TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:
Project Managers and/or research project investigators 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(377)*	Transportation Pooled Fund Program - Report Period: **Quarter 1 (January 1 – March 31)** Quarter 2 (April 1 – June 30) Quarter 3 (July 1 – September 30) Quarter 4 (October 1 – December 31)
Project Title: Enhanced Traffic Signal Performance Measures	

Name of Project Manager(s): James R. Sturdevant	**Phone Number:** (317) 691-9091	**E-Mail** jsturdevant@indot.in.gov
Lead Agency Project ID: TPF 5(377)	**Other Project ID (i.e., contract #):**	**Project Start Date:** July 1, 2018
Original Project End Date: June 30, 2021	**Current Project End Date:** June 30, 2021	**Number of Extensions:** 0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$633,000	$273,508.79	40%

***Quarterly* Project Statistics:**

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$112,352.69	58%

Project Description

Background

The Pooled Fund Project TPF-5(258) led by Indiana and with participation from FHWA, California, Georgia, Minnesota, Mississippi, New Hampshire, Pennsylvania, Texas, Utah, Wisconsin, and City of Chicago produced the following technical reports:

- Performance Measures for Traffic Signal Systems: An Outcome-Oriented Approach. http://dx.doi.org/10.5703/1288284315333 [1]
- Integrating Traffic Signal Performance Measures into Agency Business Processes. http://dx.doi.org/10.5703/1288284316063 [2]

The following states have made commitments totally $750,000 for TPF-5(377): Enhanced Traffic Signal Performance Measures: Georgia, Minnesota, Texas, Utah, Wisconsin, North Carolina, Pennsylvania, Ohio. Indiana has committed $275,000 via SPR-4205 Connected Vehicle Corridor Deployment and Performance Measures for Assessment. In addition, College Station, TX, has committed $3,000 to join the PFS as a local agency partner.

Project Objectives

The project will address the following initiatives that complement and expand on the past work the multi-state team has done in the area of traffic signal performance measures:

1. **Traffic Signal Data Logger Update**: Update the data logger specification to provide secure file transfer, incorporate new enumerations that have emerged, and logging new connected vehicle messages.
2. **Probe Data**: Current probe data tools are focused on freeway data. There is a need to build upon the work of Indiana and Pennsylvania DOTs to develop methodologies and tools for using high resolution vehicle trajectory data to compute traffic signal performance measures.

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

July 1 – September 30, 2018
- Conducted telecom for participating states on May 2, 2018, and reached concurrence on the project objectives, task list and timeline.
- INDOT issued a purchase order for $30,000 to Purdue University to establish the project. Additional funds will be transferred to Purdue as funds are received by INDOT from participating states.
- Participating states approved tasks for University of Alabama for work on the traffic signal data logger update. A sub-contract proposal was submitted by University of Alabama to Purdue University for those tasks.

October 1 - December 31, 2018
- Additional funds were received by partner states and INDOT issued a purchase order to increase the project budget by $170,000.
- Established a subcontract to University of Alabama for work on the traffic signal data logger.
- A project kick-off telecom is scheduled for January 23, 2019.
- A face-to-face meeting is scheduled on the Purdue University campus for March 27-28, 2019.

With regards to the scope of work, the following tasks have been accomplished by University of Alabama:
(#1) Identify a set of current issues – This list is based on the issues identified by UDOT and Kittelson.
- **Pedestrian call** – issues with event codes 45 and 90 and how they were reported for multiple ped button actuations (source: Jamie Mackey, UDOT)
- **Coordination** – Event code 150 and 151 are handled differently for the local zero and transition (source: Jamie Mackey, UDOT)
- **Phase gap out** – Event code 10 and event code 9 are being reported differently between controllers. The definition of phase gap out may be interpreted multiple ways. (source: Kittelson)

The manufacturers were asked about this, but no additional issues were identified.

