![MoDOT logo]

LRTP
Long-Range Transportation Plan

Emerging Technologies

DRAFT

Introduction

Source: MoDOT

Transportation technologies are advancing quickly, reshaping how transportation agencies plan, operate and invest in their systems. The Missouri Department of Transportation (MoDOT) is preparing for this shift, guided by its core pillars of Safety, Service and Stability and informed by the strategies outlined in the MoDOT Transportation Systems Management and Operations (TSMO) Plan. Together these provide the innovation to enhance public safety, deliver value to customers and sustain a reliable transportation system for the future. MoDOT focuses on a core set of emerging technologies that support the state's long-range goals to use innovation and stewardship to deliver and maintain a safe, reliable and connected transportation system that will strengthen Missouri's economy.

In Missouri, These Innovations Could

- Reduce congestion across Missouri's transportation network

- Extend the life of critical transportation assets

- Enhance safety for all roadway users

- Strengthen Missouri's economy by ensuring reliable and efficient movement of people and goods

- Align with MoDOT's TSMO strategies and core pillars

- Support proactive, data-driven management of Missouri's multimodal transportation system

Missouri's Transportation System

- Includes 33,814 miles of state highway and 10,427 bridges, making it one of the largest networks in the United States.

- Supports essential industries such as agriculture, manufacturing and logistics.

- Connects major metropolitan areas— including St. Louis, Kansas City and Springfield with rural communities throughout the state.

- Serves as a central freight corridor for the Midwest, positioned at the intersection of I-70, I-44, I-55 and I-35, which places it at the center of national goods movement.

Emerging technologies present an opportunity for MoDOT to strengthen its strategic role while improving safety, reliability and economic competitiveness. Through its Stability pillar and TSMO plan, MoDOT emphasizes system reliability, asset management and workforce readiness to support the sustainability of operational and technological advancements over time.

MoDOT is well positioned to learn from peer states and national leaders in technology deployment while tailoring solutions to Missouri's urban, suburban and rural communities. MoDOT is preparing for a transportation future that is both data-driven and user-focused, with initiatives in varying

phases of implementation such as adaptive traffic signals, smart work zones, truck platooning pilots, predictive maintenance and freight corridor digital twins. These efforts directly support the TSMO plan's focus areas of safety, reliability and efficiency, demonstrating MoDOT's service commitment to innovation and customer value while upholding its Safety and Stability pillars across all communities.

As the Long-Range Transportation Plan (LRTP) establishes a long-term vision for investment across all modes, emerging technologies will play a critical role in addressing challenges related to congestion, safety, system condition and accessibility. By integrating the TSMO framework and the Safety, Service and Stability pillars, MoDOT can support technology deployment that complements operational strategies, performance management and public trust.

This chapter will examine four technology areas most relevant to Missouri:

- **Smart Infrastructure and Intelligent Transportation Systems (ITS)**

- **Connected Vehicles and Autonomous Vehicles (CV/AV)**

- **Digital Twins and Predictive Analytics**

- **Smart Freight and Logistics**

For each area, the chapter will review benefits, challenges and costs of implementation, drawing on case studies from peer states.

Definitions and Examples

Smart Infrastructure and Intelligent Transportation Systems

Smart Infrastructure and Intelligent Transportation Systems (ITS) applies advanced technologies, such as sensors, communication networks and data analytics, to improve the safety, efficiency and sustainability of transportation networks by enabling real-time management of traffic flow, optimizing journeys and providing user information.
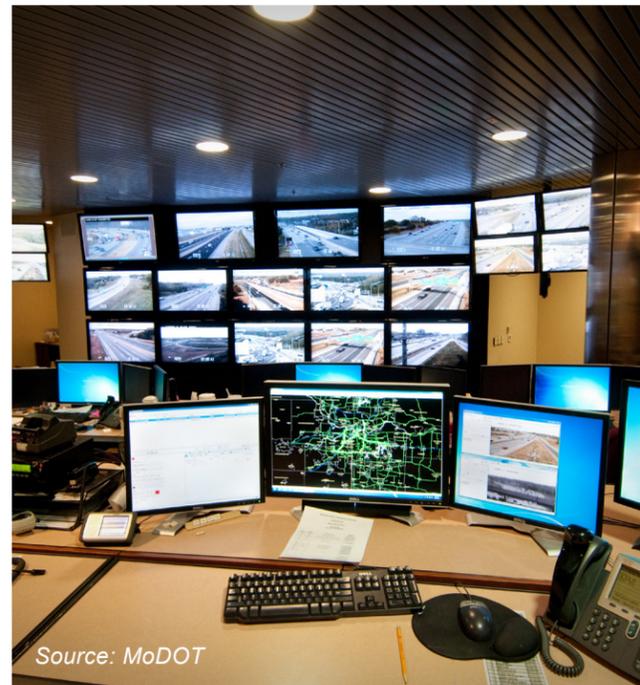
Source: MoDOT

Opportunities for Statewide Expansion

Missouri's existing Transportation Management Centers (TMCs) in St. Louis, Kansas City and Springfield already provide a strong foundation for ITS expansion. By building on these successes, MoDOT can:

- **Expand Smart Corridor Management:** Scale up successful KC Scout and Springfield pilots statewide

- **Integrate ITS into Rural Highways and Freight Corridors:** Enhance safety and reliability, especially in areas affected by frequent weather and work zone disruptions

- **Improve Real-Time Safety:** Deploy technology for proactive incident detection and response

- **Optimize Freight Movement:** Support efficient goods transport across Missouri's extensive highway network, including truck parking

Connected and Autonomous Vehicles

Connected and Autonomous Vehicles (CV/AV) are transformative transportation technologies that operate autonomously, use sensors, artificial intelligence (AI) and communication networks to enhance safety, efficiency and mobility. They analyze their surroundings and communicate with other vehicles and infrastructure to navigate and control themselves, with the goal of reducing accidents, alleviating traffic congestion and expanding transportation access for various users.

