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(258)*	**Transportation Pooled Fund Program - Report Period:** Quarter 1 (January 1 – March 31) **XX**Quarter 2 (April 1 – June 30) Quarter 3 (July 1 – September 30) Quarter 4 (October 1 – December 31)
Project Title: Traffic Signal Systems Operations and Management	

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(258)**	**Other Project ID (i.e., contract #):**	**Project Start Date:** January 1, 2012
Original Project End Date: **December 31, 2015**	**Current Project End Date:** **June 30, 2017**	**Number of Extensions:** 2

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**
$475,000	$465,985.63	97%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$49,686.46	82%

Project Description:

Signalized arterials represent a substantial component of the highway transportation network in the United States. The National Transportation Operations Coalition (NTOC) in their 2007 Traffic Signal Report Card noted that nationally 5 to 10 percent of all traffic delay is caused by improper traffic signal timings along major roadways. In 2007, the National Report Card for overall traffic signal systems operations was a D. The situation is not expected to improve as travel demand is forecast to grow significantly faster than network capacity. The increase in national attention on sustainable and livable communities necessitate a concentrated effort be placed upon improved management and operation of our nations traffic signal system inventory.

The Transportation Management Center (TMC) Pooled fund study (SPR-2(207)) initiated in 2000, has been very successful at generating consensus on best management practices for traffic management centers oriented mainly towards freeway operations. It is desirable to develop a similar pooled fund study oriented toward traffic signal operations and management that would complement SPR-2(207) and engage a broad cross section of agencies on the leading edge of active traffic signal management.

Project Objectives

Develop a network of transportation agencies to i) develop consensus on operational standards of performance, ii) define a central management model that can leverage commercial wireless IP offerings that can be competitively outsourced, and iii) asset management principles for using a central system to identify when and where resources are most needed to maximize return on investment.

The level of participation and associated funding commitments will allow for additional opportunities over time or in parallel to explore additional traffic signal initiatives beyond those described herein. For example, the evaluation of adaptive control field deployments and associated systems engineering guidance documents under development by FHWA.

Progress Jan-Mar 2013 (includes meetings, work plan status, contract status, significant progress, etc.):

- A white paper was distributed with near final scope this past quarter. Some minor edits were received from Utah and California and were incorporated. The final scope is available at: https://dl.dropboxusercontent.com/u/1007813/pfs/2013_03/Workplan_PFS_2012_04_30.docx
- Developed draft of Performance Measure Guidebook defined in Task 1.1. A draft of that document is at: https://dl.dropboxusercontent.com/u/1007813/pfs/2013_03/signalmoe__2013_04_30.docx
- Interacted with Utah DOT (Task 1.2) to gain experience with other states deploying performance measures. They have aggressively implemented at several intersections and prepared a dedicated web site: http://udottraffic.utah.gov/signalperformancemetrics/

Progress Apr-June 2013 (includes meetings, work plan status, contract status, significant progress, etc.):

- Continued collaboration with Utah DOT on integration of performance measures into their web site.
- Extended the split failure performance measures to incorporate ACS-Lite oriented "Green Occupancy Ratios" and "Red Occupancy Ratios". A link to a paper documenting that work is at: https://dl.dropboxusercontent.com/u/1007813/pfs/2013_06/GOR_ROR_Concept.pdf
- Extended the PCD concept to accommodate multiple contributing phases serving the interior movement of a diamond interchange https://dl.dropboxusercontent.com/u/1007813/pfs/2013_06/Diamond_PCD.pdf

Progress July–Sept 2013 (includes meetings, work plan status, contract status, significant progress, etc.):

- Continued collaboration with Utah DOT on integration of performance measures into their web site.
- Developed methodology for integrating high resolution controller data from City of Richardson, Texas and Utah DOT into Indiana Performance Measure Web Page
- Integrated newly released Siemens high resolution controller data into performance measure web page (We now have Econolite, Peek, and Siemens)
- Initiated dialog with Intelight-ITS and Naztec to integrate high resolution data from those controllers.

Progress Oct-Dec 2013 (includes meetings, work plan status, contract status, significant progress, etc.):

- Continued collaboration with Utah DOT on integration of performance measures into their web site. See next page on significant progress that shows Utah, Indiana, and Michigan data being integrated in each other's web based platform. This data sharing has received very positive national attention because it demonstrates the portability/scalability of these performance measures across agencies.
- Collaborated with the AASHTO TIG group to provide them information to disseminate nationally.
- Collaborated with Utah, Indiana, Minnesota, and FHWA colleagues to prepared an ITE Article for the March 2014 issue of the ITE Journal on Performance Measures. This will be followed by a series of three national webinars to share experience and solicit broader stakeholder input.
- Continued dialog with Intelight-ITS and Naztec on high resolution data logging. Naztec has completed a beta data logger that Purdue begin testing in January. Current status of high resolution data loggers
    - Econolite ASC 3 – deployed in Indiana and Utah
    - Peek –deployed in Indiana
    - Siemens –deployed in Indiana
    - Naztec – beta testing at Purdue University
    - Intelight-ITS – beta testing with City of Richardson, TX
- Developed a portable data collection using device for agencies to participate in web sites without having to provide an IP link. We have tested that at 5 intersections in Indiana. March webinar will provide opportunity to bring additional states into test (we had preliminary dialog with Georgia DOT during TRB).
- Finalized Performance Measure Guidebook defined in Task 1.1 that was distributed for panel review in March 2013. Electronic and hard copies of the final document will be distributed to panel in February.

