

ITS Communications Structure

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:

- **ITS Communications Structure** – A structure for communications statewide that is needed to support any device/system installed throughout the state.

Context of Existing Capabilities

ADOT has developed a fairly broad network of fiber communications throughout the Phoenix metropolitan region, along most of the freeway corridors. The network consists of node buildings located approximately every 6-8 miles, serving the fiber segments along the freeways. There are essentially two rings covering the Valley, which also provides redundancy along each ring. Additional redundancy could be achieved if the two rings were connected, thus eliminating much of the ring that fiber would go down for any segment along the primary backbone. Fiber throughout the rest of the state is fairly sporadic. In Tucson, it is located along I-10. Fiber is also being added along the I-17 and I-19. There are also a few locations where ADOT leases fiber from third parties. ADOT has established a Broadband office, which is coordinating with the Arizona Commerce Authority's Arizona Broadband Office to develop a strategy for providing broadband communication throughout the state. There are a number of projects currently that are being designed that are following several broadband efforts – I-40, I-19, I-17, and I-10. ADOT also utilizes wireless and cellular communications throughout the state to connect to ITS devices and traffic signals that are not able to connect directly to existing fiber.

While there is a solid foundation of Communications infrastructure and processes in place, there are challenges and gaps in the reach of the communications to connect communities around the state and also connect the existing ITS infrastructure that drive the recommendations outlined in this System Layer Plan.

Challenges and Gaps

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 ITS Communications Structure:

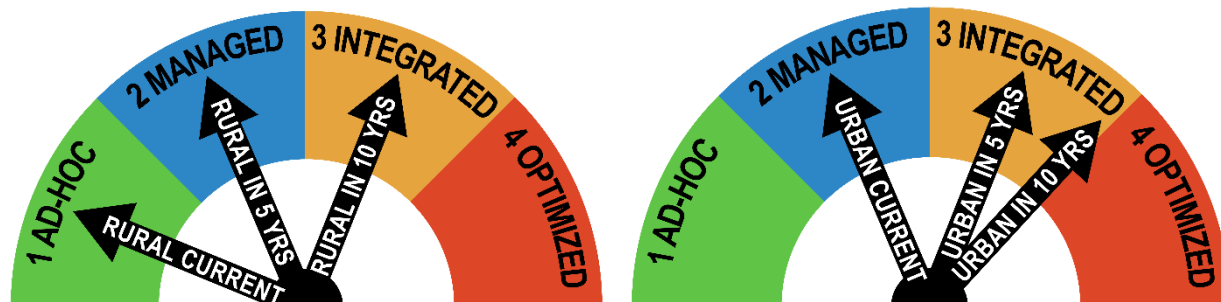
- Operational inefficiency in areas where communication is not available with ITS devices.
- Needs to update communication standard periodically.
- Communication gaps in rural areas.

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 Communications, the workshop was held on June 16, 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 is partnering with the Broadband Office to invest in a broadband backbone along all interstates with the goal of providing communications to all communities and corners of the state. ADOT will continue to leverage this backbone of broadband communications to connect to ITS devices, traffic signals, and node facilities statewide through a variety of communications media to increase communications redundancy and resilience for each device. A clear demarcation of operations and maintenance responsibility from the broadband side to the ITS network side

should be at the pull box infrastructure. In urbanized areas of Phoenix and Tucson, ADOT should have ownership over the operations and maintenance of all communications. In rural areas, ADOT should leverage private sector partnerships for operations and maintenance of communications. Proper funding based on needs for both the human and resources side as well as the capital investment side should be allocated to support District operations and maintenance. Providing a reliable backbone throughout the state as well as responsible operations and maintenance funding and resource support will propel the state into the next generation of being able to accept innovations in communicating with the traveling public and the communities that ADOT serves.

Recommendations

This section provides a summary of important steps that can 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:

- Evaluate various communication structure ownership strategies, including Department-owned, leased, public-public relationships and public-private partnerships.
- Evaluate/recommend each major type of communication media such as fiber or wireless to connect the middle miles/end miles based on the challenges of any strategic location.

