

Georgia Department of Transportation

Automated Traffic Signal Performance Measures

Component Details

Prepared for:



Georgia Department of Transportation
600 West Peachtree Street, NW
Atlanta, Georgia 30308

Prepared by:

ATKINS

Atkins North America
1600 RiverEdge Parkway, NW Suite 600
Atlanta, GA 30328

Special Thanks to the Utah Department of Transportation:



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	David Bremer, Atkins	
	Brian Ritchson, Atkins	
REVIEWED BY:	Karen England, Atkins	11/08/2016
	Karen England, Atkins	11/15/2016
	Ron Meyer, Atkins	12/9/2016
TECHNICAL REVIEW:	Mark Taylor, UDOT	
	Jamie Mackey, UDOT	
	Shane Johnson, UDOT	
	Derek Lowe, UDOT	
MODIFIED BY:	Devin Squire & Mark Taylor, UDOT	May 28, 2019
	Mark Taylor, UDOT	January 20, 2020
	Alan Davis, GDOT	February 3, 2020
COMPLETED BY:		

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List of Acronyms and Abbreviations

AoG/AOG	Arrivals on Green
AoR/AOR	Arrivals on Red
ATSPM	Automated Traffic Signal Performance Measures
CPU	Central Processing Unit
GDOT	Georgia Department of Transportation
GOR	Green Occupancy Ratio
fLU	Lane Utilization Adjustment Factor
FTP	File Transfer Protocol
IP	Internet Protocol
MPO	Metropolitan Planning Organization
PCD	Purdue Coordination Diagram
PHF	Peak Hour Factor
ROR	Red Occupancy Ratio
UDOT	Utah Department of Transportation

Introduction

This is the second of three documents that comprise the full Georgia Department of Transportation (GDOT) Automated Traffic Signal Performance Measures (ATSPM) documentation package. Together, the three documents detail the installation and use of the Automated Traffic Signal Performance Measures website, including site navigation, reporting components, and report interpretation. This document is a detailed compilation of ATSPM website components and describes the steps necessary to configure charts and reports to display various features. The ATSPM website **About** tab, shown in Figure 1, displays a brief description of the version notes and recognizes the contributors to the open source ATSPMs.

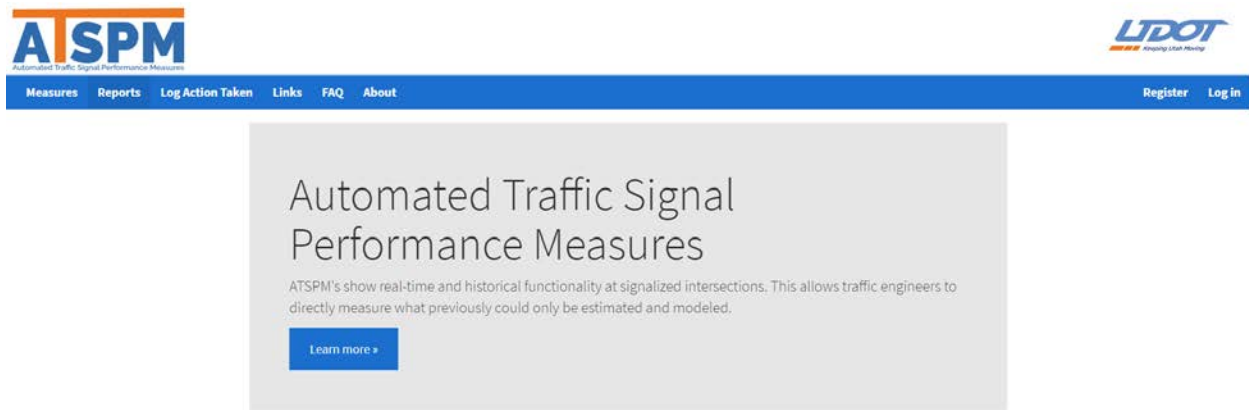


Figure 1: Automated Traffic Signal Performance Measures 4.0 About Tab

1. Measures

This section details the charting features of the software’s **Signal Measures**. These features are available from the menu by clicking **Measures>Signal**. Multiple charts can be generated from the Signal page. Selection and navigation instructions are provided in this document as well as descriptions of the ATSPM interface, the [Signal Metric Types](#) and associated charts.

1.1. Signal

As shown in Figure 2, there are five panes in the interface: **Signal Selection**, **Signal List**, **Signal Map**, **Chart Selection**, and **Date Selection**. Initially, all fields are set blank except for the date and time, which defaults to the current date and spans from 12:00 AM to 11:59 PM.

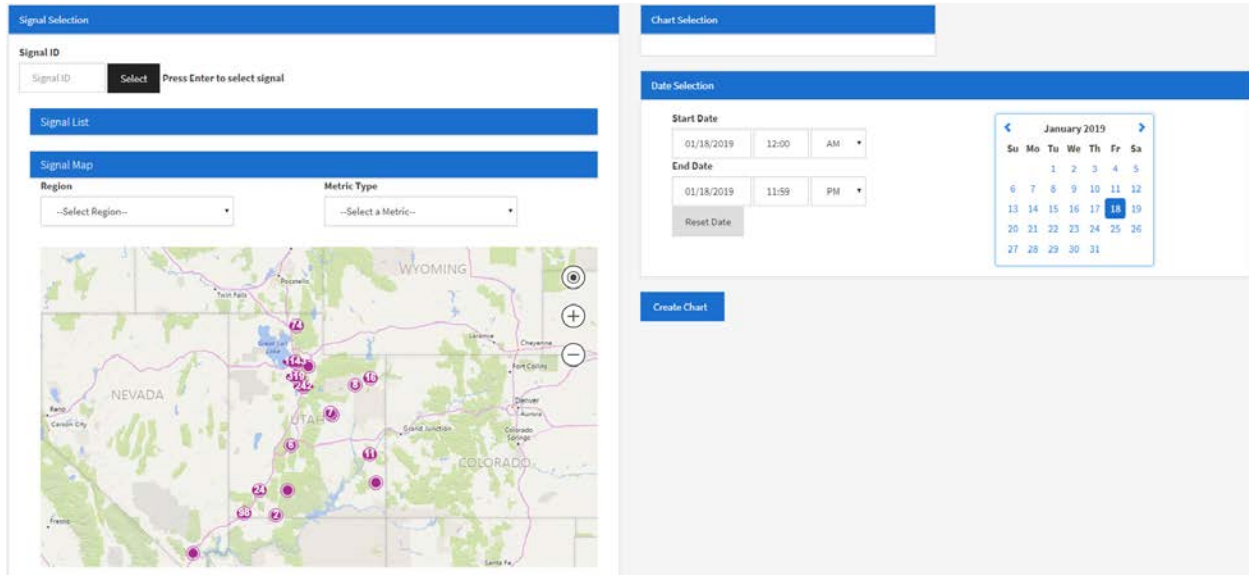


Figure 2: Default Signal Website

1.1.1. Signal Selection

The first field in Signal Selection is **Signal ID**, which begins as a blank field. If the user knows the signal ID for which they wish to generate metrics, it may be typed followed by pressing “enter.” The intersection details, main street and side street, will then display to the right of the field. These details will also display after selecting a signal by any other means (see [Signal List](#) and [Signal Map](#)). The selected signal is the signal targeted for analysis.

1.1.2. Signal List

By default, **the Signal List is hidden** and can be expanded by clicking on **the Signal List** banner (shown in Figure 3). Click again to hide it. The Signal List can filter based on Signal ID, Primary Name, and Secondary Name. The first five matches are shown in the view. Filters are inclusive to the search such that searching for a Signal ID of “60” will display Signal ID 1060 as well as 4602 or any other signal with “60” anywhere in the ID. Users can navigate to other signals by selecting the pages at the bottom of the list. After finding the desired signal, activate it by clicking “Select” in the corresponding row.