MoDOT's Connected and Automated Vehicle Action Plan

MoDOT's Connected and Automated Vehicle Action Plan was published in 2025. It established a foundation for CV/AV readiness and advancement in Missouri.[1] The key elements of CV/AV in Missouri outlined in this plan are provided in **Table 1**.

Table 1 – MoDOT's Connected and Automated Vehicle Action Plan Elements

Element	Details
Strategic Advantage	Missouri's geographic and economic profile makes it ideal for automated freight and CV/AV technology testing
Significant Freight Generators	Kansas City SmartPort and St. Louis multimodal logistics hubs
Advanced Initiatives	Truck platooning and vehicle-to-infrastructure pilots to provide immediate safety and fuel efficiency benefits
Key Collaborations	University of Missouri and Missouri University of Science and Technology for simulation modeling and readiness assessments
Major Deployment Corridors	I-70, I-55, I-49, I-44 and I-35

Source: MoDOT, "Connected and Automated Vehicle Action Plan," 2025.

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[1] MoDOT recently began using the term "Connected and Autonomous Vehicles" instead of "Connected and Automated" to align with terminology used by other state Departments of Transportation and agencies.

Data Exchange Pooled Fund Study (MoDOT-Led)

The Data Exchange Pooled Fund Study, led by MoDOT and initiated in December 2024, supports the development of a scalable, public-private transportation data exchange framework. The study is intended to enable interoperable data sharing across jurisdictions and industry partners, with a particular emphasis on supporting data-driven transportation technologies.

Study Partner States

- **Missouri**
- **California**
- **Connecticut**
- **Hawaii**
- **Kansas**
- **New Jersey**
- **Pennsylvania**
- **Texas**
- **Wisconsin**

Study Focus

- The study concentrates on the planning, design and governance of a shared data exchange environment, including:
  - Developing a multi-agency data exchange platform to support advanced transportation applications along multi-state transportation corridors
  - Establishing a public-private transportation data exchange center to enable secure, real-time data sharing and interoperability between public agencies and private sector partners
  - Identifying data standards, architectures and governance models that promote consistency, scalability and reuse across participating states
  - Advancing collaborative approaches to data sharing among DOTs, technology providers and mobility stakeholders

Study Objectives

- The primary objectives of the Data Exchange Pooled Fund Study include:
  - Facilitating seamless and secure information flow between infrastructure systems, vehicles, traffic management centers and operators
  - Improving transportation safety, mobility and operational efficiency through enhanced data availability and integration
  - Reducing duplication of effort by enabling shared solutions and best practices among participating agencies
  - Preparing Missouri and partner states' transportation corridors for broader deployment of emerging, data-dependent technologies

Digital Twins and Predictive Analytics

Digital twins and predictive analytics are virtual models of physical assets or systems that integrate real-time data for monitoring, analysis and forecasting.

When paired with predictive analytics, digital twins allow MoDOT to simulate scenarios, assess risks and make smarter investments. These tools support proactive maintenance and future-proof planning.

Statewide Digital Twin Pilot

Building on MoDOT's Transportation Asset Management Plan (TAMP), a statewide digital twin pilot could enhance transportation asset management, utility coordination and autonomous ride-sharing expansion by providing the following benefits:

- **Integrated Platform:** Link bridge condition, pavement performance and weather data into one system
- **Visualization:** Engineers can see system-wide vulnerabilities and test investment strategies
- **Forecasting:** Predict asset needs and plan maintenance proactively
- **Pilot Focus:** Target high-traffic freight corridors like I-70 for initial implementation

Digital Twin Technology for Utility Management

Digital twin technology also offers significant benefits for utility management within highway right of way, providing MoDOT with enhanced capabilities to document, visualize and coordinate underground and above ground utility assets by providing the following benefits:

- Improves the accuracy of utility location records for MoDOT
- Proactively identifies potential utility conflicts during project planning and design
- Minimizes unexpected utility impacts during construction
- Helps reduce project delays, control costs and maintain construction schedules
- Supports more efficient plan development in utility management
- Enhances safety throughout the project lifecycle

Autonomous Ride-Sharing Expansion

Investing in digital twin technology presents valuable opportunities for ride-sharing in Missouri.

- **Market Opportunity:** Digital twins for Kansas City and St. Louis make these regions attractive for autonomous rideshare companies

- **Potential Providers:** Innovative companies like Waymo and Tesla can leverage local digital twin data

- **Regional Impact:** Positions Missouri communities as leaders in advanced transportation technology

Source: MoDOT

Smart Freight and Logistics

Smart Freight and Logistics is a technology-driven approach that uses AI, internet of things (IoT) and data analytics to optimize the entire freight and logistics process, from tracking and management to delivery and resource use. This method enhances supply chain visibility, reduces operational costs, increases efficiency and speed and improves customer satisfaction.