Table 1 provides recommendations that can assist ADOT in improving their current readiness level to move toward Level 3 capabilities for ITS Communications Structure 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 – ITS Communications Structure 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								
Update Communication Standards	Create ITS standards for broadband deployment.	<p>Steps: As ADOT builds the broadband network, revisions to these standards and specifications will be required but ADOT should standardize on a complete set from which the private sector and local communities can expect.</p> <p>Outcomes: ITS broadband standards and specifications.</p>	As ADOT is deploying broadband around the state, ADOT is utilizing a few types of broadband designs for pull box configuration, conduit sizing and installation, and fiber sizing and splicing. As the state gets more consistent with broadband deployments it will be important to standardize on a set of broadband design and specifications from which to pull from to streamline future projects.	ADOT Broadband Office Program Administrator	MPD, Contracts and Specifications, and TSMO as well as any others involved in broadband designing and constructing statewide	\$50K	\$0	Out-source – either RFP or TSMO On-Call
PERFORMANCE MEASURES								
None								
STAFFING STRUCTURE								
None								
PROCESS STRUCTURE								
Establish Funding Pool for Middle Mile / Last Mile Connections	ADOT has an established Statewide Broadband Master Plan to support the backbone for the state. This ITS Master Plan will define additional connections that should be established throughout the state. The needs for each District vary widely. There will need to be a consistent funding mechanism implemented over many years to broaden the communications capabilities throughout the state where dead zones exist, devices need to be managed, and traveler need better information. The broadband planning has not allocated separate funding for broadband deployments and, based on the number of miles required in the Expand Broadband Fiber Statewide recommendation below, there needs to be a significant amount of funding set aside for broadband deployments. This funding pool should be able to be used for new capital investment as well as replacement of existing backbone, maintenance activities, and recurring leased communications costs.	<p><i>Steps and Outcomes could be incorporated in the Establish ITS Program Funding Pools action item in the Traffic Management System Layer Plan – although because of the significance of funding required for broadband deployment statewide, ADOT should identify additional funding just for that deployment and add to the Funding Pools.</i></p>	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.	ADOT Broadband Office Program Administrator and Assistant State Engineer TSMO	TSMO Division Director, Deputy State Engineer, Assistant State Engineer, Region RTEs	See table under Steps and Outcomes in the Establish ITS Program Funding Pools action item in the Traffic Management System Layer Plan	See table under Steps and Outcomes in the Establish ITS Program Funding Pools action item in the Traffic Management System Layer Plan	TIP funding programs established that ADOT TSMO can pull from as projects to apply to Districts

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										
None	The ongoing lifecycle replacement needs should be considered in the O&M Funding Pool over time. The inventory to be completed for the state as part of the <i>GIS-Based Asset and Work Order Management</i> recommendation in the <i>Traffic Management System Layer Plan</i> should include fiber and other communications infrastructure to determine this need over time.									
EXPANSION OF ADOT TECHNOLOGY DEPLOYMENT										
Establish Fiber Tracking Inventory	Expand the fiber as-built recording in the ADOT TSMO Fiber Database statewide. ADOT should track the utilization of their fiber and incorporation of statewide fiber into the existing Central District fiber mapping software will achieve this.	<p>Steps: Gather from the ADOT Broadband Office and TSMO groups existing fiber deployments and as-built records throughout the state. Incorporate records into fiber management software. If an extension of the software support or mapping is required, ADOT should initiate that expansion.</p> <p>Outcomes: Statewide fiber mapping database.</p>	A robust effort is underway within the Central District to incorporate fiber as-builts records into a living fiber management database that tracks fiber usage and connections to infrastructure to properly manage the fiber assets. As the state deploys broadband statewide, the state should also incorporate new communications assets into the fiber management database. Fiber tracking will be important as the state manages the conduit and pull box infrastructure for ADOT purposes as well as conduit sharing with private sector to support broadband access throughout the state.	TSMO Fiber Database Manager	TSMO Systems Maintenance Engineering Manager, ADOT Broadband Office Program Administrator	ADOT to pursue if there is an extension required for the fiber database to be expanded statewide	\$0	\$0	\$0	In-house
Establish Connection to All ADOT ITS Devices and Traffic Signals	Allocate funding specifically to connect fiber (either existing or new) where there are existing ITS devices and traffic signals statewide in proximity.	<p>Steps: Identify infrastructure that is not yet connected to fiber communications. Identify either existing fiber or new broadband projects that would install new fiber along path where infrastructure resides. Establish RFP to solicit design support for development of procurement documents to complete a set number of communications connections to existing infrastructure. 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.</p> <p>Outcomes: Communication connections to existing infrastructure.</p>	As ADOT has expanded fiber throughout the state for TSMO project implementations, there has been a focus on providing that backbone where devices exist. As the state expands broadband fiber statewide, the focus on connecting to infrastructure that the broadband travels right by is not prioritized in the construction process. Making sure to account for connections to infrastructure along fiber paths will require separate funding allotments either allocated within new broadband projects coming out or completed separately and after backbone fiber is installed. These connections will Allow ADOT districts to have real-time access and be able to adjust traffic signals to support re-routing or emergency traffic management when there is an incident.	ADOT Broadband Office Program Administrator and Assistant State Engineer TSMO	TSMO Division Director, Deputy State Engineer, Assistant State Engineer, Region RTEs				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

