TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Indiana Department of Transportation

INSTRUCTIONS:
Lead Agency contacts should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *TPF-5(519)*	**Transportation Pooled Fund Program - Report Period:** ☐X Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☐ Quarter 4 (October 1 – December 31)

TPF Study Number and Title: TPF-5(519) Expansion: Enhanced Traffic Signal Performance Measures

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Lead Agency Project ID: **TPF-5(519)**	**Other Project ID (i.e., contract #)**	**Project Start Date:** July 1, 2023
Original Project Start Date: **July 1, 2023**	**Original Project End Date:** **6/30/2026**	**If Extension has been requested, updated project End Date:**

Project schedule status:

☐X On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Funds Expended This Quarter	Percentage of Work Completed to Date
$230,000	$11,073.27	20%

Project Description:

Background & Impact

The Indiana led pooled fund traffic signal research projects have a strong history of implementation. The first study, TPF-5(259), was recognized by EDC 4 and virtually all controllers now provide high resolution data logging. There is a strong commercial base of advanced traffic signal performance measure providers. The technical reports from TPF-5(259) listed below are widely distributed and cited.

- Performance Measures for Traffic Signal Systems: An Outcome-Oriented Approach. http://dx.doi.org/10.5703/1288284315333
- Integrating Traffic Signal Performance Measures into Agency Business Processes. http://dx.doi.org/10.5703/1288284316063

Similarly, TPF 5(377) stimulated a second generation of commercial implementation of trajectory-based traffic signal performance measures. TPF-5(377) was led by Indiana and included participation from FHWA, California, Connecticut, Georgia, Minnesota, North Carolina, Ohio, Pennsylvania, Texas, Utah, and Wisconsin. The project developed methodologies and tools for using high resolution vehicle trajectory data to compute enhanced traffic signal performance measures. The technical report for TPF-5(377) was published July 6, 2023.

- Next Generation Traffic Signal Performance Measures https://doi.org/10.5703/1288284317625

Research Needs

During the April 2022 TPF-5(377) Panel Meeting in Columbus, OH, participating states supported a new PFS with the following objectives:

1. Broadening performance measures to additional modes that are impacted by traffic signal systems, particularly transit and pedestrians.
2. Identifying use cases for enhanced probe data beyond the current trajectory and hard braking/hard acceleration data.
3. Integrated Analysis of High-res Controller Data and Trajectory Probe Data

These initiatives for TPF-5(519) will complement and expand the past work the multi-state team has done in the area of enhanced traffic signal performance measures using connected vehicle data.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

April 1 – June 30, 2023

The solicitation for TPF-5(519) was posted in Spring 2023.
The following states have committed a total of $1,020,000 to TPF-5(519) as of June 30, 2023.

Connecticut
Georgia
Minnesota
Mississippi
North Carolina
Ohio
Pennsylvania
Texas
Utah

The project has a start date of July 1, 2023, and will be funded incrementally by Purdue University as funds from t participating states are transferred.

July 1 – September 30, 2023

The following submissions to 2024 Transportation Research Board (TRB) Annual Meeting were accepted for presen

- TRBAM-24-00070: A Data-driven Intersection Geometry Mapping Technique to Enhance the Scalability of Traj based Traffic Signal Performance Measures
- TRBAM-24-04389 Comparison of Estimated Cycle Split Failures from Detector and Connected Vehicle D

To date, $40,000 in funding for TPF-5(519) has been received by Purdue University. Significant work on the PFS pro pending additional transfer of funds from the partner states.

October 1 – December 31, 2023

To date, $110,000 in funding for TRF-5(519) has been received by Purdue University.

During this quarter, the Purdue research team has been seeking to identify an alternative connected vehicle data s other then Wejo (which suspended operations on June 1, 2023).

One new data provider, and perhaps a second one, has been identified. These data sources are being reviewed a evaluated by the research team.

Scheduling is underway for a webinar with all partners during the first quarter of 2024 in order to share the new dat sources, further define the scope of the study, and prioritize future activities.

