

PROJECT SUMMARY REPORT

5-7160-01: Implementing the ATSPM-in-the-Loop Simulation Solution with the TxDOT Statewide ATSPM System Deployment Plan

Background

Automated Traffic Signal Performance Measures (ATSPM) provides transportation agencies with high-fidelity information for evaluating traffic signal operations. The previous TxDOT Project 0-7160 first demonstrated how microscopic traffic simulation could be integrated with real-world ATSPM platforms to bring performance-based evaluation into the signal design stage. The implementation project 5-7160 builds on that foundation by focusing on implementation: packaging the required software, expanding controller support, documenting deployment procedures, and demonstrating the complete ATSPM-in-the-loop workflow on a TxDOT corridor. The outcome of this project is to ensure TxDOT can take over the developed software tools and operate independently.

Although most ATSPM software packages are available for free, the deployment in practice still requires substantial effort: including installing databases and web services; configuring traffic signal controllers; generating compatible event data and moving information between systems. These necessary steps are considerably time-consuming, limiting access for agencies that wish to use ATSPM for traffic signal training, planning, design, and pre-deployment testing. The project, therefore, focused on minimizing these barriers while preserving the ability to evaluate traffic signal operations using the same types of performance measures used in real-world ATSPM systems.

The developed tools and solution were implemented with RM 2244 (Bee Cave Road) corridor in TxDOT Austin District. The corridor includes 23 signalized intersections and provides a realistic environment for testing multiple controller configurations, ATSPM data-generation workflows, projected traffic demand, and signal-timing changes before field implementation.

What the Researchers Did

The research team from The University of Texas at Arlington completed a comprehensive set of software, simulation, controller-integration, and deployment tasks to convert the earlier ATSPM-in-the-loop concept into a practical implementation framework.

- Documented the installation and configuration of UDOT ATSPM and UTA-In-Motion (UTAIM), including the database, web server, and visualization components required to operate both platforms in host computers (the current practice).
- Developed a Docker-based TxDOT ATSPM Digital Twin package that combines the required ATSPM applications and databases in a standardized environment. The packaged deployment reduces setup time and improves portability and reproducibility across computers.

- Configured PTV VISSIM and developed special software libraries to generate high-resolution signal transitions, detector actuations, pedestrian events, and simulated vehicle trajectories in formats that can be converted for ATSPM analysis.
- Implemented three signal-control emulators within the RM 2244 model: VISSIM's built-in Ring-Barrier Controller (RBC), the Econolite EOS software-in-the-loop simulation EOS-SILS, and a physical Q-Free MAXTIME controller connected through a new TxDOT hardware-in-the-loop simulation control interface device or TxDOT HILS-CID that was developed for this project.
- Developed and refined parsing and transferring tools that convert simulated and controller-generated events into the UDOT ATSPM database structure and transfer applicable records and vehicle trajectories to UTAIM.
- Applied the complete process to the 23-intersection RM 2244 corridor. The team evaluated a 2023 baseline scenario, a projected 2025 demand scenario, and selected signal-timing modifications using VISSIM outputs, UDOT ATSPM performance measures, Purdue Coordination Diagrams, and UTAIM trajectory-based time-space diagrams.

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What They Found

The project demonstrated that the ATSPM-in-the-loop framework can operate with different signal-controller environments within the same corridor model. RBC, Econolite EOS, and the physical Q-Free MAXTIME controller were all used to generate or support controller-event data that could be processed for ATSPM analysis. It was found that each signal control software interpreting standards differently and additional parsing efforts were needed for each signal controller brand. These challenges were all addressed in the delivered software packages.

The developed parsing tools can seamlessly parse and transfer from simulation data to the ATSPM databases. Approach-volume trends generated by UDOT ATSPM closely followed the corresponding VISSIM outputs. Approach-delay values differed because the two systems calculate delay differently, but the temporal patterns remained comparable. The comparison showed that the simulated ATSPM data, after being parsed, can be used to generate most ATSPM diagrams as with real-world controllers.

The RM 2244 case study also showed how the framework can support before-and-after evaluation. Under the projected traffic-demand scenario, several locations experienced increased queues, vehicle delay, and arrivals on red. The trajectory-based time-space diagrams made the deterioration in progression especially visible through denser trajectories, more frequent stops, and additional split failures.

Selected signal-timing parameters were then modified as a demonstration. The optimized scenario showed shorter and less frequent stops, reduced queueing near the selected intersections, and improved corridor progression. However, the case study aims to offer a step-by-step example for TxDOT's future adoption due to lack of the latest traffic volumes.

What This Means

Project 5-7160 provides TxDOT with a reproducible environment for comprehensively evaluating traffic signal operations before changes in the field. Engineers can use the same framework to prepare traffic demand, connect simulated or physical signal controllers, generate ATSPM-compatible event data, and review performance through familiar ATSPM measures and visualizations.

Docker-based deployment reduces the technical effort needed to establish UDOT ATSPM and UTAIM for testing and training. The HILS-CID extends the framework beyond software-only simulation by allowing a physical traffic signal controller to exchange signal indications, detector actuations, and pedestrian calls with VISSIM in real time. This creates a controlled environment for testing controller behavior without exposing field traffic to unverified settings.

The RM 2244 demonstration shows how the framework can support projected future demand studies and signal-timing re-optimization. ATSPM visualizations can help engineers identify locations where traffic progression deteriorates, compare alternative timing strategies, and use the results to support engineering judgment before field implementation. The same process can be reproduced on other corridors with different controller types, and traffic scenarios.

Next Steps

The project documentation, digital-twin package, controller-integration procedures, and software tools provide a foundation for broader TxDOT use. Future implementation can focus on additional controller platforms, expanded training and technology-transfer activities, and application of the framework to other TxDOT corridors and operational scenarios. The research team will keep the research momentum to integrate the latest UDOT-ATSPM v5 into this framework in near future.

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