Signal List			
Filter			
--Select a Filter ▼		Filter	Clear Filter
Signal ID	Primary Name	Secondary Name	
1001	1200 West	600 North	Select
1002	California Ave	Glendale Drive	Select
1003	900 West	600 North	Select
1004	900 West	200 South	Select
1005	900 West	400 South	Select
1 2 3 4 5			

Figure 3: Signal List

1.1.3. Signal Map

The Signal Map visually depicts the location of traffic signals. The Signal Map, shown in Figure 4, will show the entire state by default. Zoom levels can be adjusted with the Minus and Plus icons in the top left corner of the map, or by using the mouse scroll wheel while hovering over the map. Signal locations will ungroup as zoom level increases. The map includes dropdown selectors for **Region** and **Metric Type**. Choosing a **Region** focuses the map view to that region. Selecting a **Metric Type** from the dropdown menu filters the map view so that it only displays signals supporting the selection. Clicking on a signal location will zoom the map to that signal location, and once selected, will display the Signal ID and Primary Name (see Figure 5).

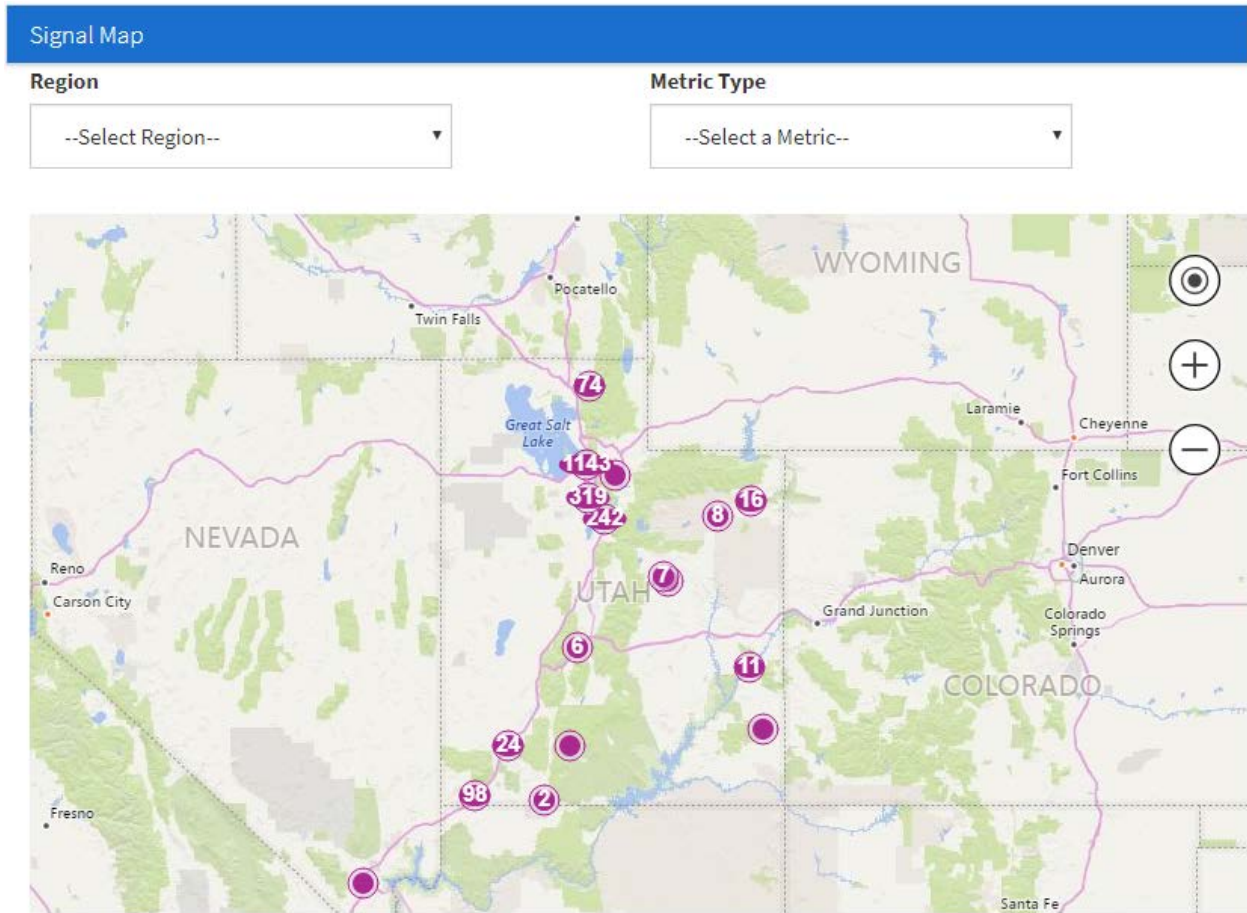


Figure 4: Signal Map

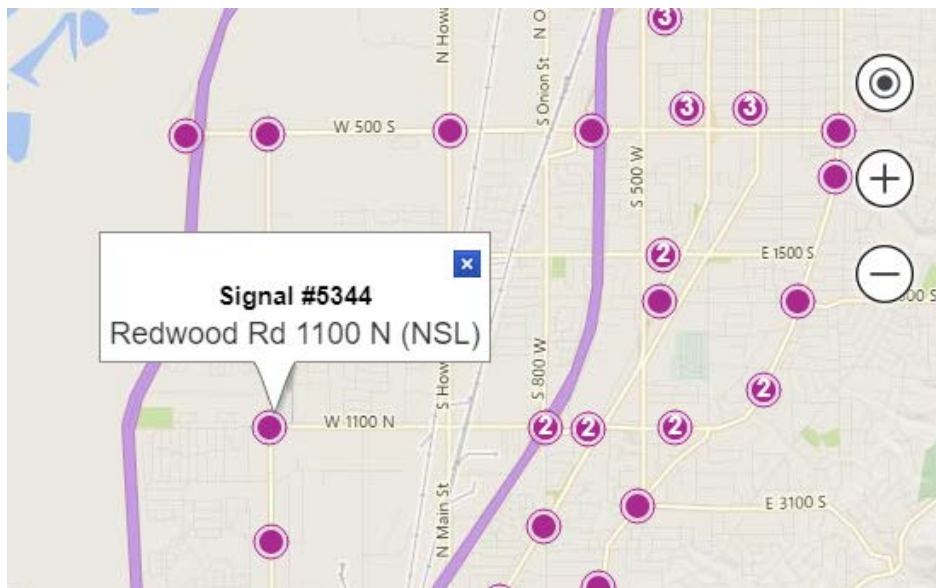


Figure 5: Signal Selected from Map

1.1.4. Chart Selection

This area is blank until a signal is selected. Once a signal is selected, the Purdue Phase Termination is displayed as the default chart and all other available metrics for the selected signal appear (see Figure 6 below). Chart Options are shown by default to the right of Chart Selection and are different for each metric.