Opportunities in Missouri

- **Chokepoints along I-70, I-44 and I-55** could benefit from real-time freight monitoring and truck parking technology.

- **Expanding truck parking availability and electrification**, particularly along the 1-70 and I-44 corridors, can:
  - Reduce idling
  - Improve driver safety
  - Support sustainability

- **MoDOT can leverage partnerships** with private carriers, railways and river port authorities to:
  - Enhance intermodal connectivity
  - Strengthen digital freight management systems

Transportation Systems Management and Operations Capability Areas

MoDOT organizes its Transportation Systems Management and Operations (TSMO) Program around several capability areas that reflect where emerging technologies deliver the greatest operational benefits:

- **Traffic Incident Management (TIM):** Coordinated detection, response and clearance of roadway incidents

- **Work Zone Management (WZM):** Safe and efficient traffic movement through construction and maintenance zones

- **Traffic Signal Coordination:** Optimizing timing and coordination to enhance mobility and reliability

- **Planned Special Events Management:** Coordinated planning to manage travel demand during major events

- **Road Weather Management:** Monitoring and responding to weather impacts through a road weather information system (RWIS) and decision-support tools

- **Freight and Logistics Operations:** Enhancing efficiency for freight corridors, ports and intermodal connections

Table 2 – Emerging Technologies and TSMO Capability Areas

	Emerging Technologies			
Capability Areas	**Smart Infrastructure and ITS**	**CV/AV**	**Digital Twins and Predictive Analytics**	**Smart Freight and Logistics**
TIM	✕	✕	✕	✕
WZM	✕	✕	✕	✕
Traffic Signal Coordination	✕	✕	✕	✕
Planned Special Events Management	✕			
Road Weather Management	✕	✕	✕	✕
Freight and Logistics Operations	✕			✕

Table 2 aligns how the emerging technologies discussed above align with these TSMO capability areas.

Across all capability areas, emerging technologies strengthen MoDOT's institutional capacity by improving business processes, system interoperability and performance-based decision making. They enhance:

- **Business Processes:** Data integration and performance-based investment prioritization

- **Systems and Technology:** Interoperable architecture enabling real-time information exchange

- **Performance Measurement:** Metrics for travel time reliability, clearance times and weather response

- **Culture and Workforce:** Building technical proficiency and data literacy

- **Collaboration:** Shared platforms and partnerships with public safety, freight and local agencies

Together, these innovations enable a connected, adaptive and resilient transportation system that anticipates conditions, coordinates responses and optimizes performance for all users.

LRTP Goals and Objectives

MoDOT's performance-based planning and programming framework begins with the LRTP, which sets the vision for how Missouri will invest in and manage its transportation system through 2050. As part of this effort, MoDOT has identified emerging technologies as critical tools to achieve its long-term goals. The emerging technologies identified support MoDOT's strategic goals as discussed below.

Stewardship: Technology strengthens asset management and financial stewardship by enabling data-driven decisions that extend infrastructure life and optimize resources

Safe: Emerging technologies collectively enhance roadway safety by enabling earlier detection, faster response and prevention of crashes

Reliable: Technologies improve travel time consistency and system resilience under changing conditions

Connected: Connectivity supports Missouri's transportation system serves all users and modes seamlessly

Innovative: Innovation drives continuous improvement through collaboration, testing and learning

Prosperous: Emerging technologies drive economic growth by improving freight efficiency, reliability and statewide connectivity

Case Studies

This section presents comparative case studies illustrating how state Departments of Transportation (DOTs) across the United States (U.S.) are integrating technology, data and innovation into long-range transportation planning. Each example highlights a distinct yet complementary approach to preparing for an evolving mobility landscape.

- **The I-10 Corridor Coalition,** uniting DOTs from California, Arizona, New Mexico and Texas, demonstrates how CV/AV and Smart Freight technologies enhance corridor safety and reliability. Its Truck Parking Availability System (TPAS) leverages real-time connected vehicle data and roadside sensors to guide drivers to open parking, reducing unsafe stops and improving freight efficiency through coordinated, multistate TSMO strategies.

- **The Wisconsin Department of Transportation (WisDOT)** demonstrates how Smart Infrastructure and ITS can be embedded into a statewide vision for safety and efficiency.

- **The Michigan Department of Transportation (MDOT)** focuses on CV/AV as transformative tools for improving roadway performance and safety.

- **The Iowa Department of Transportation (Iowa DOT)** showcases how digital twins, predictive analytics and freight focused ITS applications can enhance logistics and system reliability.

- **The Pennsylvania Department of Transportation (PennDOT)** emphasizes Smart Freight and Logistics technologies as a foundation for multimodal connectivity and economic competitiveness.

Source: MoDOT

MoDOT aligns closely with these agencies in its strategic direction. Like Wisconsin, Iowa and Pennsylvania, Missouri recognizes that the future of transportation depends on leveraging technology to build a system that is safer, more efficient and more operationally resilient. The following case studies demonstrate how MoDOT's initiatives in connected vehicle readiness, intelligent corridor management and multimodal freight integration parallel national best practices. Collectively, they provide insight into how states are adapting to technological change, addressing shared challenges such as broadband access and funding and building collaborative frameworks to modernize transportation networks across both urban and rural settings.

