division Director, Deputy State Engineer, Assistant State Engineer, Region RTEs	See table under Steps and Outcomes	See table under Steps and Outcomes ADOT should reevaluate these funding pools year-over-year to appropriately project out need at least 5 years in advance	TIP funding programs established that ADOT TSMO can pull from as projects to apply to Districts

PROCESS Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Total Funding Required	Annual Funding Required	Contracting Mechanism
PROCESS STRUCTURE								
Interjurisdictional Agreements	Develop agreements with local jurisdictions along interstate routes to permit for district/regional access to remotely view and control CCTV during work zones, incidents or day-to-day monitoring if ADOT is not using CCTV. Agreements should also include permitting for after-hours signal operations with pre-approved incident signal timing plans in cases of emergencies for areas identified with historical needs and issues. Develop transition plan to give operational control over ADOT signals during business hours and for ADOT to operate after hours.	**Steps:** Identify local jurisdictions that would like to have access and control to ADOT CCTV and for what purpose. Identify agencies that would need to be transferred operational control of ADOT signals where desired by both ADOT and the local agency partner. Create master agreement with agencies for the two functions (CCTV and signal operation) and involve individual agencies to sign the master IGA. **Outcomes:** IGA with local jurisdictions.	This recommendation captures the desire to share access to and control of ITS and signal infrastructure around the state particularly with the local agency that is locally responsible for the impacts to their local network from ADOT roadways. Local agencies are more in tune with local requirements, adjustments, travel patterns than ADOT can be as a statewide entity. This is formalizing a state-local partnership.	TSMO Traffic Signal Timing Manager	ADOT owner of CCTV control, local agencies	-	-	In-house
Formalize ADOT ITS Committee Across TSMO Division	Establish formal review process with a committee of representatives from various groups of TSMO to vet recommendations against guidelines for how to deploy ITS applications. This group should meet quarterly on actions and progress per plan. Committee agendas should be established in advance and incorporate topics such as needs / issues to address, implementation of plan, and discussion of staff and funding available before engaging in pilot projects that adds to system.	**Steps:** Identify participants that should be included in an ongoing quarterly ADOT ITS Committee within TSMO. Establish standard agenda from which to discuss and invite participants each meeting. Agenda to include update of action items, guest topic/invitee, request for assistance of action items, identification of new action items, etc. Establish location on intranet to serve as archive of Committee activities and location where action items can be updated by all staff. Set calendars for one year in advance for quarterly meetings. Facilitate discussions. Provide all materials and outcomes of discussions on intranet and send notice to all TSMO staff of latest status and location of intranet resources. **Outcomes:** Quarterly meetings for ongoing coordination and management of the intranet archive of materials and outcomes.	An ongoing committee discussion about implementation of a centralized plan for the ITS Program will show ADOT upper management action behind this plan and following the plan as well as updating the plan annually over time. Showing progress and completion of activities will solicit more support and recognition for accomplishments.	Assistant State Engineer TSMO	Include all champions acting on any activity outlined in this Plan – initiate this with TSMO Group Managers and cascade to include others as needed	-	-	In-house