The following University of Alabama tasks are underway:
- **(#3) Characterize the current issues** – YouTube videos and write-ups are being generated for the Econolite, Intelight, and Siemens controllers.
  - Siemens M50
    - **Data**: https://youtu.be/nEESZ0V9bmw
    - **Ped**: ***FLASH***
  - Intelight X3
    - **Data**: https://youtu.be/Cm8JM0kSBtU
    - **Ped**: https://youtu.be/a0cJpPLLr_4
  - Econolite Cobalt
    - **Data**: https://youtu.be/MKD3ulsM9Qs
    - **Ped**: https://youtu.be/X5rXC7SKzxE
- **(#4) Develop and define a new XML specification** – The computer science team is working on this specification. Many details such as the header information, filename, and other key data have been examined.

January 1 – March 31, 2019
The pooled fund study face-to-face two day meeting was held at Purdue University on March 27-28, 2019. The meeting was attended by representatives from FHWA, state DOT's (California, Utah, Minnesota, Wisconsin, Georgia, Pennsylvania, Oh North Carolina, Indiana), City of College Station, private sector (McCain, Iteris, Econolite, Siemens, Miovision, Intelight, TT Ford).
- Each participating agency provided an overview of their signal infrastructure, including updates on central system initiatives, communication architecture, detection and signal controllers. They also shared various challenges and success stories using SPM's. Finally, they wrapped up with related innovations for signal management, especially preparations for connected vehicle deployments
- Dr. Alex Hainen from University of Alabama shared his updates on potential ambiguities in the current data logger specifications. He highlighted the inconsistency on "phase gap-outs" across three signal controllers and proposed relevant solutions. His team also stressed on the importance of secure file transfer protocol (SFTP) to combat cyber security threats. His team will reach out to all participating agencies and vendors to gather other

potential inconsistencies and concerns before publishing the draft version of the recommendations in the next 3-6 months.

- Private sector participants provided a brief overview of the topics-of-interest for the vendor panel discussion to follow the next day. The vendor moderated panel on day 2 discussed the enumerations activities, challenges and future opportunities. Representatives from the auto industry (Audi/Ford) discussed interests of automotive industry in traffic signal performance measures

Figure 1: Photography of panel meeting on March 28, 2019 in West Lafayette, IN.

April 1 – June 30, 2019
- Professor Alex Hainen and the University of Alabama team met with traffic signal vendors to review enumerations and develop recommendations for revisions and additions.
- A webinar for participants was held on June 25. Alex Hainen provided an overview of the process to obtain feedback and engage with signal vendors. This process resulted in recommendations for 24 new enumerations and revision of 3 existing enumerations.
- Following discussion of the recommendations, the revised Indiana Traffic Signal Hi Resolution Data Logger Enumerations document was distributed to the panel for review.

July 1 – September 30, 2019
- Panel feedback was collected from the previous webinar. Five states replied with suggestions for a total of 27 new considerations.
- All new enumerations and comments were incorporated into the published draft. A total of 49 new enumerations were added to the original 2012 set, along with 9 modifications to existing definitions.
- A webinar was held on September 9 for the panel to discuss the published enhanced enumerations document.
- Feedback from vendors is new controllers will begin deploying these new enumerations in 2020
- Exploratory hard braking event data has been obtained to assess feasibility of developing dilemma zone performance measures
- Developed white paper describing performance measure calculations for Populating SAE J2735 Message Confidence Values for Traffic Signal Transitions along a Signalized Corridor (see results)

October 1 – December 31, 2019
- A webinar was held on December 9, 2019, with member participation from 11 states, Purdue University, and University of Alabama
- Alex Hainen reported on the Traffic Signal Data Logger update:
  - Most vendors plan to implement the new enumerations in Q1 of 2020.
  - Alabama team is developing a white paper on how to partially automate the exercising & testing of the new enumerations.
  - Full automation will require close collaboration with vendors to get access to their MIB, but a reasonable level of automation will likely be possible without full MIB access.