I-10 Corridor Coalition

The I-10 Corridor Coalition, a partnership among the DOTs in California, Arizona, New Mexico and Texas, demonstrates how multistate collaboration and emerging technologies can modernize freight mobility and highway operations. Spanning more than 2,500 miles, the coalition focuses on improving safety, reliability and efficiency along one of the nation's busiest freight corridors. Its flagship initiative, the TPAS, integrates real-time monitoring, sensor networks and connected data platforms to identify open truck parking spaces and share that information through dynamic message signs, traveler information systems and in-cab communication tools that connect drivers to dispatch.

Program Elements

- TPAS funded by a $6.85 million U.S. Department of Transportation Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant, with matching funds from participating states

- Two TSMO capability areas of smart infrastructure and freight technology supporting freight operations and incident management for safe and efficient corridor performance

- Shared data architecture, coordinated operations and consistent technology standards extending TSMO benefits beyond state borders

- Governance structure emphasizing interoperability, real-time information exchange and joint performance evaluation

Program Goals and Outcomes

- Reducing illegal shoulder parking, optimizing rest area use and strengthening driver safety

- Lowering emissions by decreasing vehicle idling and search time

- Making freight deliveries more predictable across state lines

Considerations for Missouri

- Adapt I-10 framework for major freight corridors: I-70, I-44, I-55, I-49, I-35

- Implement real-time parking availability and harmonized data sharing across states

- Apply corridor-based TSMO strategies to enhance freight reliability and reduce congestion

- Advance connected and automated freight technologies using the I-10 Coalition framework

WisDOT (Connect 2050) – Smart Infrastructure and ITS

WisDOT's Connect 2050 Vision Plan serves as a roadmap for building and modernizing Wisconsin's transportation system over the next three decades. Recognizing the rapid pace of technological change, the plan integrates CV/AVs, adaptive traffic management and ITS as core elements of a safe and efficient future network.

CONNECT 2050
Wisconsin's Statewide Long-Range Transportation Plan
Source: WisDOT

Plan Elements

- Recognition of Smart Infrastructure as both a challenge and an opportunity under Goal Five of the plan, Maximizing Technology Benefits

- Collaboration through the Wisconsin Automated Vehicle External Advisory Committee (WAVE) engaging industry, local agencies and advocacy groups

- Expansion of ITS and automated traffic management to reduce congestion, improve safety and enhance disaster response

- Deployment of connected vehicle technologies including lane departure assistance, adaptive cruise control and Vehicle-to-Infrastructure (V2I) communication to transform personal travel and freight operations

- Strong partnerships to support CV/AV research, adaptive traffic management and real-world implementation across Wisconsin and Missouri

Considerations for Missouri

- Collaborate with Missouri Center for Transportation Innovation (MCTI) to support innovation on I-70 and I-44

- Address limited rural broadband access and connectivity challenges

- Mitigate high ITS implementation costs impacting deployment

- Plan transition from dedicated short-range communications (DSRC) to cellular vehicle-to-everything (C-V2X) communications

- Balance urban congestion management with rural connectivity and access

- Combine technological investment with collaborative planning for safer, more reliable and responsive systems

MDOT – CV/AVs

MDOT views CV/AVs as transformative tools, reshaping how transportation systems are planned, designed and operated. In its 2045 Long-Range Transportation Plan, Michigan Mobility 2045 (MM2045), MDOT identifies automation, electrification and data connectivity as key drivers influencing safety, infrastructure performance, travel behavior and economic competitiveness.

Source: MDOT

- Statewide readiness for AVs, V2I and truck platooning through integrated planning
- Strategic investments in EV charging, broadband and intelligent traffic systems
- Partnerships with the University of Michigan's Mcity testing facility and the American Center for Mobility for CV/AV testing and policy alignment
- Alignment with Moving Ahead for Progress in the 21st Century Act (MAP-21) and Fixing America's Surface Transportation (FAST) Act priorities on safety, reliability and multimodal sustainability
- CV/AV technologies to reduce crashes and improve freight efficiency
- Emphasis on connected freight corridors and truck automation to maintain mobility leadership
- Cross-sector collaboration to support workforce development and adaptive infrastructure
- Innovation-driven approach balancing system preservation with automation readiness
- Long-term vision for a connected transportation network supporting economic growth through 2045

Considerations for Missouri

- Manage high infrastructure upgrade costs
- Address cybersecurity risks and data management challenges
- Expand rural broadband coverage to enable technology deployment
- Foster collaboration among government, academia and private sectors for harmonization and adaptive planning
- Balance system preservation with readiness for future automation
- Leverage strategic investments in ITS, EV infrastructure and partnerships (e.g., Michigan's approach)

Iowa DOT – Digital Twins and Predictive Analytics

Freight mobility is central to Iowa's transportation strategy, reflecting its agricultural and manufacturing economy and its critical role in national supply chains. The Iowa in Motion 2050 plan emphasizes that efficient freight systems are vital to economic growth and regional connectivity. It identifies key freight corridors, intermodal hubs and rural-to-urban links as essential for reliability and performance.