INFRASTRUCTURE DEPLOYMENT Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Quantity	Cost Per Unit	Total Capital Cost	Total O&M Cost	Contracting Mechanism
LIFECYCLE REPLACEMENT										
Develop ITS Technology Upgrade Program	Develop strategic detection implementation plan statewide to include locations at signaled intersections but also at strategic locations that warrants agency-owned data collection where private sector data is not reliable or available. Include evaluation and deployment at POE's for enhanced operations and key interstate/highway entry points to accurately gauge the amount of traffic traveling through corridor. ADOT should assess their current inventory of ITS and traffic signal technology at signalized intersections and along urban freeways to understand what equipment is being utilized, what works well, and what needs to be replaced. Minimum standards can be established for particular equipment or ITS devices such as utilizing a particular vendor for controllers or vehicle detection. This would allow locations to be identified where equipment needs to be upgraded to the new standard to support integration with the system. This could include alternate route decision points, bridges, or flooding areas. This would include systematic replacement of the current freeway management system detection in the Phoenix metropolitan area.	**Steps:** Develop SOQ or RFP to solicit support to collect inventory of traffic signal equipment, detection, and other infrastructure located at signalized intersections and development of infrastructure plan. Consider the option to create complete data sets of ITS infrastructure to support digital twin requirements in the future during inventory collection. Conduct collection of inventory for updating in database. Identify and prioritize location needs to establish replacement plan for signal technology to allow for ATSPM, adaptive operations, IP addressability, frequently used truck ramps, etc. Apply the Arizona Management System (AMS) Problem Solving Tool to determine solution. Evaluate alternative technologies to loop detection for more reliable data and easier maintenance over time. Upgrade and/or install roadway detection near ramp meter locations to support more advanced operations such as corridor adaptive ramp metering. Identify in established TIP funding program for lifecycle and capital new investments the priority locations and packages that will occur in the upcoming fiscal year. Develop SOQ or RFP to solicit design support for development of procurement documents. Manage design process through bidding. Bid construction project. Acquire contractor. Manage construction with assistance from designer. During construction of first phase, initiate design of next phase. This replacement funding should come out of the new capital Funding Pool cited above. **Outcomes:** Plan with specific recommendations for use of funding pool for lifecycle replacement. Next step is procurement and replacement and ingesting the data into centralized ADOT platform.	There is a broad set of existing detection capabilities throughout the state. There are a number of gaps around the state in terms of where detection could be upgraded or could be collecting data that would be valuable and cost effective to have physical infrastructure located. Currently all regions have different types of controllers and there needs to be consistency across regions to provide consistent functionality. The current freeway management system detection is regularly not functioning or reporting traffic data. The decline of the quality of detector health data challenges the ability for ADOT to support real-time traffic management, incident response support, and travel times messaging statewide. Defining which signals need updated controllers and detection and which have or need ATSPM to support management is needed. With many ITS devices existing under ADOT's responsibility, a plan should be put in place to systematically inventory, identify, and recommend replacements throughout the system.	TSMO Systems Maintenance Engineering Manager	TSMO Traffic Signal Timing Manager, TSMO RTEs, District Maintenance personnel	Until a thorough inventory is complete it is unknown how many devices require upgrade or replacing	Cost for new capital upgrade or replacing is reflected in the Funding Pools	Cost for new capital upgrade or replacing is reflected in the Funding Pools	Cost for new capital upgrade or replacing is reflected in the Funding Pools	Out-source – either RFP or TSMO On-Call assignment for signal inventory and plan

INFRASTRUCTURE DEPLOYMENT Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Quantity	Cost Per Unit	Total Capital Cost	Total O&M Cost	Contracting Mechanism
EXPANSION OF ADOT TECHNOLOGY DEPLOYMENT										
Real-Time Roadway Condition Enhancements – DMS and CCTV	Deploy or replace existing equipment supports for real-time road condition technologies at regular locations of inclement weather, high incident rates, and rock falls as provided in the **Prioritization Tool**. This includes recommendations to deploy CCTV for monitoring roadway conditions in real-time and also to deploy messages in key areas to route and warn travelers of special, incident, and weather events. Deploying CCTV and DMS on all major interstates entering/leaving the Phoenix metro area before key alternative routes allows for travelers to receive traveler information and adjust routing choices accordingly. This also includes expanding to dual-sided DMS in locations with DMS in single direction.	**Steps:** Identify in established TIP funding program for lifecycle and capital new investments the priority locations and packages that will occur in the upcoming fiscal year. Assess DMS and CCTV location needs throughout state on a yearly basis based on traffic, incident, weather, and event management needs. Some CCTV locations may be able to be captured by third party data. Conduct traveler information gap analysis and determine strategic locations for DMS placement proximity of RWIS stations. Assess and log DMS lifecycle replacement needs and develop plan to address needs accordingly. Consider changes to CCTV and DMS design guidelines to adjust where these devices are located in order to capture multiple traveler needs (wrong way driving, weather, low bridge, detouring, etc.). This includes locations with seasonal fluctuations in traffic (weather, seasonal, and festivals). Develop SOQ or RFP to solicit design support for development of procurement documents. Manage design process through bidding. Bid construction project. Acquire contractor. Manage construction with assistance from designer. During construction of first phase, initiate design of next phase. Utilize new capital Funding Pool for design and construction. **Outcomes:** Design and construction of DMS and CCTV statewide in incremental manner.	There is a broad set of existing DMS and CCTV throughout the state. Although there are a number of gaps around the state in real-time condition collection and reporting that would be valuable and cost effective to have physical infrastructure located. Priorities likely need to be for traffic management detouring purposes as well as road weather purposes. Weather conditions can be very localized, and messaging should match available conditions. Installing DMS at or near RWIS allows for more accurate messaging to the public.	TSMO RTEs	District Maintenance Managers, one representative from each TSMO group	Refer to Tool – quantity will depend on specific location where deployed	$150K for mini DMS $400K for full DMS $35K for each CCTV and pole	Refer to Tool – cost will depend on quantities included at specific locations where deployed	$15K per DMS $1.5K per CCTV	Out-source – either RFP or TSMO On-Call assignment