Progress Jan-Mar 2014 (includes meetings, work plan status, contract status, significant progress, etc.):

- Interfaced with Utah DOT to plan logistics for field deployment of DDI performance measures.
- Interfaced with Utah DOT to conduct link pivot analysis on selected corridors
- Completed performance measure monograph that summarizes portfolio of performance measures developed to-date. Citation and hyperlink to report is:

  Day, C. M., D. M. Bullock, H. Li, S. M. Remias, A. M. Hainen, R. S. Freije, A. L. Stevens, J. R. Sturdevant, and T. M. Brennan. *Performance Measures for Traffic Signal Systems: An Outcome-Oriented Approach*. Purdue University, V Lafayette, Indiana, 2014. doi: 10.5703/1288284315333.
  http://dx.doi.org/10.5703/1288284315333

Progress Mar-Jun 2014 (includes meetings, work plan status, contract status, significant progress, etc.):

- Prepared technical paper with INDOT and Utah DOT on DDI performance measures for TRB.
- Prepared technical paper with INDOT on Diamond interchange performance measures and submitted to TRB.

Progress July-Oct 2014 (includes meetings, work plan status, contract status, significant progress, etc.):

- Prepared for November 12 Pooled Fund Workshop
- Submitted following TRB Papers

Day, Christopher, M., H. Li, A.M. Hainen, A.L. Stevens, J.R. Sturdevant and D.M. Bullock, "System-Level Analysis of Local Congestion Metrics for Protected and Permitted Movements at Signalize Intersections." Transportation Research Board, Paper No. 15-0062, recommended for presentation.

Day, Christopher, M., Remias, S.M., H, Li, M.M. Mekker, M.L. McNamara, E.D. Cox and D.M. Bullock, "Performance Ranking of Arterial Corridors Using Travel Time and Travel Time Reliability Metrics," Transportation Research Board, Paper No. 15-0063, recommended for presentation and publication.

Lavrenz, S.M., C.M. Day, A.M. Hainen, W.B.Smith, A.L. Stevens, H. Li and D.M. Bullock, "Characterizing Signalized Intersection Performance using Maximum Vehicle Delay," Transportation Research Board, Paper No. 15-0385, recommended for presentation and publication.

Hainen, Alexander, M., H. Li, A.L. Stevens, C.M. Day, J.R. Sturdevant and D.M. Bullock, "Sequence Optimization at Signalized Diamond Interchanges Using High-Resolution Event-Based Data," Transportation Research Board, Paper No. 15-0644, recommended for presentation and publication.

Hainen, Alexander, M., A.L. Stevens, C.M. Day, H. Li, J. Mackey, M. Luker, M. Taylor, J.R. Sturdevant and D.M. Bullock, "High-Resolution Controller Data Performance Measures for Optimizing Diverging Diamond Interchanges and Outcome Assessment with Drone Video," Transportation Research Board, Paper No. 15-0645, recommended for presentation and publication.

Li, Howell, S.M. Lavrenz, C.M. Day, A.L. Stevens and D.M. Bullock, "Quantifying Benefits of Signal Timing Maintenance a Optimization Using both Travel Time and Travel Time Reliability Measures," Transportation Research Board, Paper No. 1 1343, recommended for presentation and publication.

Progress Oct. – Dec. 2014 (includes meetings, work plan status, contract status, significant progress, etc.):

- Conducted Pooled Fund Study Workshop on November 12. Workshop was attended by representatives from California, Chicago, Georgia, Minnesota, Texas, Utah, Wisconsin, Pennsylvania, FHWA, and Indiana.
- Conducted Texas Workshop in DFW area on in collaboration with panel member Henry Wickes.

