TPF-5(377) Expansion: Enhanced Traffic Signal Performance Measures

Background & Impact

The Pooled Fund Project TPF-5(377) is led by Indiana and includes 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. Significant outcomes from the study are listed at the end of this document in the reference section.

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) is now stimulating a second generation of commercial implementation of trajectory based traffic signal performance measures. The current TPF 5(377) project end date is June 20, 2023.

Research Needs

During the April 2022 PFS Panel Meeting in Columbus, OH, participating states expressed interest in developing a new study led by a neutral state/academic partner in the following areas:

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 would 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.

Research Tasks

1. Identify commercial probe data sets that are available and procure one month of probe data for each participating state. This task is important as there has been substantial growth in connected vehicle data attributes since TPF 5(377) was initiated. In addition to passenger car trajectories and hard braking, there are now data elements that include finer gradations of hard braking, finer gradations of acceleration, traction control (winter conditions), commercial truck trajectories, and electric vehicles. In consultation with the panel, the research team will acquire as broad and inclusive connected vehicle data as financially feasible.
2. Perform penetration analysis of connected vehicle data to understand how it varies by state. There is broad interest in ensuring that the connected vehicle is representative and has sufficient penetration to provide accurate performance measures. The previous pooled fund study looked at penetration of passenger cars in the participating states (Figure 1) in August 2021. There was considerable regional variation (Figure 2). A preliminary analysis of connected

trucks data in Indiana, indicated that connected truck data should also be considered to increase penetration. Although truck data is relatively modest during peak hours, including truck data provides a more representative analysis of how a traffic signal performs.

3. Update performance measure analysis techniques to examine how mix of commercial vehicles and passenger cars impact a traffic signal operation. For many decades, the highway capacity manual has used the heave vehicle (f_{hv})adjustment factor. However, the validation on this has been quite limited. We now have an opportunity to evaluate the impact of heavy vehicles on traffic signals at scale.
4. Identify transit agencies in participating states that have AVL/connected bus data available to share with research team. This task is important as the infrastructure bill has several programs that touch both transit and traffic signal systems so it is important to enhance performance measure analysis to be inclusive of transit vehicles. We anticipate this providing an important framework for factual and constructive dialog between traffic signal operators and transit operators. For example, we now have the ability to directly compare transit operating performance measures with passenger cars and trucks operating in the same stream. Figure 4 illustrates a heatmap showing bus performance measures that can be overlayed with traffic signal performance measures to identify if there are opportunities to improve traffic signal operation.
5. Integrate trajectory data and high resolution data to characterize how performance measures such as split failure and arrival on green vary depending if they are calculated using trajectory data or traditional high resolution data. This will be important to document so agencies that have well established ATSPM programs using traditional hi-res data can easily transition to trajectory based ATSPM.
6. Integrate trajectory data and high resolution controller data for multi-modal analysis. Pedestrian push button information have long been available in hi-resolution logs, but they do not provide demand level data. Many of the new camera systems (such as Miovision) can provide reasonable measurement of pedestrian movements in cross walks. This task will look at opportunities to integrate traffic signal data, such as pedestrian movements, with trajectory based traffic signal performance measures so that there is an opportunity for constructive and factual dialog on how to most effectively operate traffic signals in areas where pedestrian demand varies by time and location.
7. Prepare final report.

Funding Request

$120,000 ($40,000 per year for three years) from each participating state.