EXPANSION OF ADOT TECHNOLOGY DEPLOYMENT										
<p>Expand Broadband Fiber Statewide</p>	<p>Expand broadband fiber statewide. Leverage the existing broadband projects to expand statewide. Two projects utilize Dura-line FuturePath conduit with pull boxes every 3K feet and every traffic interchange with 7 MicroDucts. Each MicroDuct can accommodate up to 288 fibers.</p> <ul style="list-style-type: none"> I-17 (Phoenix to Flagstaff): Estimated to be complete in early 2023. I-19 (Tucson to Nogales): Estimated to be complete in early 2023. <p>I-40 West (Flagstaff to California border): Design underway. Construction in 2024.</p>	<p>Steps: 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. All fiber communications should include connections to any ADOT facility and include the last mile connection cost estimate. Gaps in broadband infrastructure around the state include:</p> <ul style="list-style-type: none"> I-10 West (Phoenix to California border): ~ 122 miles – ADOT should leverage Verizon, XO Communications, or Windstream existing fiber in the area I-10 Central between Phoenix and Tucson = approx. south of the Wild Horse Pass Motorsports Park to Tamarack Way (23 miles) and Picacho Peak Rd to Ina Rd (30 miles) I-40 East (Flagstaff to New Mexico border): ~ 163 miles I-10 East (Tucson to New Mexico border): ~ 124 miles – ADOT should leverage Verizon or XO Communications existing fiber in the area US-60 East (Phoenix to either Show Low or Safford): ~ 55 miles I-8 West (I-10 to California border): ~180 miles – ADOT should leverage Windstream or Syringa existing fiber in the area <p>Outcomes: Expansion of broadband.</p>	<p>The ADOT Statewide Broadband Master Plan provides a justification for the expansion of broadband infrastructure statewide, although it is limited on ADOT-specific project planning and does not mention connecting to ITS devices along the path. Expansion of broadband statewide would significantly close the communication gap not only for connection to ITS devices along the paths but also to close dead zone gaps statewide. A large majority of devices in the Phoenix urbanized area are connected to fiber communications or reliable wireless radios. However, throughout the rest of the state, communications to ITS devices and traffic signals are not entirely consistent nor reliable. This lack of connectivity significantly reduces incident response effectiveness and roadway visuals, particularly in remote rural areas, when issues arise, or adjustments need to be made. Expanding communications in areas with dead zones via cell towers, radios, and fiber would not only allow traffic signal connectivity, but also ITS device expansion to support traffic management. Rural communications may need to be a combination of radio, satellite, or third-party leased lines, although this should be evaluated once broadband expansion plans are completed. ADOT should prioritize making connections to the infrastructure that has none today or has unreliable communications that does not support operators and management of the infrastructure.</p>	<p>ADOT Broadband Office Program Administrator and ADOT Broadband Office Broadband Coordinator</p>	<p>ADOT TSMO Director and Operational Traffic & Safety Manager, Assistant State Engineer TSMO</p>	<p>~ 520 miles</p>	<p>~ \$265K per mile (one direction)</p>	<p>Based on size of broadband expansion projects</p>	<p>~10% of size of broadband expansion projects</p>	<p>Out-source – either RFP or TSMO On-Call</p>

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										
Construct Middle Mile / Last Mile Connections	Expand high-speed communication availability to un(der)served areas, ITS devices, State facilities currently not connected through fiber.	<p>Steps: 1. Assemble a team that includes the Systems Technology group, the Systems Maintenance group, and the Broadband Communication group.</p> <p>2. Based on the potential underprivileged areas to be connected, identify all potential middle mile and last mile locations.</p> <p>3. Establish criteria and prioritize areas to be connected in the next 2-3 years in conjunction with the Arizona Broadband Statewide Middle-Mile Strategic Plan.</p> <p>4. Estimate and secure the funds needed to complete the connectivity from the priority list.</p> <p>5. Design and construct the connections.</p> <p>Outcomes: More connected populations and ITS devices.</p>	<p>As a result of the COVID-19 pandemic, high-speed, reliable broadband has gone from being seen as an optional to an essential service. By connecting to major networks, local networks can ensure reliable high-speed Internet service for even the most remote communities. The push to expand this coverage has identified ADOT roadway and fiber networks as a possible avenue of connection.</p> <p>These middle/last mile connections between major networks and un(der)served communities help both to bring broadband to the public and State facilities in these areas and to give ADOT an opportunity to connect ITS devices to a more efficient system of communication.</p>	TSMO Systems Maintenance Engineering Manager	Broadband Communication group, Systems Maintenance Group, and Districts	TBD	Per Mile	TBD	TBD	Out-Source/ TSMO On-Call
DEMONSTRATED TECHNOLOGIES FOR ADOT DEPLOYMENT										
None	ADOT priorities for communications should reside in connecting existing infrastructure and providing broadband communications to communities along major ADOT-owned roadways. Any activities outside of that fall within the long-term timeframe and should not be prioritized over any recommendations listed in this System Layer Plan.									
EMERGING TECHNOLOGY FOR ADOT PILOTING										
None	ADOT priorities for communications should reside in connecting existing infrastructure and providing broadband communications to communities along major ADOT-owned roadways. Any activities outside of that fall within the long-term timeframe and should not be prioritized over any recommendations listed in this System Layer Plan.									

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 ITS Communications Structure System Layer Plan.

Performance Measurement Topic	Performance Measure	Measure Applicability
Reliability of equipment communications of ITS infrastructure	Increased ITS infrastructure health – fiber IP, wireless radios, nodes	% of devices / systems from which a signal is received
Communications coverage of the state	Increased communications availability of the state	% of state-owned roadway mileage with ADOT broadband coverage
	Increased communications connectivity to ITS infrastructure	% of devices with fiber versus other types of communications connectivity