INFRASTRUCTURE DEPLOYMENT Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Quantity	Cost Per Unit	Total Capital Cost	Total O&M Cost	Contracting Mechanism
EXPANSION OF ADOT TECHNOLOGY DEPLOYMENT										
Expansion of Specific Technology Deployment Projects	New types of technology applications have been occurring in the state for some time now and warrant a more thorough look at applications beyond their initial deployment. Below are specific technology deployment project types that warrant further consideration. **Visibility –** In combination with speed management, providing visibility detection and traveler information warnings can be useful, but needs to be based on crash data analysis. ADOT has already completed a dust warning system on I-10 around Picacho Peak between Phoenix and Tucson and is implementing a VSL/visibility system along I-40 for around 24 miles spanning west to east centered on Flagstaff. Further expansion of visibility systems should be based on a thorough data analysis to determine appropriate locations elsewhere in the state. Urban areas can be considered but need considerable warranting because of the added cost for maintenance. **Ramp Meters –** Expanding adaptive ramp metering across all ramp meters in Phoenix. Implementing adaptive ramp metering in Tucson along I-10 and I-19. Most of I-10 from downtown to Marana has infrastructure to support ramp metering, if implemented.	**Steps:** Conduct weather (visibility) and incident (ramp meter) analysis statewide using INRIX data to identify areas of interest for expansion of these technology deployments. Cross-check with planned ITS maps what infrastructure is already proposed or planned for those areas identified. Identify in established TIP funding program for capital new investments extra funding available after priority phases for establishing real-time condition infrastructure in DMS, CCTV, and detection that are considered for the upcoming fiscal year. Develop SOQ or RFP to solicit design support for development of procurement documents for projects chosen. Manage design process through bidding. Bid construction project. Acquire contractor. Manage construction with assistance from designer and make sure process for notifications is established prior to project completion. Utilize new capital Funding Pool for design and construction. * It is recommended that ADOT pursue these projects after achieving the real-time infrastructure recommendations outlined earlier in this System Layer. **Outcomes:** Design and construction of specific application of technologies statewide in incremental manner.	ADOT has conducted several pilot demonstration projects throughout the state that have potential to be able to be deployed elsewhere to address issues. Expansion is not a driver of this ITS Master Plan. Preservation and thorough operational capabilities utilizing existing technologies is the driver. It is important to continue to pursue expansion of demonstrated technologies that have been important to explore in the past. There needs to be data-driven decision making on whether or not to pursue expansion of these technologies further that has not been done to date and needs to occur separately from this Plan.	Assistant State Engineer TSMO	TSMO Traffic Signal Timing Manager, TSMO RTEs, District Maintenance personnel	Initial study to review potential areas around the state to focus on	$25K for data analysis study Cost per unit of VSL, DMS, detection, and other ITS devices are captured in Funding Pools	Cost per unit of VSL, DMS, detection, and other ITS devices are captured in Funding Pools	Cost per unit of VSL, DMS, detection, and other ITS devices are captured in Funding Pools	Out-source – either RFP or TSMO On-Call assignment