Proposed Start Date
January 1, 2023

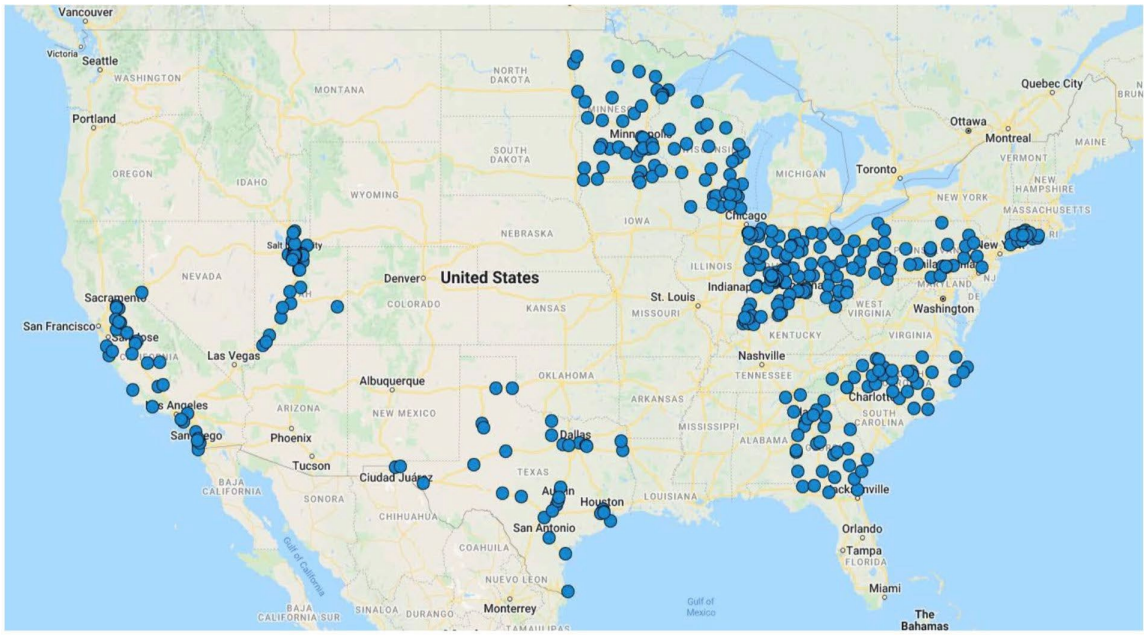

Figure 1: Location of 386 count stations across eleven states analyzed for passenger car penetration

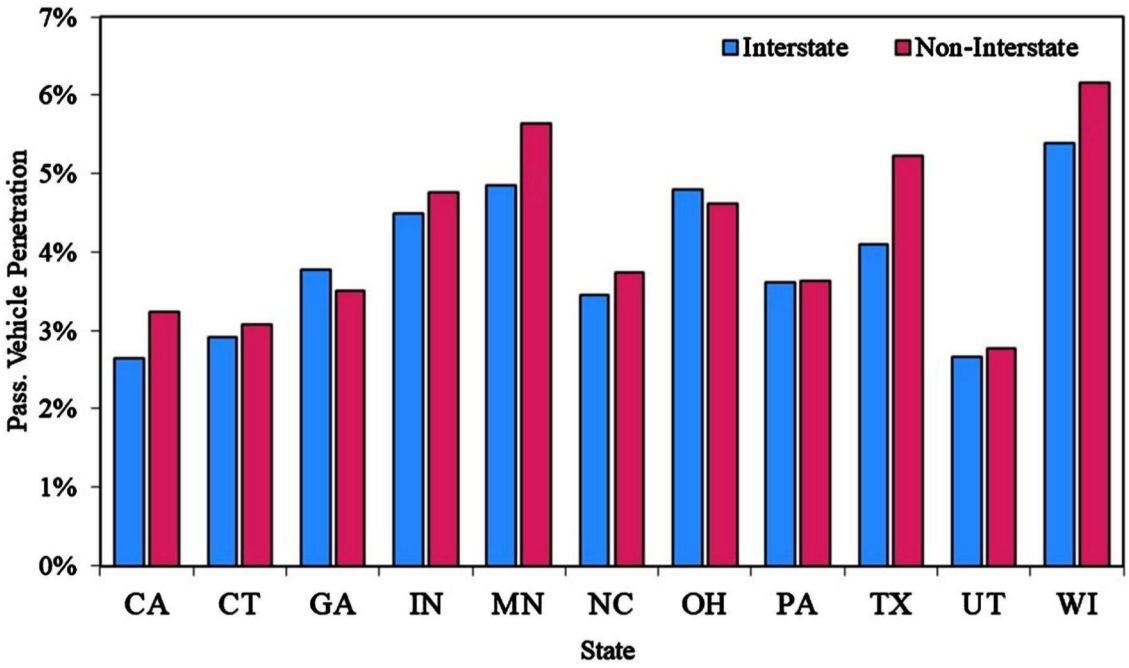

Figure 2: Passenger car penetration on interstates and non-interstates across eleven states in August 2021.