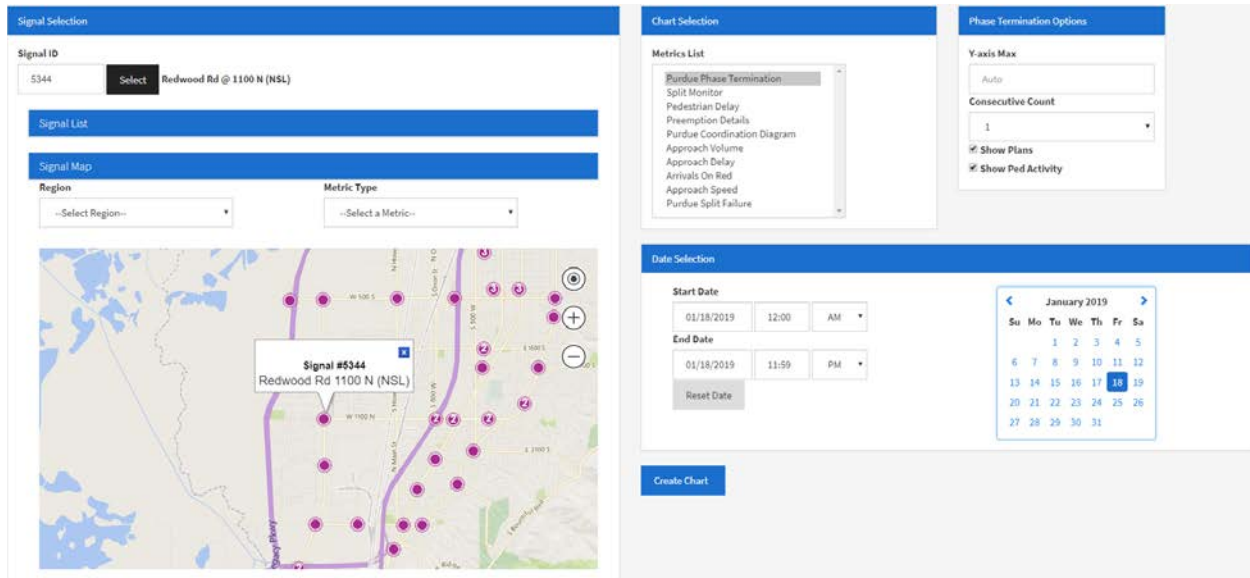


Figure 6: Chart Selection

1.1.5. Date Selection

Figure 7 shows the pane in which a time and date range may be selected for the metric. The span can be minutes, hours, days, or years. Click a day in the calendar to generate metrics for that day, or enter the desired parameters in the **Start Date** and **End Date** fields to fine-tune start and end times. Default times are from 12:00 AM to 11:59 PM within the current day. To reset to this default, click **Reset Date**.

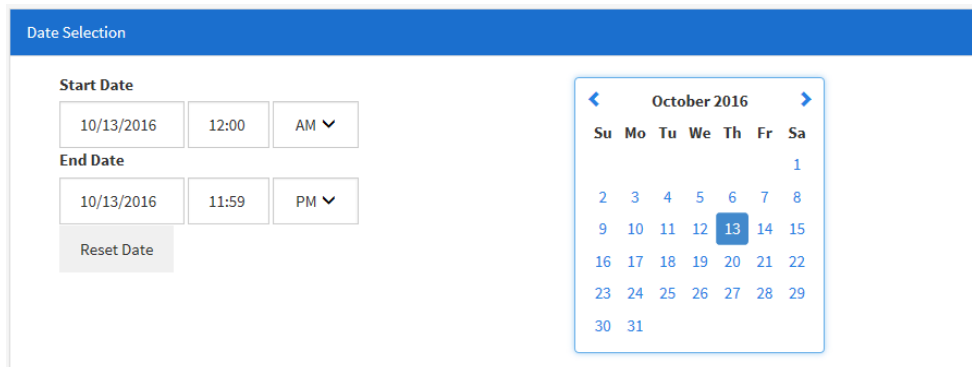


Figure 7: Date Selection

1.2. Signal Metric Types

The following is a list of Signal Metric Types.

- [Purdue Phase Termination](#)
- [Split Monitor](#)
- [Pedestrian Delay](#)
- [Preemption Details](#)
- [Turning Movement Counts](#)
- [Purdue Coordination Diagram](#)
- [Approach Volume](#)
- [Approach Delay](#)
- [Arrivals on Red](#)
- [Approach Speed](#)
- [Yellow and Red Actuations](#)
- [Purdue Split Failure](#)
- [Timing and Actuation](#)

1.2.1. Purdue Phase Termination

This metric plots the controller's phases and the reason the phase terminated. The metric plots phase terminations due to force off, gap out, or max out, and shows pedestrian actuations.

When **Purdue Phase Termination** is selected, the options shown in Figure 8 are available for generating the plot:

- **Y-axis Max:** This defaults to **Auto**, but can be changed to limit the number of phases displayed.
- **Consecutive Count:** Filters to include only points where this event type terminated the phase the specified consecutive number of times.
- **Show Plans:** Changes background color when the signal plan changes.
- **Show Ped Activity:** Displays orange dots depicting pedestrian phase actuations (note that this does not affect phase termination).

Phase Termination Options

Y-axis Max

Auto

Consecutive Count

1 ▼

Show Plans

Show Ped Activity

Figure 8: Phase Termination Options

Click **Create Chart** to generate the plot.

Figure 9 is an example plot of the **Purdue Phase Termination**, including Ped Activity and Plans.

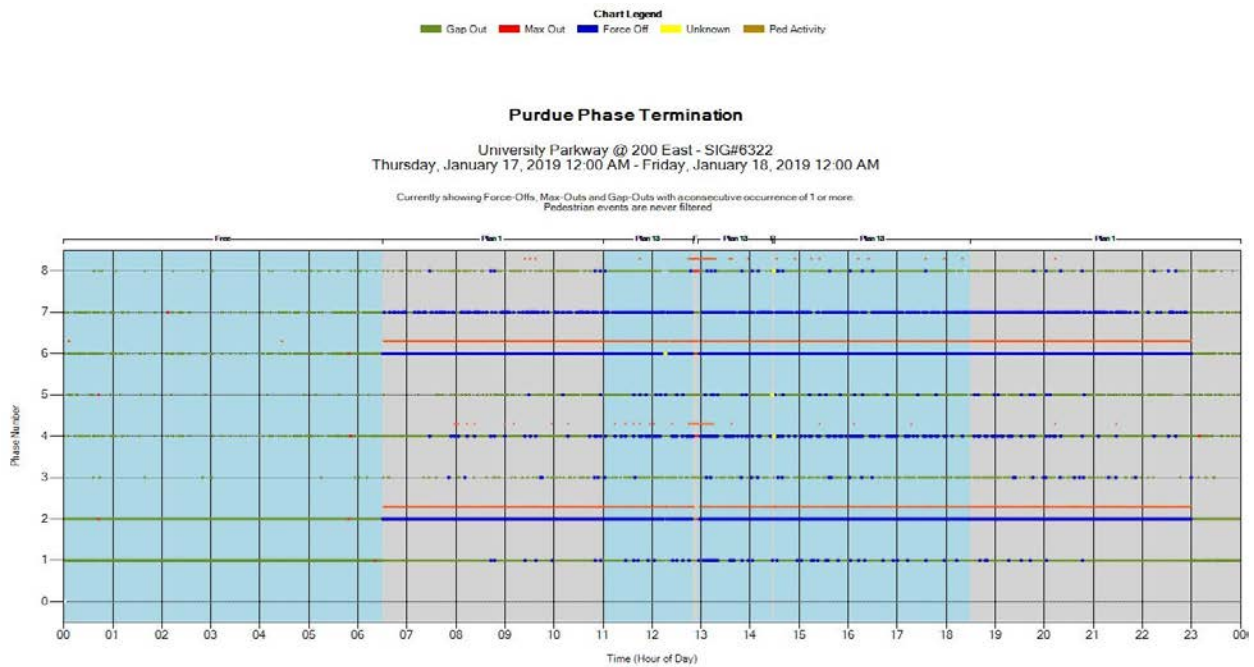


Figure 9: Purdue Phase Termination

1.2.2. Split Monitor

This metric generates separate plots for each phase on the controller. Each plot depicts the length of the phase in seconds by time of day and the reason the phase terminated.

Figure 10 shows the options available for generating the plot when the **Split Monitor** is selected.

Figure 10: Split Monitor Options

- **Y-axis Max:** Constricts all plots to the same height in seconds. Otherwise, the plots will auto-expand to the maximum height. Default value is **Auto**.
- **Percentile Split:** Includes the length of the phase at this percentile during the duration of each signal plan. The available options in the dropdown list are No Percentile Split, 50, 75, 85, 90, and 95. The default value is **85**.
- **Show Plans:** Changes background color when the signal plan changes. This must be selected for the plan data to show.
- **Show Ped Activity:** Displays orange dots depicting pedestrian phase activations.
- **Show Average Split:** Includes the average time of the phase during the duration of each signal plan.
- **Show % Max Out/Force Off:** Includes the percentage of phase terminations due to max out or force off during the duration of each signal plan.
- **Show Percent GapOuts:** Includes the percentage of phase terminations due to gap out during the duration of each signal plan.
- **Show Percent Skip:** Includes the percentage of times this phase was skipped outright due to lack of demand.