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EXPANSION OF ADOT TECHNOLOGY DEPLOYMENT										
Deploy Automated Closure Gates	Implement automated closure gates at strategic locations with associated mini DMS at key rural interstate entrances.	**Steps:** Work with District staff to confirm locations needed for automated closure gates. Identify in established TIP funding program for lifecycle and capital new investments the priority locations and packages that will occur in the upcoming fiscal year. Assess automated closure gates and associated mini DMS location needs throughout state on a yearly basis based on incident, weather, and event management needs. Consider communications needs to new devices. Develop SOQ or RFP to solicit design support for development of procurement documents. Manage design process through bidding. Bid construction project. Acquire contractor. Manage construction with assistance from designer. During construction of first phase, initiate design of next phase. Utilize new capital Funding Pool for design and construction. **Outcomes:** Design and construction of automated closure gates and associated mini DMS statewide in incremental manner.	There is some use of automated closure gates in the state, although there are opportunities to utilize this type of infrastructure to enhance the safety and mobility of the traveling public. Especially in the NC District, there are opportunities to close particularly challenging to get to in adverse weather conditions for one or smaller two lane roads remotely to keep traffic from getting stuck or entering an unsafe roadway.	TSMO RTEs	District Maintenance Managers	Northern Region: 26 locations Central Region: 2 locations Southern Region: 4 locations Total: 32 locations	$50K for automated closure gate $150K for mini DMS $25K for comm.	Northern Region: $5.85M Central Region: $450K Southern Region: $900K Total: $7.2M	$15K per DMS Total: $480K	Out-source – either RFP or TSMO On-Call assignment

INFRASTRUCTURE DEPLOYMENT Recommendation Title	Description	Steps and Outcomes	Context for Recommendation	Recommended Champion	Recommended Stakeholder Involvement in Implementation	Quantity	Cost Per Unit	Total Capital Cost	Total O&M Cost	Contracting Mechanism
DEMONSTRATED TECHNOLOGIES FOR ADOT DEPLOYMENT										
Queue Management	Identify areas with recurring backups and historically long and difficult to manage queues and develop plan to deploy queue management. Assess need for queue warning detection and deploy in warranted areas. Queue management technologies can be considered as real-time detection, CCTV, lane control signs, and DMS, or some combination thereof for queue condition notification purposes. Further expansion of queue management systems should be based on a thorough data analysis to determine appropriate locations elsewhere in the state. Urban areas can be considered but need considerable warranting because of the added cost for maintenance.	**Steps:** Conduct bottleneck and congestion analysis using INRIX data to identify areas with recurring backups and queuing. Cross-check with planned ITS maps what infrastructure is already proposed or planned for those areas identified. Identify in established TIP funding program for capital new investments extra funding available after priority phases for establishing real-time condition infrastructure in DMS, CCTV, and detection are considered for the upcoming fiscal year. Develop SOQ or RFP to solicit design support for development of procurement documents. Manage design process through bidding. Bid construction project. Acquire contractor. Manage construction with assistance from designer and make sure process for notifications is established prior to project completion. Utilize new capital Funding Pool for design and construction. **Outcomes:** Design and construction of queue management technologies statewide in incremental manner.	There are queuing issues that occur throughout the state at borders, ports of entry, and various other locations during seasonal activities. The notification of queuing when it is occurring is crucial to determine resources necessary to support and manage the queue for the safety of the traveling public. ADOT has recently applied for a SMART grant along SR-85 moving toward the border for a queue management deployment project. ADOT can deploy strategic technology to address these queuing areas, but only after foundational real-time condition reporting infrastructure is prioritized. Expansion is not a driver of this ITS Master Plan. Preservation and thorough operational capabilities utilizing existing technologies is the driver. There needs to be data-driven decision making on whether to pursue expansion of these technologies further that has not been done to date and needs to occur separately from this Plan.	TSMO Systems maintenance Engineering Manager	TSMO Traffic Signal Timing Manager, TSMO RTEs, District Maintenance personnel	Initial study to review potential areas around the state to focus on	$25K for data analysis study Cost per unit of SFS, VSL, DMS, detection, and other ITS devices are captured in Funding Pools	Cost per unit of SFS, VSL, DMS, detection, and other ITS devices are captured in Funding Pools	Cost per unit of SFS, VSL, DMS, detection, and other ITS devices are captured in Funding Pools	Out-source – either RFP or TSMO On-Call assignment