Progress Jan. – March 2015 (includes meetings, work plan status, contract status, significant progress, etc):

- Presentation at TRB in January of research findings (see papers above)
- Development of Traffic Detector Health Performance Measures
- Workshop with Cranberry Township in Pennsylvania
- Planning for May workshop with Georgia DOT

Progress Apr. - June 2015 (includes meetings, work plan status, contract status, significant progress, etc):

- Collaboration with Pennsylvania DOT on proposal for Implementation of Performance Measures
- Conducted Performance Measure Workshop with Georgia DOT on May 13, 2015
- Conducted Performance Measure Workshop at Wisconsin ITE Conference on April 22, 2015

Progress July – September 2015 (includes meetings, work plan status, contract status, significant progress, etc,)

- Initial planning for January 2016 Automated Traffic Signal Performance Measures Workshop in collaboration with AASHTO Aii and NOCoE.
- Participated in FHWA Vermont Scanning Tour on September 22, 2015.
- Presented Performance Measure Project Findings at ITS Midwest on September 28, 2015.
- Participated in FHWA Pennsylvania Scanning Tour on October 19, 2015.
- Submitted following TRB papers:
  Day, Christopher M., S.M. Lavrenz, A.L. Stevens, R.E. Miller, and D.M. Bullock, "Extending Link Pivot Offset Optimization to Arterials with Single Controller Diverging Diamond Interchange," Submitted to Transportation Research Board, August 1, 2015, Paper No. 16-0111. Recommended for presentation and publication.

  Day, Christopher M. and D.M. Bullock, "Opportunities for Detector-Free Signal Optimization with Limited Connected Vehicle Market Penetration: A Proof-of-Concept Study," Submitted to Transportation Research Board, August 1, 2015, Paper No. 16-0112. Recommended for presentation and publication.

  Lavrenz, Steven M., C.M. Day, W.B. Smith, J.R. Sturdevant, and D.M. Bullock, "Assessing Longitudinal Arterial Performance and Traffic Signal Retiming Outcomes," Submitted to Transportation Research Board, August 1, 2015, Paper No. 16-0113. Recommended for presentation and publication.

  Lavrenz, Steven M., J. Grossman, R.S. Freije, and D.M. Bullock, "Use of High Resolution Signal Controller Data to Identify Red Light Running Vehicles," Submitted to Transportation Research Board, August 1, 2015, Paper No. 16-0209. Recommended for presentation and publication.

  Li, Howell, C.M. Day, J.R. Sturdevant, and D.M. Bullock, "Scaling Detailed High-Resolution Data Split Performance Measures to Statewide System Level Management," Submitted to Transportation Research Board, August 1, 2015, Paper No. 16-4149. Recommended for presentation.

Progress Oct – Dec 2015 (includes meetings, work plan status, contract status, significant progress, etc,)

- Continued planning for January 2016 Automated Traffic Signal Performance Measures Workshop in collaboration with AASHTO Aii and NOCoE.
- Submitted PFS Monograph Volume II to PFS members for review.
  http://web.ics.purdue.edu/~cmday/signalprocess_2015_12_22.pdf
- Presentation at Ohio Transportation Engineering Conference (OTEC), October 28, 2015.
- Presentation at Maryland ITS on November 9, 2015.
- Presentation at Pennsylvania Transportation Engineering and Safety Conference on December 10, 2015.

Progress Jan – Mar 2016 (includes meetings, work plan status, contact status, significant progress, etc.)

- Made the following presentations at TRB in January 2016

  Day, Christopher M., S.M. Lavrenz, A.L. Stevens, R.E. Miller, and D.M. Bullock, "Extending Link Pivot Offset Optimization to Arterials with Single Controller Diverging Diamond Interchange," Paper No. 16-0111.

  Day, Christopher M. and D.M. Bullock, "Opportunities for Detector-Free Signal Optimization with Limited Connected Vehicle Market Penetration: A Proof-of-Concept Study," Paper No. 16-0112. Publication pending.

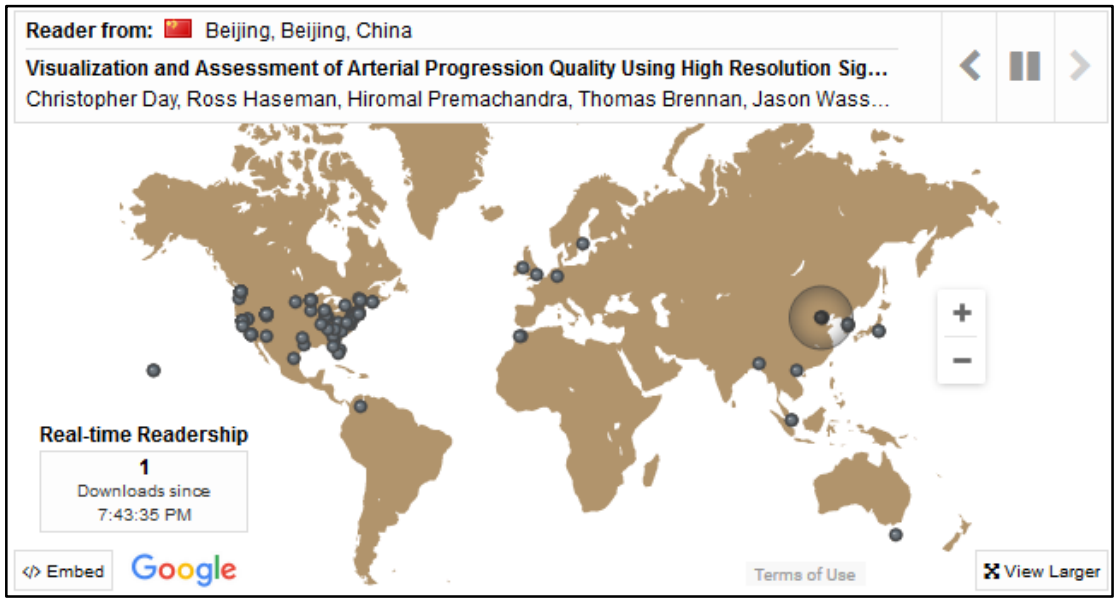
  Lavrenz, Steven M., C.M. Day, W.B. Smith, J.R. Sturdevant, and D.M. Bullock, "Assessing Longitudinal Arterial Performance and Traffic Signal Retiming Outcomes," Paper No. 16-0113. Publication pending.