Click **Create Chart** to generate the plot.

Figure 11 shows an example Split Monitor plot with all options in their default settings. The phase termination reasons are color-coded and include force off, gap out, max out, and unknown. The split length programmed into the controller (if applicable) and pedestrian activity are also shown.

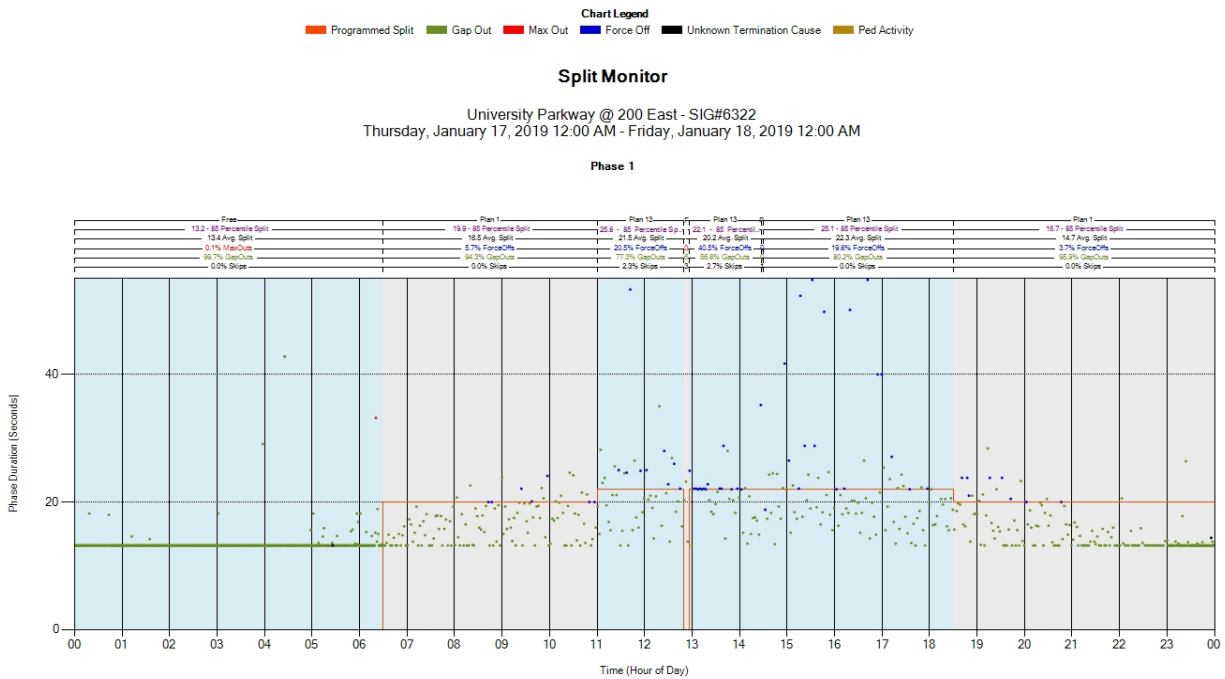


Figure 11: Split Monitor

1.2.3. Pedestrian Delay

This metric depicts the delay, in minutes, associated with each pedestrian actuation. Note that these are actual ped button actuations and will show even if the coordinated phase is programmed to cycle for the ped. As of 1/2019 this metric is not reporting correctly for Maxtime controllers.

Figure 12 shows the options available for generating a plot when **Pedestrian Delay** is selected.

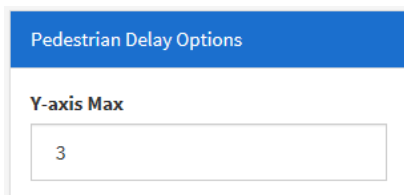


Figure 12: Pedestrian Delay Options

- Y-axis Max (Pedestrian Delay):** The maximum height in minutes of the vertical axis. The default is 3 minutes.

Click **Create Chart** to generate the plot.

Figure 13 is an example of a Pedestrian Delay plot with a default delay axis of 3 minutes. Each blue bar represents the delay associated with each pedestrian actuation. The signal plans are color-coded and the total number of actuations (PA) and average delay in mins (AD) are tallied for the duration of each plan.

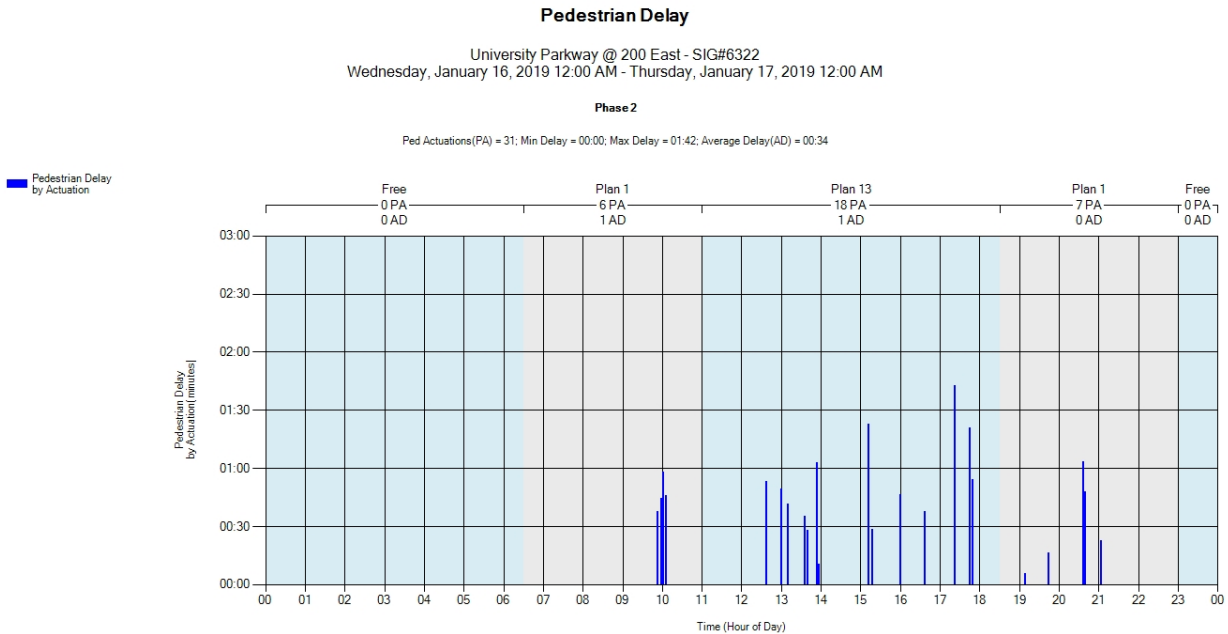


Figure 13: Pedestrian Delay

1.2.4. Preemption Details

This metric details the preemption events at the signal. This metric does not provide any options to configure the output. Click **Create Chart** to generate the plot.

Figure 14 is an example of a Preemption Details plot. Plots are generated for each preempt configured in the controller.

- The first plot depicts when preempt requests were received.
- The second plot depicts when preempts were serviced.
- The third plot shows details from the preempt events with seconds on the vertical axis. Gate Down, Input Off, Input On, Call Max Out, Dwell time, Track Clear, Time to Service, and Delay are plotted for each event.