January 1 – March 31, 2024

A webinar with held on February 16, 2024 with representatives from FHWA and partner states (CA, CT, GA, IN, MN NC, OH, PA, UT). Webinar included the following updates.

- The research team presented a comparison on high resolution and connected vehicle performance measures and provided the following references for more details.
  https://doi.org/10.1177/03611981231168116
  https://doi.org/10.4236/jtts.2023.134032
- Connected car data is transitioning from Wejo to Streetlight. The research team is reviewing data specifica And agreements with Streetlight and anticipates receiving data for evaluation purposes in April 2024.
- Mark Taylor shared an example of LiDAR data available at an intersection in Utah. Utah has two intersectio LiDAR on-line and Ohio has one intersection in the early deployment stage. Further investigation into this data so planned for future meetings

Subsequent to the webinar, the research team began work on deriving traffic signal performance measures from L
Sensors at a signalized intersection in Utah. This work included:

- Identifying dataset challenges and proposed a filtering approach to verify sampled trajectories
- Generating a Purdue Probe Diagram to estimate delay, arrivals on green, split failures, and downstream blo
- Analyzing the same intersection with CV data to provide a comparison

A data set of LiDAR-derived trajectories at Intersections published in collaboration with Utah colleagues is availab
Li, T.; Taylor, M.; Saldivar-Carranza, E. D.; Bullock, D. M. (2024). Traffic Signal LiDAR-derived Vehicle Trajectories Dataset. Purdue University Research Repository. https://doi.org:10.4231/MYZ4-8S55

The next PFS Webinar is scheduled for May 2, 2024.

Anticipated work next quarter:

- Continue to identify and/or strengthen private sector partnerships for collecting and analyzing enhanced probe data for traffic signal performance measures.
- Continue outreach activities to share findings with a broader audience and solicit participation in the PFS Expansion: Enhanced Traffic Signal Performance Measures.
- Publish a paper on "*Deriving Vehicle Trajectories from LiDAR Sensors Data to Evaluate Traffic Signal Performance*"
- Evaluate purchased CV data with a focus on the impact of data fuzzification on traffic signal performance measures
- Obtain access to LiDAR data at additional signalized intersection to further analyze its capabilities to generate operational performance measures

Significant Results:

Saldivar-Carranza, E. D., Li, H., Mathew, J. K., Desai, J., Platte, T., Gayen, S., Sturdevant, J., Taylor, M., Fisher, C & Bullock, D. M. (2023). Next generation traffic signal performance measures: Leveraging connected vehicle data. Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317625

Saldivar-Carranza, E. D., Li, H., Gayen, S., Taylor, M., Sturdevant, J., & Bullock, D. M. (2023). Comparison of Arrivals on Estimations from Vehicle Detection and Connected Vehicle Data. Transportation Research Record, 0(0). https://doi.org/10.1177/03611981231168116

Saldivar-Carranza, E. and Bullock, D. (2023) A Data-Driven Intersection Geometry Mapping Technique to Enhance Scalability of Trajectory-Based Traffic Signal Performance Measures. Journal of Transportation Technologies, 13, 44 https://doi.org/10.4236/jtts.2023.133021

Gayen, S., Saldivar-Carranza, E. and Bullock, D. (2023) Comparison of Estimated Cycle Split Failures from High-Res Controller Event and Connected Vehicle Trajectory Data. Journal of Transportation Technologies, 13, 689-707. https://doi.org/10.4236/jtts.2023.134032

Saldivar-Carranza, E.D., Gayen, S. & Bullock, D.M. Intersection Type Classification from Connected Vehicle Data Using a Convolutional Neural Network. *Data Sci. Transp.* **6**, 2 (2024). https://doi.org/10.1007/s42421-023-00087-6

Saldivar-Carranza, E.D.; Gayen, S.; Li, H.; Bullock, D.M. Comparison at Scale of Traffic Signal Cycle Split Failure Identification from High-Resolution Controller and Connected Vehicle Trajectory Data. Future Transp. 2024, 4, 236-256. https://doi.org/10.3390/futuretransp4010012

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation: N/A