Lavrenz, Steven M., J. Grossman, R.S. Freije, and D.M. Bullock, "Use of High Resolution Signal Controller Data to Identify Red Light Running Vehicles," Paper No. 16-0209. **Received TRB AHB25 Committee 2016 Best Paper Award**. Publication pending.

Li, Howell, C.M. Day, J.R. Sturdevant, and D.M. Bullock, "Scaling Detailed High-Resolution Data Split Performance Measures to Statewide System Level Management," Paper No. 16-4149.

- Automated Traffic Signal Performance Measure (SPM) Workshop in Salt Lake City on January 26-27, 2016 Collaborated with Utah DOT to plan and deliver workshop attended by over 169 participants from 85 different organizations as represented by the map below.

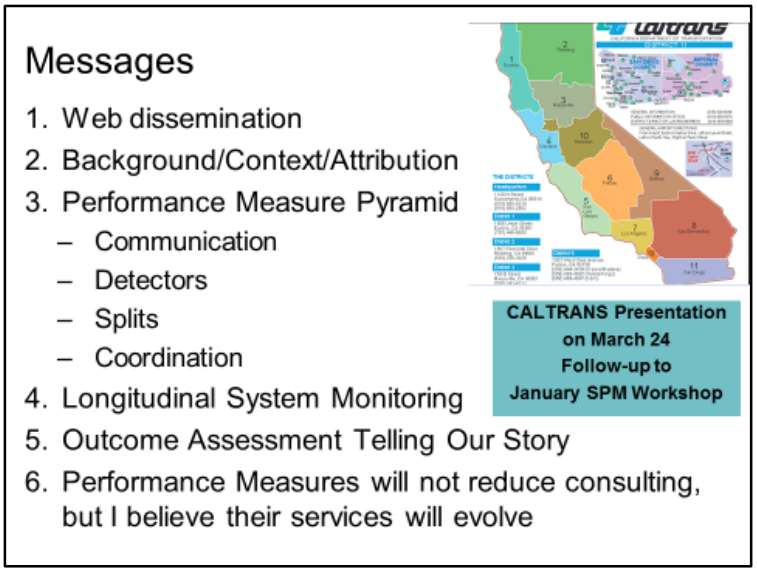
- SPM Workshop Presentations and Posters are archived on Purdue e-Pubs: http://docs.lib.purdue.edu/atspmw/ From January 26 through April 5, 2016, the presentations and posters have been downloaded 554 times. A map representing the worldwide impact of these proceedings is shown below.



- Responded to review comments for PFS Monograph Volume II entitled “Integrating Traffic Signal Performance Measures into Agency Business Processes,” finalized the author manuscript and submitted for typesetting. Final publication and print production is pending. Citation and link to author’s manuscript:

  Day, C. M., D. M. Bullock, H. Li, S. Lavrenz, W. B. Smith, and J. R. Sturdevant, J. R. *Integrating Traffic Signal Performance Measures into Agency Business Processes.* Purdue University, West Lafayette, Indiana, 2015. http://dx.doi.org/10.5703/1288284316063

- Conducted SPM Webinar for CalTrans on March 24, 2016.