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EMERGING TECHNOLOGY FOR ADOT PILOTING										
Artificial Intelligence Using Existing CCTV	Establish a pilot utilizing individual locations where CCTV currently exist. ADOT should investigate the use of AI vendors to collect insights and data from the existing images to support identification of safety concerns. Alerts can be established from the AI-based system to inform the ADOT TOC of safety risks, delay occurrences, and incidents.	**Steps:** Reference safety analysis and studies and cross-check against existing CCTV locations to determine appropriate locations for piloting AI technology at existing equipped locations. Establish RFP or direct-select AI vendor for piloting data collection and insights in partnership with the Operational Traffic & Safety TSMO group. Conduct pilot project. Report on data outcomes and anticipated use. Utilize new capital Funding Pool for design and construction. **Outcomes:** Pilot technology demonstration at spot locations around the state.	There is a trend in DOTs to utilize existing CCTV imagery for obtaining insights not able to be collected before. The vendor environment is being established and it is cost-prohibitive to implement statewide. Suggest a pilot to demonstrate the technology and data use prior to expansion. Alerts will help the ADOT TOC have better situational awareness to support response.	TSMO Systems Technology Manager	State Traffic Safety Engineer and other at the Operational Traffic & Safety group, ADOT TOC for real-time use	1	$75K	-	-	Out-source – either RFP or TSMO On-Call assignment
Digital Infrastructure	Integrating digital infrastructure with the existing technology that can improve safety mobility and lower cost including computer vision, AI, ML, sensors, data analytics. CCTV project, WWD data by ASU, and sending alerts to AZ511.	**Steps:** 1. Analyze the current need of existing technologies for heavy computation and data transmission/storage. 2. Identify the digital infrastructure that best fits the needs. **Outcomes:** Digital infrastructure to support safety and mobility while reducing the dependency on physical infrastructure.	The changing landscape of ITS is shifting the balance between physical and digital infrastructure. Moving towards digital reduces the capital and maintenance costs of infrastructure and increases the amount of information available to manage traffic efficiently and safely.	TSMO Systems Technology Manager	ITG, TOC, System Maintenance	-	-	$300K	$10K	Out-Source

Performance Measures

The ADOT TSMO Plan defines performance measures using three categories, safety, mobility, and infrastructure/system health. The following performance measures were developed to track the progress of the above recommendations associated with the Traffic Management System Layer Plan.

Performance Measurement Topic	Performance Measure	Measure Applicability
Device coverage	Increased device coverage statewide and across each Region	% of priority locations (based on incidents, congestion, weather, etc.) that are covered by each type of device
Reliability of equipment communications of ITS infrastructure	Increased ITS infrastructure health	Collecting data or not collecting data Uptime, downtime, data quality and/or functional quality of a device or system
Traffic condition trends	Status of traffic conditions throughout year	Continue to monitor speed, travel time, user delay, bottleneck month over month and year over year