Plan Elements

- Integration of technology, operations and policy to enhance freight efficiency, safety and sustainability
- Deployment of ITS for real-time monitoring, data collection and information sharing with carriers
- Management of congestion, improvement of incident response and generation of predictive insights
- Alignment with national freight goals under MAP-21 and the FAST Act
- Promotion of real-time truck parking information systems
- Fostering public-private partnerships to expand truck parking facilities
- Improvement of safety and reduction of idling
- Strengthening multimodal connectivity by linking highways, rail and river ports
- Advancement of data-driven, multimodal freight strategies and enhancement of Iowa's competitiveness in global markets

Considerations for Missouri

- Resolve truck parking shortages
- Support economy through efficient movement of agricultural and manufactured goods
- Align MoDOT's Freight and Rail Plan with Iowa's focus on ITS, predictive analytics and intermodal integration
- Build on existing investments: I-70 freight improvements, river port expansion, logistics technology
- Advance technology, policy and planning for efficient, sustainable freight systems supporting long-term growth

PennDOT – Smart Freight and Logistics

Freight is a central component of Pennsylvania's transportation system and economy. Positioned between the Northeast and Midwest, the state serves as a major national freight hub connecting highways, rail lines, ports and airports. In PA On Track, PennDOT recognizes that this strategic role drives economic growth but also places heavy demands on aging infrastructure.

PA On Track
PA'S LONG RANGE TRANSPORTATION & COMPREHENSIVE FREIGHT MOVEMENT PLAN

Source: PennDOT

Program Elements

- Adoption of smart freight and logistics technologies such as real-time data platforms, connected logistics hubs and intelligent corridor management systems

- Emphasis on tools to improve supply chain visibility, reduce bottlenecks and enhance efficiency

- Promotion of safety, congestion reduction and environmental sustainability

- Strengthening coordination among truck, rail and port systems to support reliable access in urban and rural areas

- Alignment with MAP-21 and FAST Act priorities focusing on safety, reliability and economic vitality

- Initiatives such as truck platooning and corridor monitoring to prepare the state for automation and digital logistics

Considerations for Missouri

Coordinate with private partners to manage complexity

Modernize infrastructure while balancing growth with community and environmental goals

Maintain Missouri's role as a key freight gateway with highways, river ports and rail systems critical to commerce

Align MoDOT Freight and Rail Plan with PennDOT's technology-driven logistics approach

Continue investment in real-time tracking, predictive analytics and multimodal integration to create resilient freight networks

Strategic Framework for Implementing Emerging Transportation Technologies

Policy and Regulatory Context

Federal and state policies play a critical role in shaping how emerging transportation technologies are planned, funded and implemented.

At the National Level:

- Guidance from the Federal Highway Administration (FHWA) and the Infrastructure Investment and Jobs Act (IIJA) encourages states to adopt technology-driven solutions that enhance safety, efficiency, accessibility and sustainability.

- Programs such as the Advanced Transportation Technology and Innovation (ATTAIN) Program, SMART Grants and various formula funding streams provide vital support for deploying ITS, CV/AV and data-driven infrastructure management tools.

At the State Level:

- Missouri's Show-Me Zero Strategic Highway Safety Plan aligns directly with the deployment of technologies that reduce crashes through automation, real-time alerts and advanced analytics.

- The Missouri Broadband Strategic Plan complements these efforts by expanding connectivity across rural corridors as an essential foundation for statewide ITS and CV/AV readiness.

- MoDOT's TSMO CV/AV research indicates that Missouri needs CV/AV enabling legislation to attract emerging technology and integrating these initiatives with the LRTP supports technology investments to improve safety and accessibility across all regions.

Missouri continues preparing for technology adoption by:

- **Expanding broadband**
- **Advancing transportation safety initiatives that are underway**
- **Fostering partnerships with universities and industry to support innovation**
- **Aligning the LRTP with federal guidance and state strategies to keep MoDOT eligible for funding**
- **Coordinating investments across agencies and jurisdictions is a priority**
- **Adapting strategies as federal rules and standards change, especially for connected vehicle communications, data sharing and cybersecurity**
- **Focusing efforts on maintaining consistency with national best practices to support a safe, connected and future-ready transportation system**

Future Scenarios and Strategic Foresight

Strong partnerships are essential for successful technology deployment. MoDOT will need to consider:

- Collaboration with universities, industry leaders, regional planning organizations, local governments and community groups to share knowledge and coordinate efforts
- Partnerships with academic institutions to support research on digital twins and CV/AV readiness
- Working with the freight industry can help design logistics solutions that meet both public and private needs

Engaging stakeholders early and often helps build public understanding, identify community priorities and develop solutions that reflect local contexts. These partnerships:

- Help promote interoperability
- Align investments
- Leverage outside expertise to strengthen Missouri's transportation technology strategy

Fair Access, Inclusive Design and Workforce Readiness

MoDOT must support the deployment of emerging technologies that promote fair access, inclusive design and workforce readiness across all communities. As tools such as CV/AVs, smart infrastructure and advanced data analytics reshape the transportation landscape.

Accessibility should remain a core design principle. Infrastructure, vehicles and digital systems must follow universal design standards that serve users of all ages and abilities. Emerging technologies should expand mobility options for people with disabilities, older adults and those without access to private vehicles by improving multimodal connections and creating accessible digital interfaces.