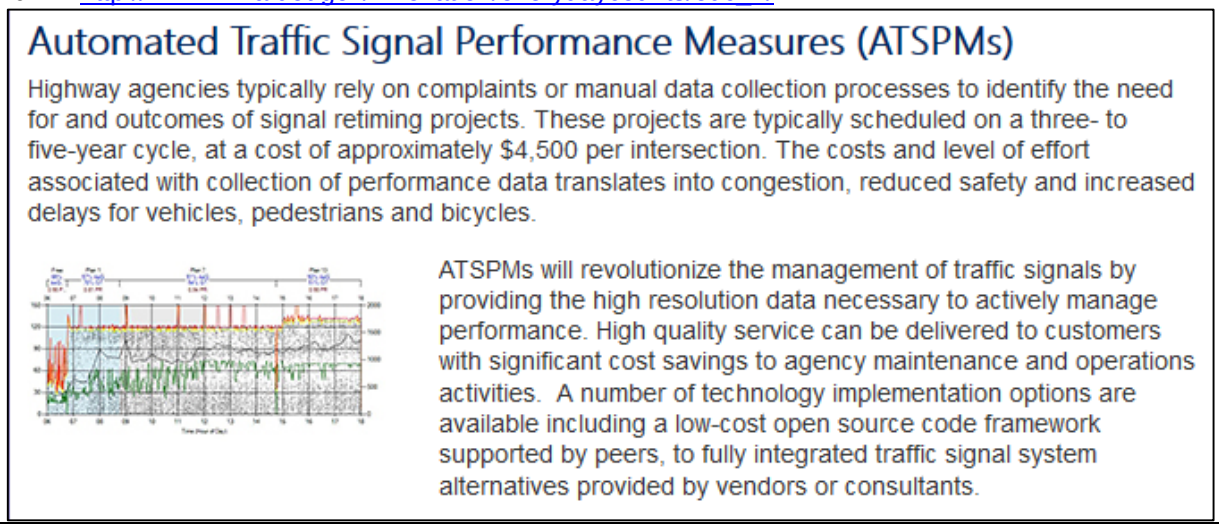


Progress April – June 2016 (includes meetings, work plan status, contact status, significant progress, etc.)

- Published the PFS Monograph:

  Day, C. M., D. M. Bullock, H. Li, S. Lavrenz, W. B. Smith, and J. R. Sturdevant. *Integrating Traffic Signal Performance Measures into Agency Business Processes.* Purdue University, West Lafayette, Indiana, 2015 http://dx.doi.org/10.5703/1288284316063

- Distributed copies of PFS Monograph “Integrating Traffic Signal Performance Measures into Agency Business Processes” to PFS members, Utah SMP workshop attendees, and other stakeholders.
- Automated Traffic Signal Performance Measures (ATSPMs) was selected as an Every Day Counts Iinnovation in Round 4. http://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/



- Initiated a project with Pennsylvania DOT entitled “Implementation of Probe Data Performance Measures” aimed at developing and implementing a series of data-driven performance measure dashboards for Pennsylvania’s highway system.

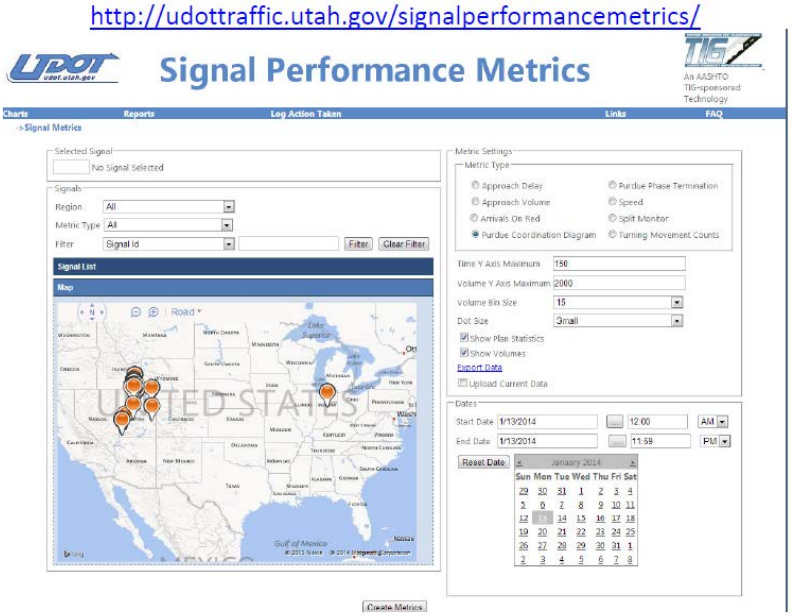
Anticipated work next quarter (July – September, 2016):

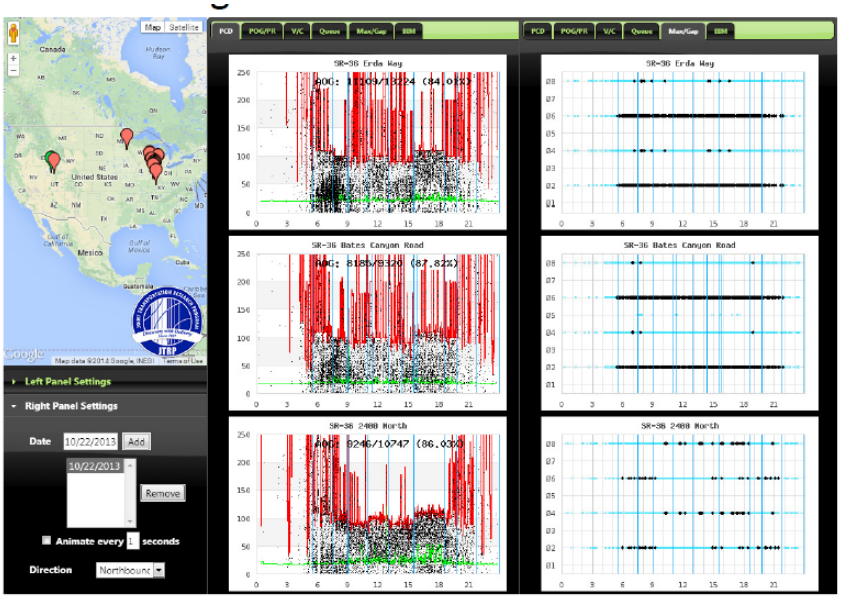
- Participate on EDC-4 Implementation Team for Traffic Signal Performance Measures
- Continue engagement with Pennsylvania DOT on implementation of performance measures
- Continue engagement with UTAH DOT on implementation of performance measures
- Continue support of AASHTO TIG Group (This group continues to be a strong partner in disseminating research results)
- Develop and submit TRB papers relative the traffic signal performance measures.