Table 2 – Existing ITS Devices Annual Maintenance Costs

DEVICE	CENTRAL		NORTHERN			SOUTHERN					CN	SW	NC	NE	NW	SC	SE
ITS Device	CN	SW	NC	NE	NW	SC	SE	Total	Annual	Total	Annual	Annual	Annual	Annual	Annual	Annual	Annual
CCTV								**567**									
Highways and Signals	342	9	16	7	38	53	15	480	$ 500	$ 240,000	$ 171,000	$ 4,500	$ 8,000	$ 3,500	$ 19,000	$ 26,500	$ 7,500
Dust						5		5	$ 500	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ 2,500	$ -
RWIS		6	14	14	6			40	$ 500	$ 20,000	$ -	$ 3,000	$ 7,000	$ 7,000	$ 3,000	$ -	$ -
DMS			23	9	10			42	$ 500	$ 21,000	$ -	$ -	$ 11,500	$ 4,500	$ 5,000	$ -	$ -
Detection								**1127**									
WWD Designated (Thermal)	67							67	$ 500	$ 33,500	$ 33,500	$ -	$ -	$ -	$ -	$ -	$ -
WWD Designated (Radar)	6			2	2			10	$ 500	$ 5,000	$ 3,000	$ -	$ -	$ 1,000	$ 1,000	$ -	$ -
Dust (Radar)						1		1	$ 500	$ 500	$ -	$ -	$ -	$ -	$ -	$ 500	$ -
Dust (Spot)						13		13	$ 500	$ 6,500	$ -	$ -	$ -	$ -	$ -	$ 6,500	$ -
Dust (Loop)						6		6	$ 150	$ 900	$ -	$ -	$ -	$ -	$ -	$ 900	$ -
RWIS		3	7	7	3			20	$ 7,000	$ 140,000	$ -	$ 21,000	$ 49,000	$ 49,000	$ 21,000	$ -	$ -
Counters	302							302	$ 250	$ 75,500	$ 75,500	$ -	$ -	$ -	$ -	$ -	$ -
Ramp Meters	261							261	$ 1,500	$ 391,500	$ 391,500	$ -	$ -	$ -	$ -	$ -	$ -
TS Detection (Thermal)	98	16	23	14	76	48	15	290	$ 500	$ 145,000	$ 49,000	$ 8,000	$ 11,500	$ 7,000	$ 38,000	$ 24,000	$ 7,500
TS Detection with WWD Thermal)	152							152	$ 500	$ 76,000	$ 76,000	$ -	$ -	$ -	$ -	$ -	$ -
Truck Escape Ramp (Loop)			2		2			4	$ 150	$ 600	$ -	$ -	$ 300	$ -	$ 300	$ -	$ -
Truck Escape Ramp (Thermal)			1					1	$ 500	$ 500	$ -	$ -	$ 500	$ -	$ -	$ -	$ -
Signs								**389**									
DMS	192	9	24	13	20	34	8	300	$ 2,500	$ 750,000	$ 480,000	$ 22,500	$ 60,000	$ 32,500	$ 50,000	$ 85,000	$ 20,000
VSL						32		32	$ 2,000	$ 64,000	$ -	$ -	$ -	$ -	$ -	$ 64,000	$ -
SFS	12				12	2		26	$ 40	$ 1,040	$ 480	$ -	$ -	$ -	$ 480	$ 80	$ -
WWD Flashers	31							31	$ 40	$ 1,240	$ 1,240	$ -	$ -	$ -	$ -	$ -	$ -
Signals								**613**									
Traffic Signals	198	28	71	38	101	129	37	602	$ 1,500	$ 903,000	$ 297,000	$ 42,000	$ 106,500	$ 57,000	$ 151,500	$ 198,500	$ 55,500
PHB's	2	1		2	1	3	2	11	$ 500	$ 5,500	$ 1,000	$ 500	$ -	$ 1,000	$ 500	$ 1,500	$ 1,000
ASCT	13					22		35	$ 3,000	$ 105,000	$ 39,000	$ -	$ -	$ -	$ -	$ 66,000	$ -
Communications																	
Nodes	19							19	$ 4,500	$ 85,500	$ 85,500	$ -	$ -	$ -	$ -	$ -	$ -
Fiber Miles	522					60		582	$ 1,500	$ 873,000	$ 783,000	$ -	$ -	$ -	$ -	$ 90,000	$ -
Grand Totals	**2217**	**72**	**181**	**106**	**271**	**408**	**77**	**3332**									
Urban Totals	**1567**	**0**	**0**	**0**	**0**	**128**	**0**	**1695**		**Total**	**$2,486,720**	**$101,500**	**$254,300**	**$162,500**	**$289,780**	**$560,980**	**$91,500**
Rural Totals	**650**	**72**	**181**	**106**	**271**	**280**	**77**	**1637**									