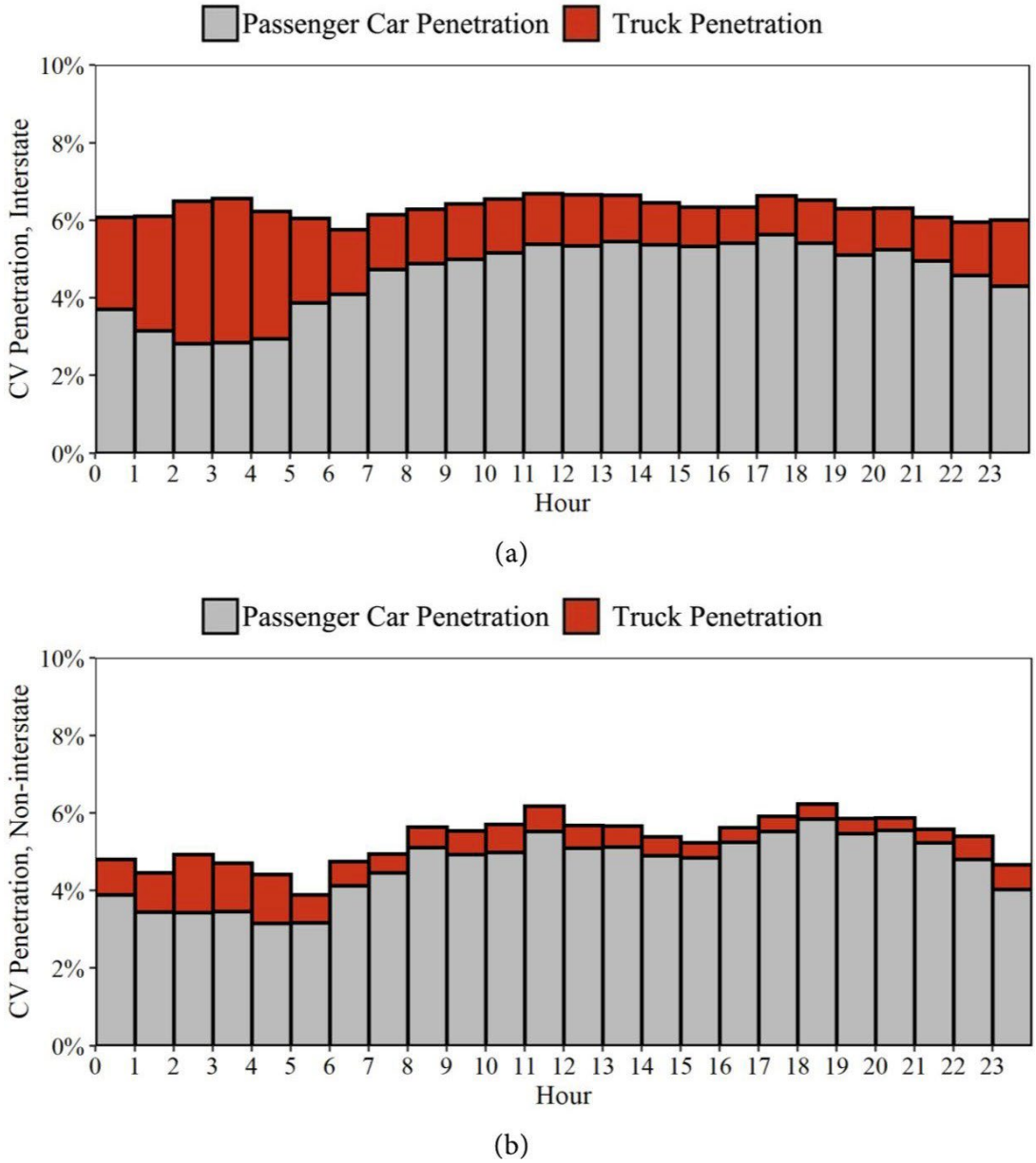

Figure 3: Hourly penetration of connected passenger cars and trucks on Indiana interstates (a) and Indiana non interstates (b).