- Darcy Bullock noted that data sharing is a significant concern for automotive manufacturers and takes considerable time to navigate. He provided updates on enhanced probe data activities with auto manufacturers
  - General Motors
    - Negotiating an agreement to get statewide trajectory and hard braking event data for July & August 2019 and January 2020.
    - Travel time distributions are straightforward and will improve fidelity of before/after travel time analysis because they will use trajectory data instead of average segment speed.
    - Team has begun preliminary fusion with Green distributions with enhanced probe data that provides hard braking events.
    - To provide a scalable path, the team is evaluating using cloud services to facilitate processing of the large data sets.
  - Ford Motor Company
    - Two Purdue employee vehicles now reporting into Ford's Big Data Drive.
    - Team met with Ford colleagues in Ft. Wayne on November 20 to receive training on a loaner F150 that can provide enhanced probe data for research purposes to validate use cases.

January 1 – March 31, 2020
- Alex Hainen/University of Alabama update on Traffic Signal Data Logger automation activities:
  - The updated enumerations posted at https://docs.lib.purdue.edu/jtrpdata/4/ has been downloaded over 160 times. Vendors have been engaging with Alex to interpretation. We expect to post an updated document in the next month or two with some minor changes and clarifications.
- Darcy Bullock/Purdue University update on enhanced probe data activities with auto manufacturers:
  - General Motors
    - GM/Wejo agreement for data was signed and statewide trajectory and hard braking event data for July 2019, August 2019, and January 2020 was received.
    - Research team is processing the data sets and developing analysis tools to fuse GM data with signal data.
  - Ford Motor Company
    - Data for two Purdue employee vehicles for September/October 2019 has been received from Ford's Big Data Drive. Additional data is expected in the next quarter.
  - Trajectory Data Analysis
    - Research team has developed algorithms for identifying split failures from high fidelity trajectory data. These algorithms are vendor neutral. A manuscript is being prepared that documents these algorithms and will be applied to the large data set.
- Purdue University submitted the following papers:
  - ASCE International Conference on Transportation & Development (ICTD 2020): "Methodology for Evaluating Impact of Actuated Traffic Signal Control on Connected Vehicle Green Light Prediction"
  - ITS World Congress 2020: "Using Crowdsourced Vehicle Braking Data to Identify Road Hazards"
  - Journal of Transportation Engineering, Part A: Systems: "Leveraging Connected Vehicles to Provide Enhanced Roadway Condition Information"

Anticipated work next quarter:
  - Automated Testing of Enumerations Document (University of Alabama)
  - Processing and analyzing of trajectory vehicle Data (Purdue)
  - Schedule telecom to present preliminary findings and case studies to the PFS team.

Significant Results:
The enhanced enumerations document has been published: https://docs.lib.purdue.edu/jtrpdata/4/

Li, H., A. M. Hainen, J. R. Sturdevant, T. Atkison, S. Talukder, J. K. Mathew, D. M. Bullock, D. Nelson, D. M. Maas, Jr., J. and T. Stiles. Indiana Traffic Signal Hi Resolution Data Logger Enumerations. Indiana Department of Transportation and P University, West Lafayette, Indiana, 2019. https://doi.org/10.5703/1288284316998

Mathew, Jijo, H. Li, and D.M. Bullock, "Populating SAE J2735 Message Confidence Values for Traffic Signal Transitions along a Signalized Corridor," Transportation Research Board, Paper No. 20-04533, publication pending.

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).

INDOT awards PFS funds to Purdue University after they receive transfer of funds from the partner states. Initially, the project was funded for $30,000, which was insufficient to initiate subcontract with University of Alabama and fund panel meeting planning and travel.

An additional $170,000 funding for year 1 was awarded to Purdue in early October 2018. We do not anticipate that the 90-day delay in year 1 funding will significantly affect the timeline for the project. The funds received to date will be used to initiate the sub-contract to University of Alabama, fund the first annual meeting for the partner states and begin engagement with industry stakeholders for probe data.

Potential Implementation: Traffic signal vendors will begin deploying the new enumerations in 2020.