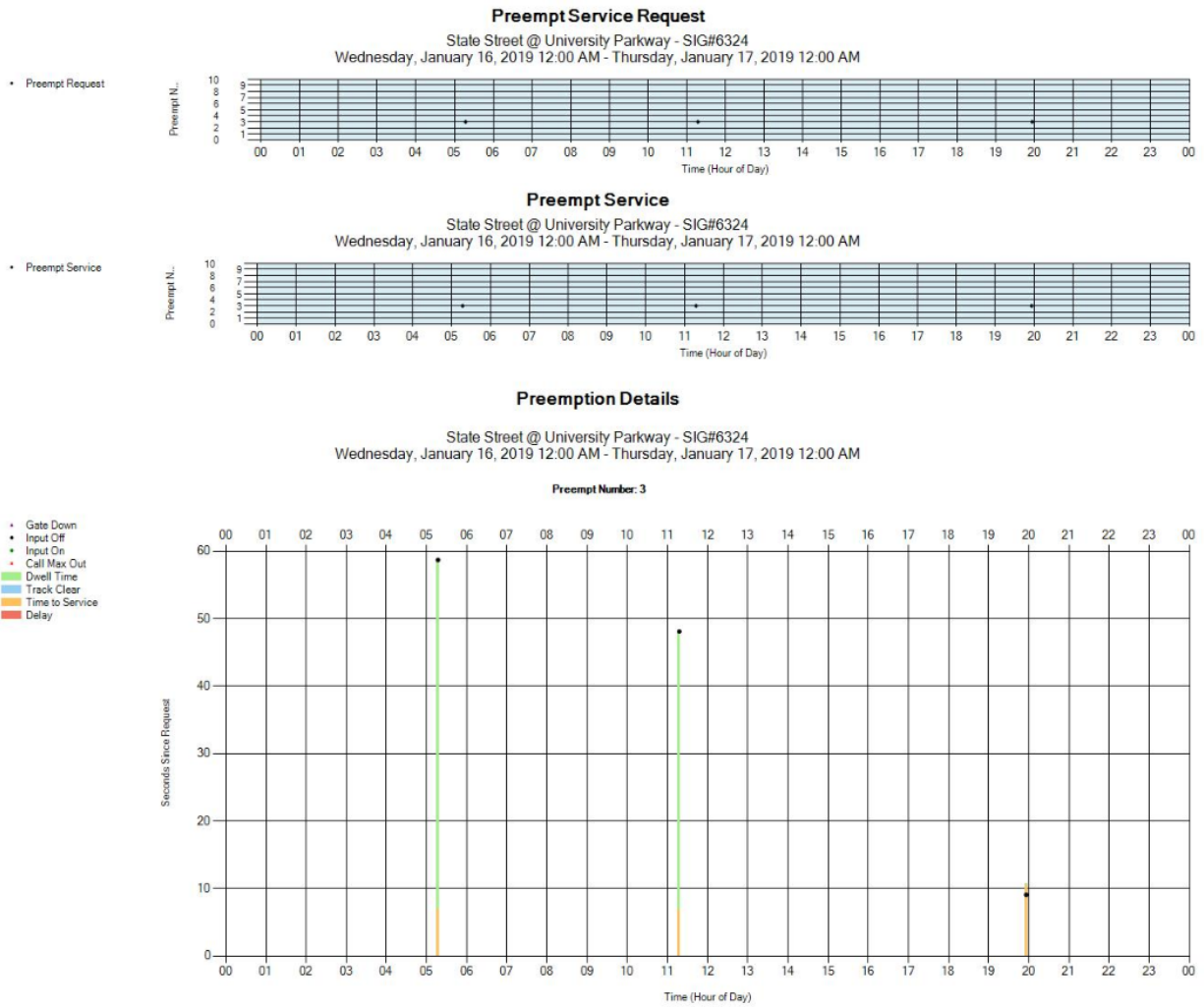


Figure 14: Preemption Details Turning Movement Counts

This metric shows counts for each movement at each approach of an intersection (ie. Left, Thru, Right).

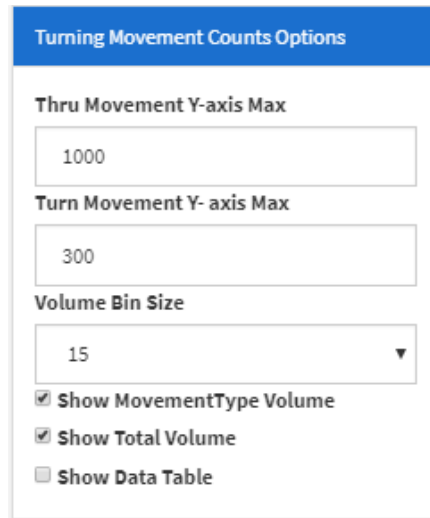


Figure 15: Turning Movement Counts Options

- **Thru Movement Y-axis Max:** This is the maximum hourly volume that can be displayed on the Y-axis of through lane charts.
- **Turn Movement Y-axis Max:** This is the maximum hourly volume that can be displayed on the Y-axis of turning lane charts.
- **Volume Bin Size:** This is the resolution of the hourly volume measurement. Sizes of 5 and 15 minutes are available with 15 as the default value.
- **Show Movement Type Volume:** This displays volumes by individual lane in the chart (ie. Two left turns are shown individually as Lane 1 and Lane 2).
- **Show Total Volume:** This is the sum of all movement type volume

Click **Create Chart** to generate the plot.

Figure 16 is a Turning Movement Count plot with volumes shown in vehicles per hour. Labels and shading denote different signal plans. The following information is included at the top of the plot:

- Total volume within the selected time period.
- Peak hour within the selected time period.
- Peak Hour Volume within the selected time period
- Peak Hour Factor (PHF) within the selected time period.
- Lane utilization adjustment factor (fLU) within the selected time period.

To obtain these calculations for a specific time period, adjust the Start Date and End Date accordingly and the data will update upon chart creation.

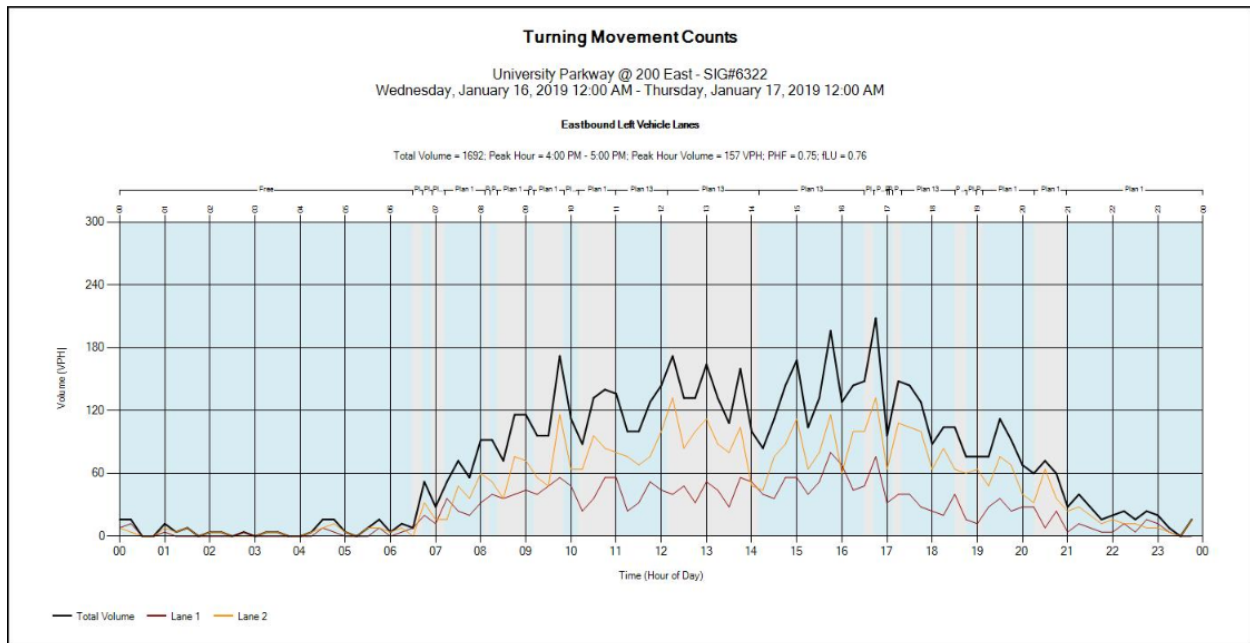


Figure 16: Turning Movement Counts

1.2.5. Purdue Coordination Diagram

The Purdue Coordinate Diagram is a powerful spatial metric. It plots vehicle arrivals against the current movement (green, yellow, red) and traffic flow in vehicles / hour.