The transition to technology-driven operations will also demand a skilled and adaptable workforce. DOTs should:

- Invest in training, reskilling and forming partnerships with educational institutions and industry to prepare employees for new roles in automation, data management and systems integration
- Embed fairness, accessibility and workforce development at every stage of planning, procurement and implementation to support technological innovation that brings widespread and lasting benefits to Missouri's transportation system

In Missouri, workforce readiness is particularly critical given the state's aging labor base. MoDOT can collaborate with community colleges and the University of Missouri System to develop specialized training in data analytics, automation systems and cybersecurity, ensuring the next generation of transportation professionals is prepared for a data-driven future.

Partnerships and Stakeholder Engagement

To help technology investments deliver meaningful results, MoDOT should consider using performance measures to evaluate outcomes over time. These measures may include:

- **Safety:** Reduction in crashes, injuries and fatalities linked to ITS and CV/AV deployments

- **Reliability:** Improvements in travel time consistency on key corridors

- **Stewardship:** Reduced lifecycle costs from predictive maintenance and smarter asset management

- **Accessibility:** Expansion of broadband access and improved transportation options for underserved communities

- **Environmental:** Decreases in emissions or fuel consumption from freight and traffic management strategies

Establishing clear metrics and tracking progress regularly will help MoDOT adjust strategies, make the case for future funding and communicate benefits to the public.

Performance tracking can be integrated into MoDOT's Tracker Framework, allowing emerging technology outcomes to be measured alongside existing performance indicators. For example, MoDOT could track adaptive signal efficiency under 'Reliable Travel,' digital twin use under 'Stewardship,' and crash reduction tied to CV/AV pilots under 'Safe Transportation.' Aligning new technological metrics with Tracker will streamline internal reporting and demonstrate accountability to the public.

Source: MoDOT

Data Governance, Cybersecurity and Privacy

Emerging technologies depend on reliable, secure and well-managed data. MoDOT's existing asset management systems already collect large amounts of information on pavement condition, bridges and traffic patterns. As technologies like digital twins, CV/AV and advanced ITS expand, the volume and sensitivity of this data will increase significantly. To manage this effectively, MoDOT will need to continue to build strong data governance policies that address how data is collected, stored, shared and protected.

Cybersecurity is also a growing concern. Connected infrastructure and vehicles introduce new vulnerabilities that must be managed to protect both users and the transportation system. Future strategies will need to include:

- Strengthened cybersecurity frameworks

- Regular risk assessments and working with public and private partners to set data-sharing agreements that respect privacy while enabling innovation

- Building public trust through clear policies and transparent practices

Funding and Implementation Pathways

Bringing emerging technologies into Missouri's transportation network requires sustained investment and strategic planning. In addition to existing state and federal funding, MoDOT will need to explore opportunities such as:

- Competitive grant programs including:
  - ATTAIN
  - Strengthening Mobility and Revolutionizing Transportation (SMART)
  - Infrastructure for Rebuilding America (INFRA)

- Partnerships with the private sector

- Coordination with regional planning partners, local governments and freight stakeholders to help align funding sources and priorities

Source: MoDOT

Resilience and Sustainability

Emerging technologies can play a powerful role in making Missouri's transportation system more resilient to extreme weather, changing travel patterns and other disruptions. By integrating resilience and environmental performance into technology planning, MoDOT can support these investments that strengthen the transportation system for decades to come. For this, the following technologies should be considered:

Predictive analytics and digital twins can help planners model the effects of climate scenarios and identify vulnerable corridors before problems occur.

Smart infrastructure can provide real-time information during storms or floods, improving incident response and keeping travelers safe.

Technologies like **truck platooning, adaptive traffic management and optimized freight routing** can reduce emissions, improve fuel efficiency and support the state's broader sustainability goals.

Missouri's climate variability from flooding in the Mississippi Basin to winter ice events makes resilience planning valuable. Integrating predictive analytics into floodplain corridors such as I-29 and I-55 could improve incident management and recovery times. MoDOT's ongoing efforts to modernize stormwater systems and enhance weather-responsive management   can be further supported by these tools.

Source: MoDOT

Innovation Priorities and Challenges

Smart Infrastructure and Intelligent Transportation Systems

Missouri's highway and bridge network is one of the largest in the country, carrying more than 200 million tons of freight each year and connecting both dense urban corridors and rural farming communities. MoDOT has already laid the foundation for smarter real-time alerts through TMCs, highway cameras and dynamic message signs and operational decision-making by using data from TMCs and connected systems into MoDOT's operational response and resource allocation. However, the demand on the system continues to grow and technology is evolving that can be used today to assist in modernizing corridors.