Significant Results:

- **INDOT, Utah, and Minnesota have all deployed high resolution data collection. That data has been exchanged and both INDOT and Utah DOT have integrated this peer data into their performance measure**

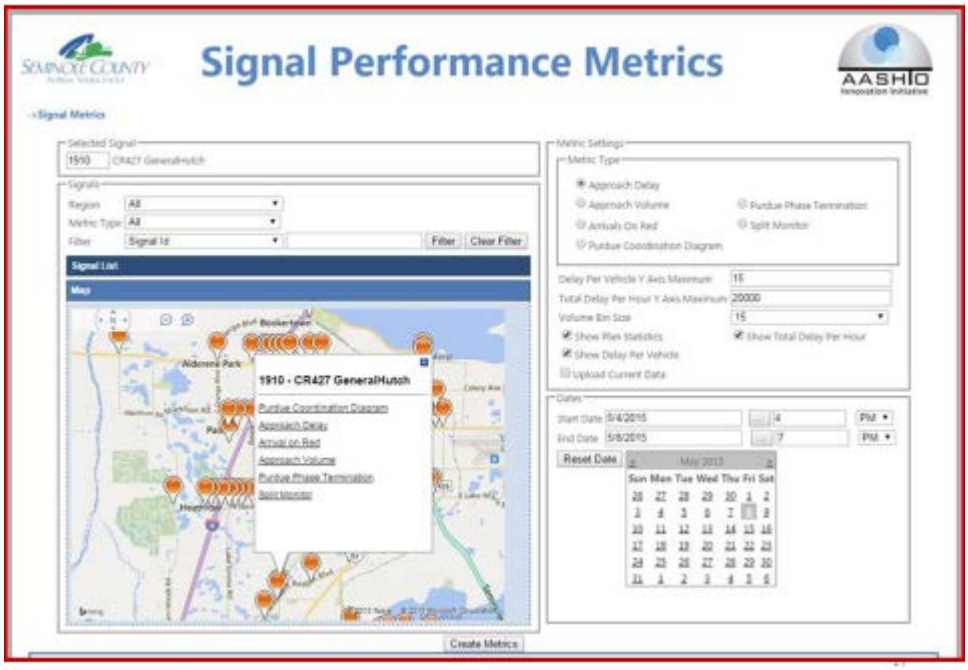
http://udottraffic.utah.gov/signalperformancemetrics/

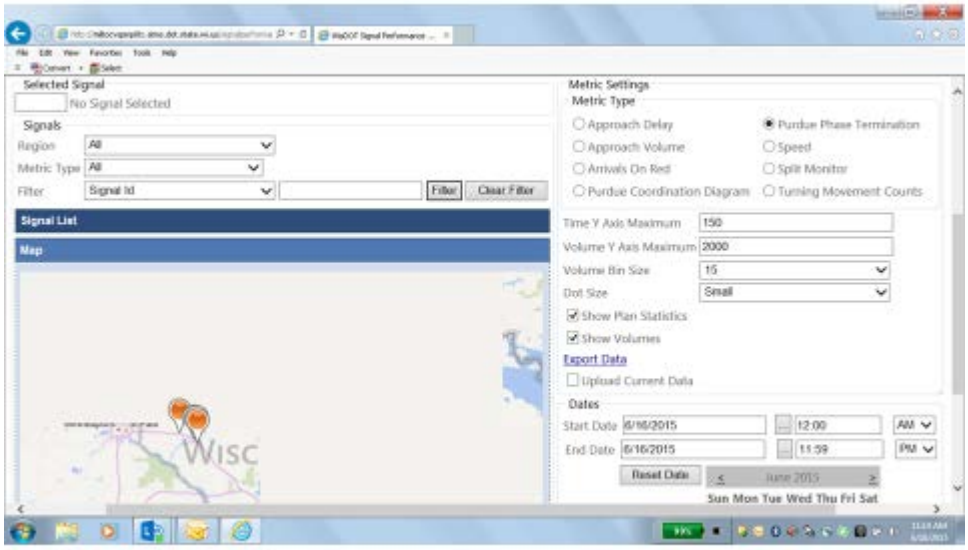




In addition, the following agencies have deployed high resolution data collection: Seminole County, FL; Wisconsin DOT; Georgia DOT; Overland Park KS; FAST, Los Vegas, NV

Examples are shown below.