Figure 17 shows the options available to generate a plot when the **Purdue Coordination Diagram** is selected.

Purdue Coordination Diagram Options

Y-axis Max

Secondary Y-axis Max

Volume Bin Size

Line Size

Dot Size

Show Plans

Show Volumes

Figure 17: Purdue Coordination Diagram Options

- **Y-axis Max:** The maximum cycle length in seconds (Left Axis)
- **Secondary Y-axis Max:** The maximum volume in VPH (Right Axis)
- **Volume Bin Size:** The resolution of the hourly volume measurement. Sizes of 5 and 15 minutes are available and 15 is the default value.
- **Line Size:** Size of the lines on the chart (Volume, Y/R/G Changes)
- **Dot Size:** The size of black dots depicting vehicle arrivals (detector activations).
- **Show Plans:** Delineates signal plans on the horizontal axis above the plot. Includes measurements for percentage of vehicles arriving on green, percentage green time, and platoon ratio.
- **Show Volumes:** Displays vehicle flow rate (vehicles per hour) on the plot.

Click **Create Chart** to generate the plot.

Figure 18 is what a typical Purdue Coordination Diagram for an entire day will look like. Figure 19 is zoomed in to show details of the PCD.

Each slanted stripe of black dots represents vehicle arrivals during one signal cycle. Starting at the X-axis, the cycle is in red, then switches to green (shown by the green plotline). After the yellow and red intervals, the next cycle restarts at the X-axis. By these means, the degree of vehicle platooning is visualized. The percentage of vehicles arriving on green and the percentage of green time in the cycle is displayed for each signal plan. The platoon ratio is also calculated.

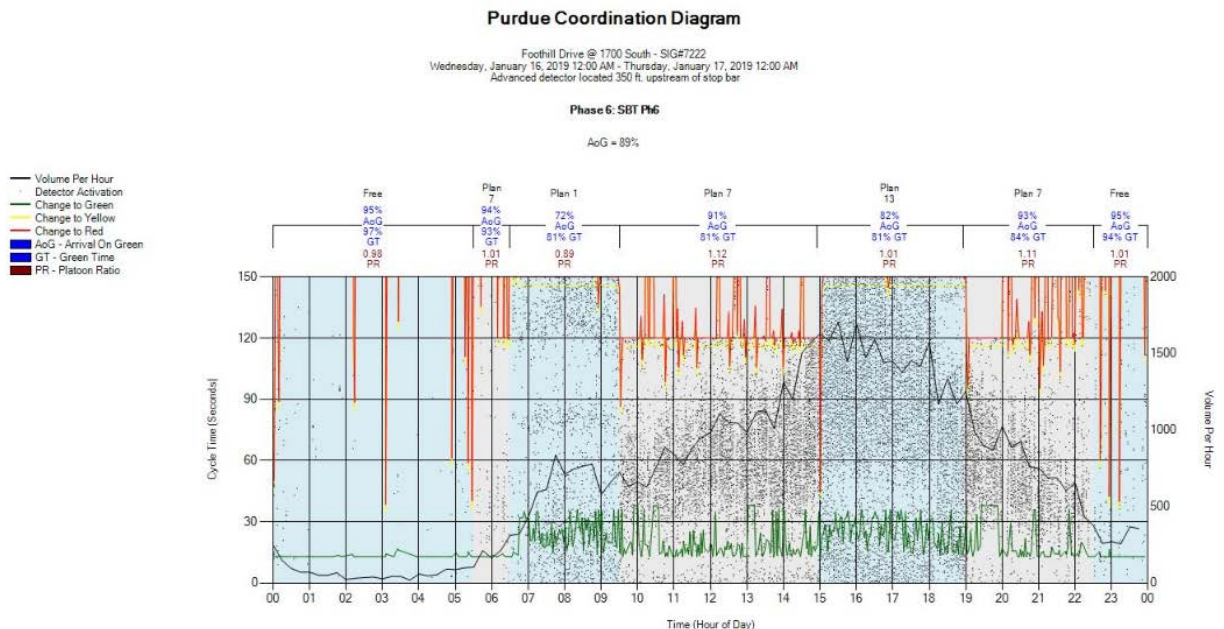


Figure 18: Purdue Coordination Diagram

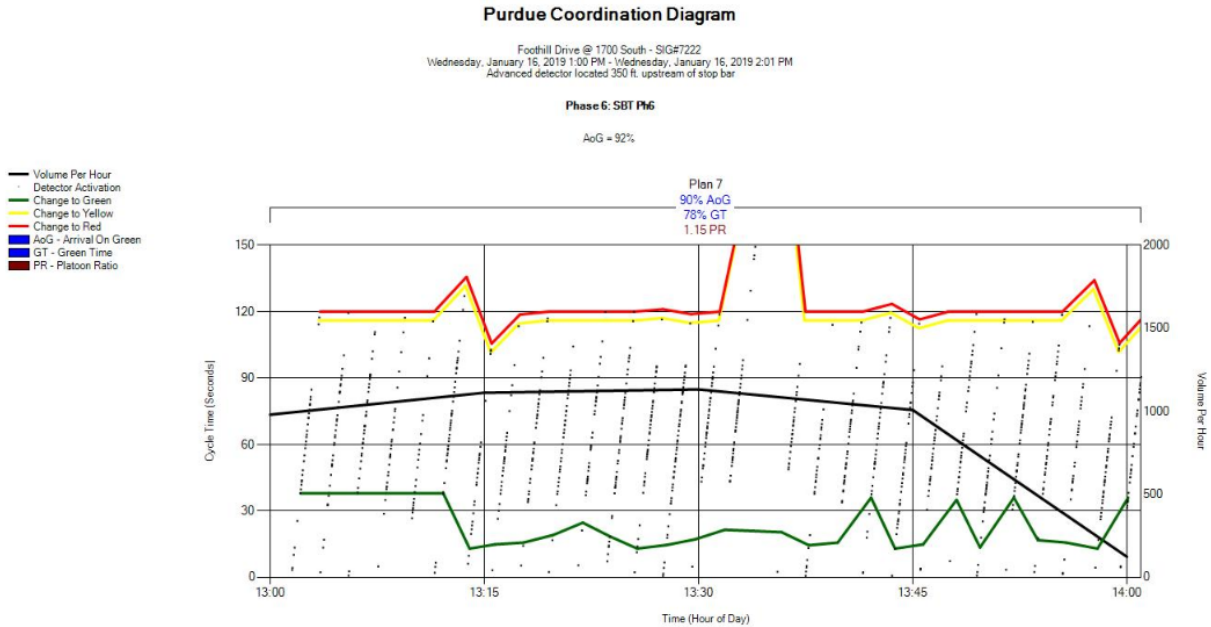


Figure 19: PCD Zoomed for Detail

1.2.6. Approach Volume

This metric plots traffic approaching an intersection with advanced analysis comparing opposing directions, detector sites, and more.

Figure 20 shows the options available for generating a plot when the Approach Volume is selected.

Approach Volume Options

Y-axis Min

Y-axis Max

Volume Bin Size

15
▼

Show Directional Splits

Show Total Volume

Show SB/EB Volume

Show NB/WB Volume

Show TMC Detection

Show Advance Detection

Figure 20: Approach Volume Options

- **Y-axis Min:** Constrains the minimum extent of the Y-axis to this value.
- **Y-axis Max:** Constrains the maximum extent of the Y-axis to this value.

- **Volume Bin Size:** Shows the resolution of the hourly volume measurement. Sizes of 5 and 15 minutes are available and 15 is the default value.
- **Show Directional Splits:** Displays dotted lines of D factors comparing each direction of traffic to the total. Default is not selected.
- **Show Total Volume:** Displays an additional line showing the sum of both directions. Default is not selected.
- **Show SB/EB Volume:** Displays the southbound and eastbound volumes.
- **Show NB/WB Volume:** Displays the northbound and westbound volumes.
- **Show TMC Detection:** Displays the data for Turning Movement Count detection at the stop bar.
- **Show Advance Detection:** Displays the plots for advance detectors, placed approximately 400 feet ahead of the stop bar.