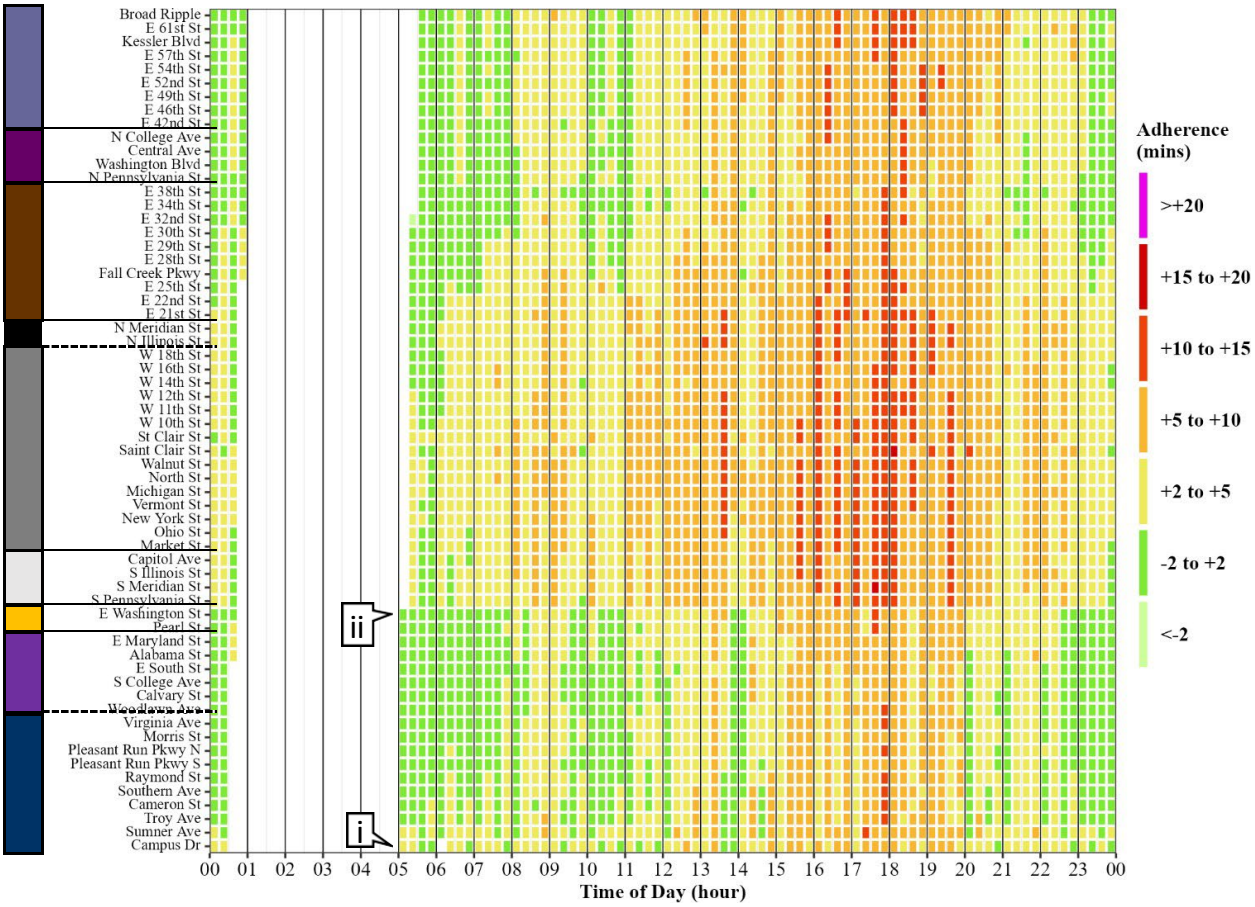

Figure 4: Average bus schedule adherence by time of day for Indianapolis Red Line (Northbound)

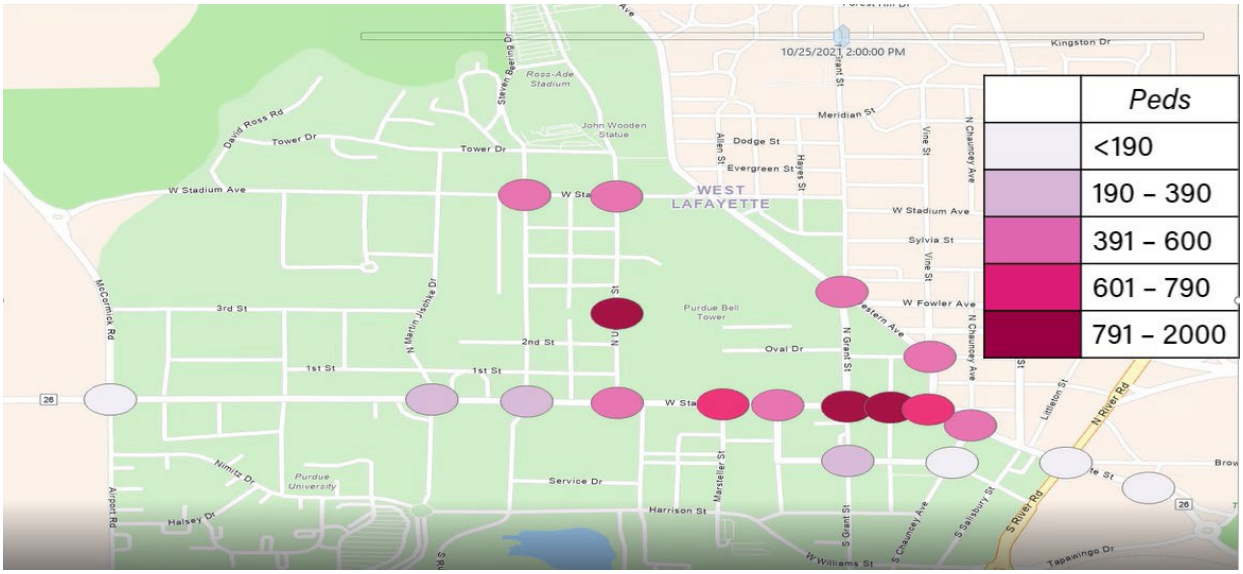

Figure 5: Illustration of varying pedestrian levels at signalized intersection on the Purdue campus at 2pm on October 24, 2021.

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