Moving forward, the following priorities and challenges should be considered:

Priorities

- Expanding broadband and roadside unit deployment to promote seamless connectivity for passenger vehicles and freight carriers

- Piloting adaptive signal systems statewide for real-time signal adjustments based on changing traffic conditions, enhancing safety and reducing delays

- Integrating multimodal ITS applications for buses, freight carriers and passenger vehicles to share real-time information, increasing system reliability for all users

- Modernizing and optimize existing assets to meet next-generation needs while maximizing use of current infrastructure

Challenges

- Limiting broadband access and traffic management in many rural areas, especially during incidents in St. Louis and Kansas City

- Facing high upfront costs for smart infrastructure such as upgraded traffic signals, roadside sensors and broadband connections

- Managing ongoing maintenance required to keep systems reliable

- Resolving compatibility issues among equipment from different vendors due to varying standards

- Justifying investment in rural areas with low traffic volumes

- Handling large data volumes, increasing responsibilities for storage, security and staff training

Connected and Autonomous Vehicles

As a freight crossroads with I-70, I-44, I-55, I-49 and I-35, Missouri plays a critical role in national goods movement. This makes the state a natural testing ground for CV/AVs. The state already has a strong focus on safety through programs like Show-Me Zero, but preparing for automation requires a different type of readiness.

Moving forward, the following priorities and challenges should be considered:

Priorities

- Maintaining pavement markings that are highly visible and ensuring signage is clear

- Strengthening digital infrastructure for autonomous vehicle operations

- Adding corridor readiness assessments to statewide asset management

- Conducting truck platooning pilots on major freight corridors such as I-70, I-55, I-49 and I-44 to reduce fuel costs, cut emissions and make freight movement more efficient

- Leveraging targeted pilots and corridor assessments to build confidence in CV/AVs

- Aligning initiatives with MoDOT's LRTP goals of safety and reliability

- Developing a clear statutory framework for testing and operation of autonomous vehicles

Challenges

- Meeting higher infrastructure standards for CV/AV operations

- Maintaining roads, pavement markings and signage to required levels with limited budgets

- Addressing interoperability across different manufacturers and systems

- Protecting against cybersecurity risks and data breaches

- Clarifying liability in the event of autonomous vehicle crashes

- Securing legislative action to establish statutory frameworks for autonomous vehicles

- Overcoming public skepticism and building trust in autonomous systems

- Managing aging infrastructure while preparing for new technologies

- Proactively addressing financial, legal and social challenges for a safe and accessible transition to CV/AV technology

Digital Twins and Predictive Analytics

MoDOT already manages one of the most comprehensive asset inventories in the nation. With more than 33,814 miles of road and 10,427 bridges, asset condition data is collected using advanced pavement sensors, automatic road analyzer (ARAN) vehicles and GIS systems. These existing tools provide a solid foundation for more advanced predictive approaches. However, the MoDOT Statewide TAMP shows many bridges are nearing the end of their design life and maintaining these assets with limited funding will be a growing challenge.

Moving forward, the following priorities and challenges should be considered:

Priorities

- Continuing to build statewide digital data exchanges to combine available data and data sources into a single system for better decision-making

- Piloting pavement lifecycle and crash-risk models to forecast maintenance needs and identify high-risk corridors before issues develop

- Training staff in data analytics and AI integration to help the workforce effectively use advanced tools

- Shifting Missouri's asset management approach further away from reactive maintenance to proactive planning building on the desire to keep good assets in good condition

Challenges

- Collecting and managing large volumes of data from diverse sources such as traffic counts, pavement conditions, crash records and weather systems

- Integrating data into a unified platform, which requires significant funding and technical expertise

- Maintaining and updating the system regularly to keep it accurate, resulting in ongoing costs

- Training staff to use new data and analytics tools, which requires additional effort and resources

- Addressing the risk that predictive forecasts might not account for sudden changes, potentially affecting the accuracy of decisions

Smart Freight and Logistics

Freight is the backbone of Missouri's economy. Every day, more than 1.5 million tons of goods move across the state's highways, railways and waterways. Yet the system faces challenges that limit efficiency, including shortages of truck parking, weather-related disruptions on interstates and congestion around freight hubs. MoDOT's Freight Plan has identified these issues, but new technology offers opportunities to address them in smarter ways.

Moving forward, the following priorities and challenges should be considered:

Priorities

- Expanding ITS on freight corridors to provide truckers with real-time information on weather, construction and traffic conditions to support safer and more efficient routing decisions

- Investing in truck parking electrification and logistics hubs to address the lack of rest areas and emissions from idling

- Equipping parking facilities with electrification technology to reduce pollution and offer essential services to drivers

- Strengthening intermodal coordination with rail and ports to enhance Missouri's role as a national trade hub and facilitate seamless movement of goods across modes

- Adopting strategies that reduce bottlenecks, lower emissions and maintain reliable freight movement through the state

Challenges

- Coordinating across agencies, private trucking companies and logistics providers due to the system's size and multi-regional nature

- Securing substantial funding for building, operating and maintaining smart freight corridors, truck parking with electrification and upgraded logistics hubs

- Addressing uneven adoption of advanced systems since not every trucking company can afford new technologies right away

- Managing unpredictable factors like weather, congestion and other unexpected issues that require constant monitoring to support smooth system performance

Overcoming Implementation Challenges and Next Steps

A phased implementation roadmap outlining a conceptual MoDOT approach to advancing smart infrastructure and ITS, CV/AVs, digital twins and predictive analytics and smart freight and logistics initiatives over the next decade is summarized in **Table 3**. It is organized into three implementation phases, each representing a stepwise progression from readiness to full statewide deployment:

- **Phase 1: Foundation (0–5 years)** - Focuses on planning, assessments and data readiness.