Click **Create Chart** to generate the plot.

Figure 21 is an example Approach Volume plot of northbound (blue) and southbound (red) movements. Both Advanced and Stop Bar detections are plotted in volume per hour (VPH) as referenced on the primary Y-axis. Directional Splits (D Factors) are depicted with a dotted line in percent as referenced on the secondary Y-axis.

The tables to the right of each plot display total volume, peak hour, peak hour volume, peak hour factor, and peak hour K factor for the analysis period. These metrics are also available for the northbound and southbound movements along with the D Factor for the peak hour.

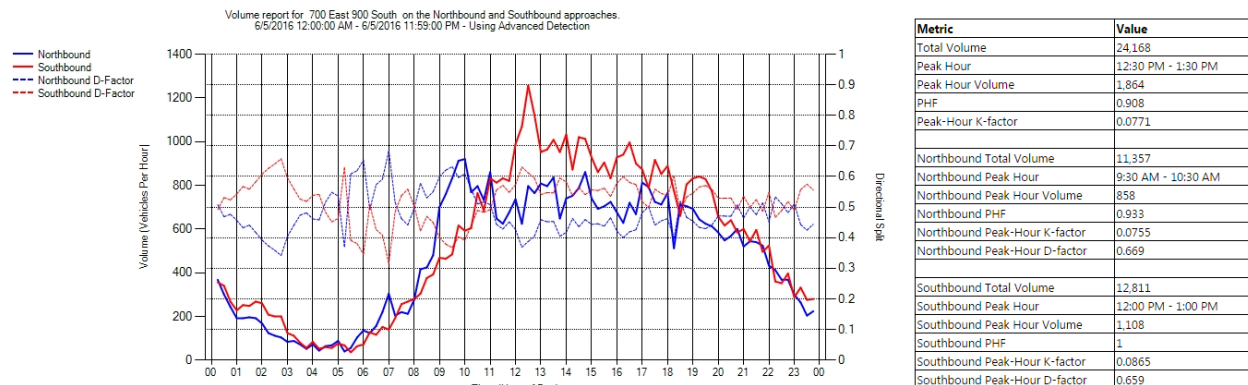


Figure 21: Approach Volume

1.2.7. Approach Delay

This metric plots a simplified approach delay experienced by vehicles approaching and entering the intersection. The delay per vehicle and total delay are both available.

Figure 22 shows options available for generating a plot when the **Approach Delay** is selected.

Approach Delay Options

Y-axis Max

Secondary Y-axis Max

Volume Bin Size

Show Plans

Show Total Delay Per Hour

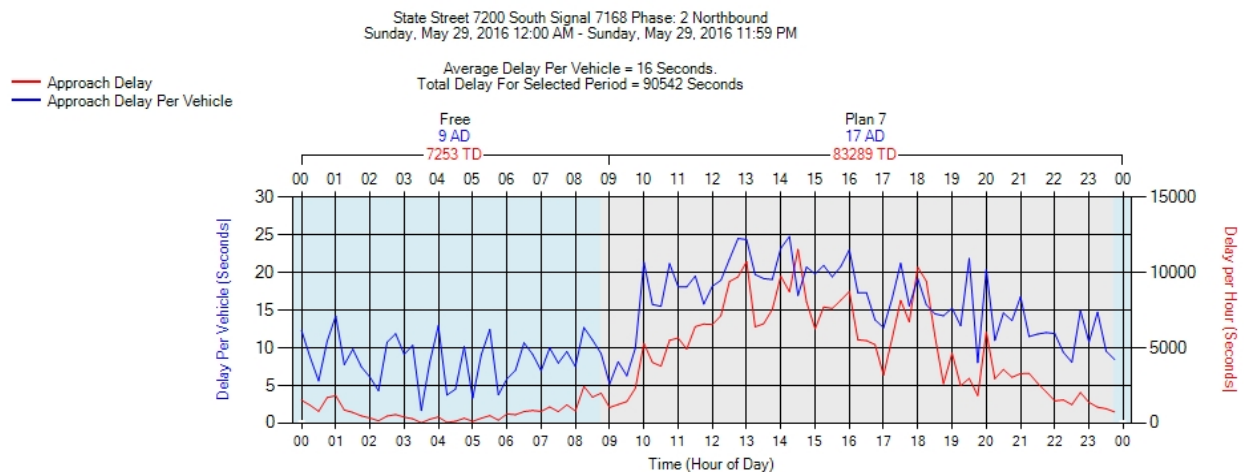
Show Delay Per Vehicle

Figure 22: Approach Delay Options

- **Y-axis Max (Delay Per Vehicle):** The maximum Y-axis extent for Delay Per Vehicle, depicted with a blue plotline. This is the left Y-axis.
- **Secondary Y-axis Max (Total Delay Per Hour):** The maximum Y-axis extent for Delay Per Hour, depicted with a red plotline. This is the right Y-axis.
- **Volume Bin Size:** The resolution of the hourly volume measurement. Sizes of 5 and 15 minutes are available and 15 is the default value.
- **Show Plan Statistics:** Located above the plot; displays average delay and total delay for each signal plan.
- **Show Total Delay Per Hour:** Toggles the Total Delay per Hour plotline (red).
- **Show Delay Per Vehicle:** Toggles the Delay per Vehicle plotline (blue).

Click **Create Chart** to generate the plot.

Figure 23 is a sample Approach Delay plot.



Simplified Approach Delay. Displays time between detector activation during the red phase and when the phase turns green. Does NOT account for start up delay, deceleration, or queue length that exceeds the detection zone.

Figure 23: Approach Delay

1.2.8. Arrivals on Red

This metric plots both the volume and percentage of vehicles arriving on red for available phases.

Figure 24 shows options available for generating the plot when the **Arrivals on Red** is selected.

Arrivals on Red Options

Y-axis Max

Auto

Volume Bin Size

15

Show Plans

Figure 24: Arrivals on Red Options

- **Y-axis Max:** The maximum extent of the Y-axis in vehicles per hour. This defaults to Auto.
- **Volume Bin Size:** The resolution of the hourly volume measurement. Sizes of 5 and 15 minutes are available and 15 is the default value.
- **Show Plans:** For each signal plan, displays the overall percentage of vehicles arriving on red (AoR), and the percentage of signal cycle in red (RT).

Click **Create Chart** to generate the plot.

Figure 25 is a sample Arrivals on Red plot with default options selected. The dotted red line depicts arrivals on red and the dotted black line depicts total arrivals (both vehicles/hour). The solid red line depicts overall percentage of vehicles arriving on red. At the top of the plot, the Total Detector Hits, Total AoR (arrivals on red), and Percent AoR for the analysis period are shown.