Signal Performance Metrics
SEMINOLE COUNTY
AASHTO
Signal Metrics
Selected Signal
1910
CR427 GeneralHutch
Signals
Region
All
Metric Type
All
Filter
Signal Id
Filter
Clear Filter
Signal List
Map
1910 - CR427 GeneralHutch
Purdue Coordination Diagram
Approach Delay
Arrival on Red
Approach Volume
Purdue Phase Termination
Split Monitor
Metric Settings
Metric Type
Approach Delay
Approach Volume
Arrivals On Red
Purdue Coordination Diagram
Purdue Phase Termination
Split Monitor
Delay Per Vehicle Y Axis Maximum
15
Total Delay Per Hour Y Axis Maximum
20000
Volume Bin Size
15
Show Plan Statistics
Show Total Delay Per Hour
Show Delay Per Vehicle
Upload Current Data
Dates
Start Date
5/4/2015
End Date
5/8/2015
Reset Date
Sun Mon Tue Wed Thu Fri Sat
Create Metrics


Selected Signal
No Signal Selected
Signals
Region
All
Metric Type
All
Filter
Signal Id
Filter
Clear Filter
Signal List
Map
Metric Settings
Metric Type
Approach Delay
Purdue Phase Termination
Approach Volume
Speed
Arrivals On Red
Split Monitor
Purdue Coordination Diagram
Turning Movement Counts
Time Y Axis Maximum
150
Volume Y Axis Maximum
2000
Volume Bin Size
15
Dot Size
Small
Show Plan Statistics
Show Volumes
Export Data
Upload Current Data
Dates
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Reset Date
June 2015
Sun Mon Tue Wed Thu Fri Sat
WISC