- **Phase 2: Pilot and Integration (6–10 years)** - Introduces field pilots, technology integration and early analytics applications.

- **Phase 3: Expansion and Optimization (10+ years)** - Scales successful strategies statewide and embeds digital transformation into daily operations.

Using these three implementation phases, each of the emerging technology focus areas outlined are:

- **Smart Infrastructure and ITS** focuses on expanding broadband connectivity, deploying adaptive signal control and improving interoperability of existing systems. This enables real-time traffic management, enhances reliability and supports connected vehicle communications statewide.

- **CV/AV** uses the MoDOT Connected and Automated Vehicle Action Plan as a framework and initial actions for the MoDOT TSMO program's CV/AV team to prepare Missouri's highway system for emerging CV/AV technologies by strengthening corridor readiness, improving pavement markings and digital infrastructure and piloting truck platooning on key freight routes. These efforts aim to enhance freight efficiency, safety and energy savings.

- **Digital Twins and Predictive Analytics** leverages data integration and modeling to move MoDOT further from reactive maintenance to proactive, data-driven asset management. Pilot projects will develop corridor-level digital twins and predictive models to forecast pavement, bridge and safety needs before problems occur.

- **Smart Freight and Logistics** expands upon Missouri's role as a national freight hub by promoting connected freight technologies, logistics data-sharing and intermodal coordination. Long-term actions establish statewide smart freight corridors and predictive freight demand systems to enhance supply chain reliability and competitiveness.

Table 3 – Emerging Technologies Phased Implementation Roadmap

Emerging Technology Focus Area	Phase 1: Foundation (Short–Term 0–5 Years)	Phase 2: Pilot and Integration (Mid–Term 6–10 Years)	Phase 3: Expansion and Optimization (Long–Term 10+ Years)
Smart Infrastructure and ITS	Expand rural broadband planning Audit ITS systems for interoperability Develop data governance policies and staff training	Deploy adaptive signal pilots Begin roadside unit (RSU) installations Integrate TMC, sensor and weather data into regional dashboard	Statewide adaptive signal control Rural broadband expansion to freight routes Establish statewide mobility data hub
CV/AVs	Pass CV/AV enabling legislation including truck platooning Conduct CV/AV readiness assessments Develop CV/AV Asset Readiness Index Plan truck platooning pilots	Launch I-70/I-44/I-55 pilot corridors Implement cybersecurity framework Establish CV/AV test zones with universities	Full CV/AV corridor upgrades Develop liability and insurance frameworks Public education and acceptance campaigns
Digital Twins and Predictive Analytics	Inventory data and gaps Initiate data integration roadmap Staff training in analytics and AI tools	Develop corridor-level digital twins Pilot predictive maintenance and crash-risk models Establish performance metrics	Expand to statewide digital twin system Integrate predictive models across assets Institutionalize data-driven decision making
Smart Freight and Logistics	Map freight corridors and data sources Engage industry stakeholders and ports Assess freight signal and broadband needs	Pilot connected truck and logistics data-sharing Test dynamic freight routing and signal priority Develop intermodal freight data exchange	Establish statewide smart freight corridors Deploy predictive freight demand models Implement public-private data collaboration network

Cross-cutting enablers support all phases and focus areas of the roadmap. These enablers represent the policies, partnerships and organizational capabilities required to support the long-term success of Missouri's transportation technology initiatives.

- **Funding Strategy**: Establishes a stable and diverse investment framework that combines state funding, federal programs such as the IIJA and Federal Highway Administration Intelligent Transportation Systems (FHWA ITS) grants and private-sector investment to sustain deployment and modernization efforts.

- **Public-Private Partnerships (P3s):** Enables collaboration with telecommunications providers original equipment manufacturers (OEMs), freight carriers and universities to accelerate research, development and implementation of emerging transportation technologies.

- **Cybersecurity and Data Privacy:** Embeds "security-by-design" principles into all digital platforms, ensuring the protection of transportation data and infrastructure from cyber threats while maintaining public trust and compliance with data protection standards.

- **Interoperability Standards:** Promotes open data and communication protocols, including the National Transportation Communications for Intelligent Transportation System Protocol (NTCIP), the Society of Automotive Engineers (SAE) and the Institute of Electrical and Electronics Engineers (IEEE) standards, to support seamless integration across vendors and systems statewide.

- **Systems Engineering and Lifecycle Planning:** Emphasizes the application of systems engineering principles within TSMO to support technology deployments that are needs based, interoperable and sustainable. Supports structured processes for defining requirements, verifying performance and managing technology assets through their full lifecycle, including maintenance, updates and replacement planning, to enhance reliability, efficiency and long-term system integration statewide.

- **Performance Management:** Emphasizes tracking measurable outcomes in safety, system reliability, congestion reduction and cost efficiency to guide ongoing improvement and accountability.

- **Workforce Development:** Helps equip MoDOT staff with the knowledge and skills to manage emerging technologies by providing training in AI, data analytics and digital asset management tools, strengthening workforce readiness to support TSMO through data-driven analysis, informed operational decision-making and effective interdepartmental coordination.

Collectively, these enablers provide the institutional, technical and workforce foundation necessary for MoDOT to deliver a connected, data-driven and resilient transportation network capable of meeting the needs of Missouri's residents, businesses and visitors for years to come.

Source: MoDOT

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