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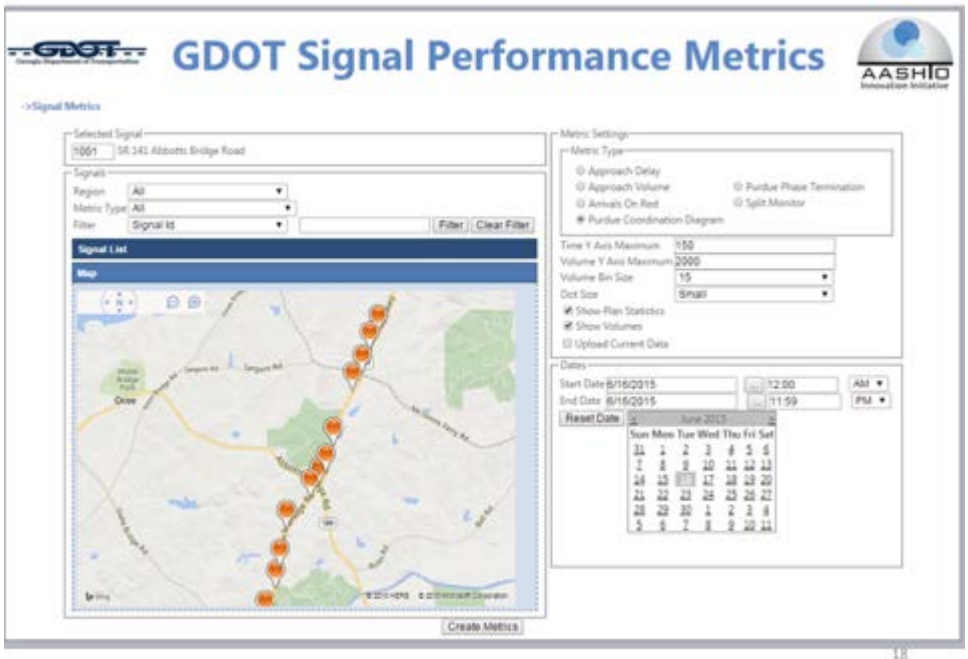
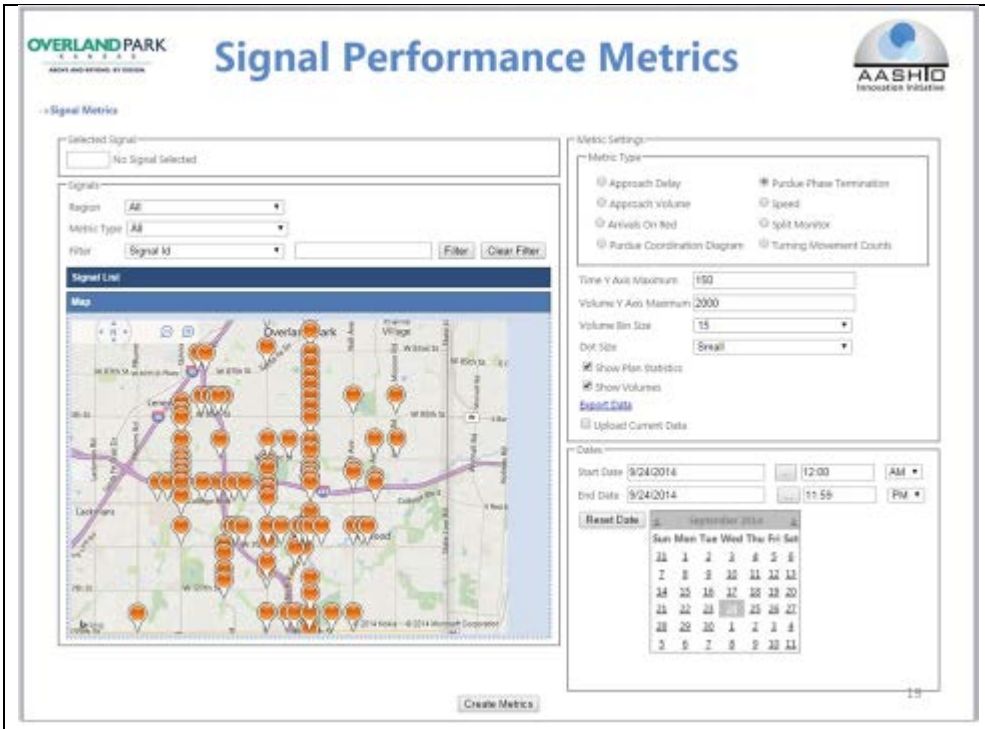
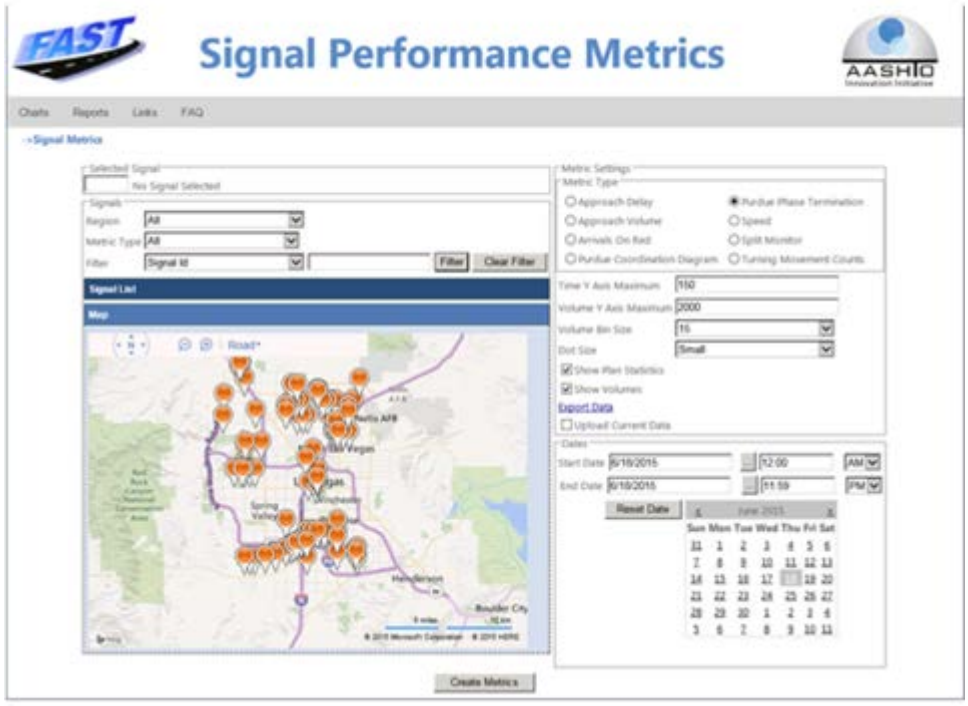

GDOT Signal Performance Metrics
AASHTO
Signal Metrics
Selected Signal
1001
SR 141 Abbotts Bridge Road
Signals
Region
All
Metric Type
All
Filter
Signal Id
Filter
Clear Filter
Signal List
Map
Metric Settings
Metric Type
Approach Delay
Approach Volume
Arrivals On Red
Purdue Coordination Diagram
Purdue Phase Termination
Split Monitor
Time Y Axis Maximum
150
Volume Y Axis Maximum
2000
Volume Bin Size
15
Dot Size
Small
Show Plan Statistics
Show Volumes
Upload Current Data
Dates
Start Date
6/16/2015
12:00
AM
End Date
6/16/2015
11:59
PM
Reset Date
June 2015
Sun Mon Tue Wed Thu Fri Sat
Create Metrics

18





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