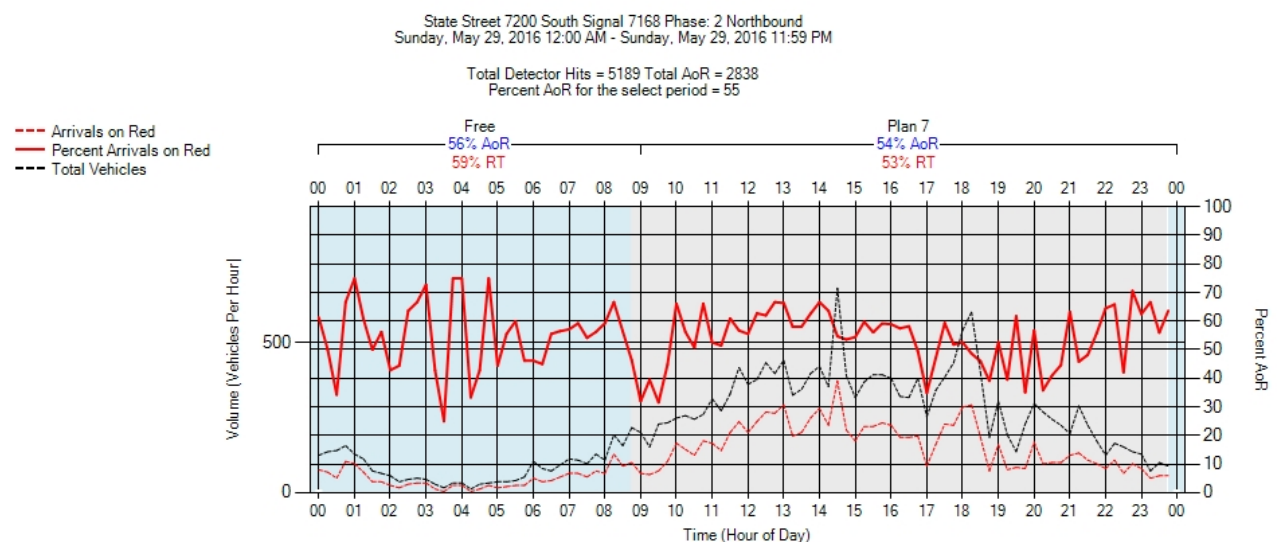


Figure 25: Arrivals on Red

1.2.9. Approach Speed

This metric tracks the speed of vehicles approaching a signalized intersection. Phases where this data are available will be plotted. This metric requires detection set back from the stop bar that can detect speed; currently the only supported product is the Wavetronix SmartSensor™ Advance.

Figure 26 shows the options available for generating the plot when the **Approach Speed** is selected.

Figure 26: Approach Speed Options

- **Y-axis Min:** Defines a minimum speed extent on the Y-axis.
- **Y-axis Max:** Defines a maximum speed extent on the Y-axis.
- **Volume Bin Size:** Displays the resolution of the hourly volume measurement. Sizes of 5 and 15 minutes are available and 15 is the default value.
- **Show Plans:** Displays header information above the plot detailing the signal plan, average 85% speed, average overall speed, and the standard deviation within the speed measurement. This option toggles background shading that denotes different signal plans.
- **Show Average Speed:** Displays the plot for average speed of approaching vehicles.
- **Show Posted Speed:** Displays a horizontal line for the posted speed limit.
- **Show 85% Speed:** Displays the plot for the 85th percentile speed of approaching vehicles.

Click **Create Chart** to generate the plot.

Figure 27 is an example of Approach Speed plots. The average speed (red) and 85th percentile speeds (blue) are plotted against the posted 55 miles per hour speed limit (green). Plan statistic headers are included above the plot showing the 85th percentile speed, average speed, and standard deviation of speed for the single signal plan within the analysis period.

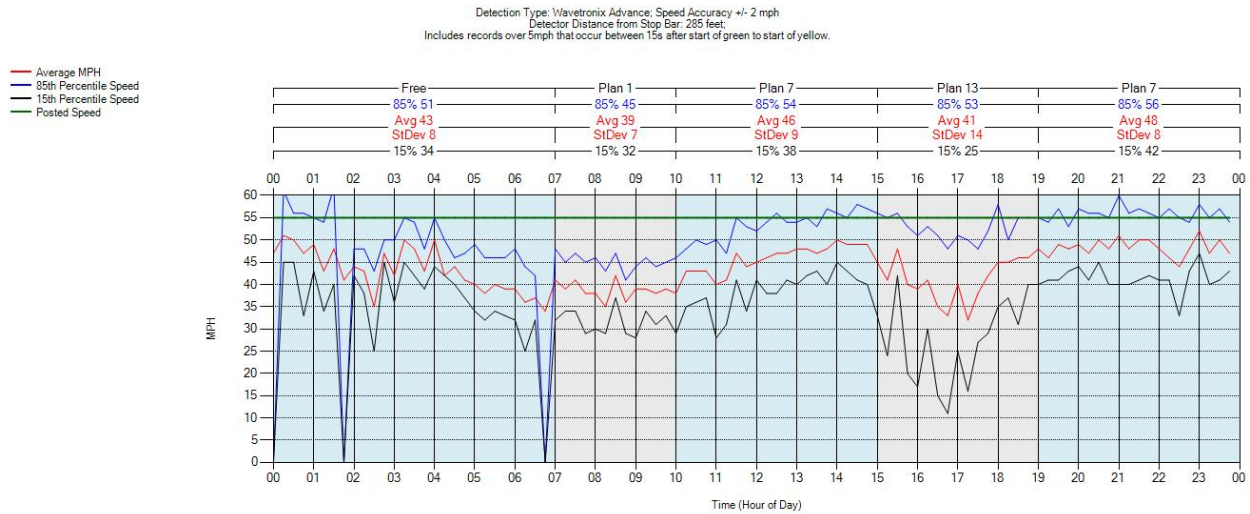


Figure 27: Approach Speed

1.2.10. Yellow and Red Actuations

This metric plots vehicle arrivals during the yellow and red portions of an intersection’s movements where the speed of the vehicle is interpreted to be too fast to stop before entering the intersection. It provides users with a visual indication of occurrences, violations, and several related statistics. The purpose of this chart is to identify engineering countermeasures to deal with red light running.

Figure 28 shows the options available for generating the plot for **Yellow and Red Actuations**

Yellow and Red Actuations

Y-axis Max

Severe Red Light Violations

Red Light Violations

Severe Red Light Violations

Percent Red Light Violations

Percent Severe Red Light Violations

Average Time Red Light Violations

Yellow Light Occurrences

Percent Yellow Light Occurrences

Average Time Yellow Occurrences

Figure 28: Yellow and Red Actuations Options

- **Y-axis Max:** Maximum vertical extent of the Y-axis in seconds. The default is 15 seconds, which would extend about 10 seconds into the Red time.
- **Severe Red Light Violations (entry field):** Records the number of seconds for a vehicle to pass through the intersection relative to the start of the red clearance. The default value is 4 (estimated from the average summation of red clearance time plus start-up loss time).

- **Red Light Violations:** For the duration of each signal plan, displays the total number of red light violations (vehicles passing through red clearance or red). Abbreviated “RLV” in the plot.
- **Severe Red Light Violations (checkbox):** Displays the total of severe red light violations for the duration of each signal plan as configured using the Severe Red Light Violations entry field. Abbreviated “SRLV” in the plot.
- **Percent Red Light Violations:** Displays the percentage of RLVs for the duration of each signal plan relative to total flow. Abbreviated “%RLV” in the plot.
- **Percent Severe Red Light Violations:** Displays the percentage of red light violations for the duration of each signal plan relative to total flow. Abbreviated “%SRLV” in the plot.
- **Average Time Red Light Violations:** Displays the average time in seconds that a violation occurs (relative to the start the cycle) for the duration of each signal plan. Abbreviated “TRLV” in the plot
- **Yellow Light Occurrences:** Display the total number of vehicles passing through the yellow light for the duration of each signal plan. Abbreviated “#YLO” in the plot.
- **Percent Yellow Light Occurrences:** Displays the percentage of yellow light vehicles relative to total flow for the duration of each signal plan. Abbreviated “%YLO” in the plot.
- **Average Time Yellow Occurrences:** Displays the average time in seconds that a vehicle passes through yellow (relative to the start of the yellow) for the duration of each signal plan. Abbreviated “TYLO” in the plot.

Click **Create Chart** to generate the plot.

Figure 29 is a sample Yellow and Red Actuations plot. The **Y-axis Max** is set to 15 seconds and the **Severe Red Light Violations** cutoff is set to 4.0 seconds. All the checkboxes described above are selected and populate information for each signal plan.

For the entire analysis period (in this sample, 4:00 PM to 7:00 PM), the following additional statistics are available at the top of the chart:

- **Total Violations:** Over the entire analysis period, the percentage of red light violations relative to total flow reported in count and percent.
- **Severe Violations:** Over the entire analysis period, the percentage of severe red light violations relative to total flow reported in count and percent.
- **Yellow Light Occurrences:** Over the entire analysis period, the percentage of yellow light violations relative to total flow reported in count and percent.

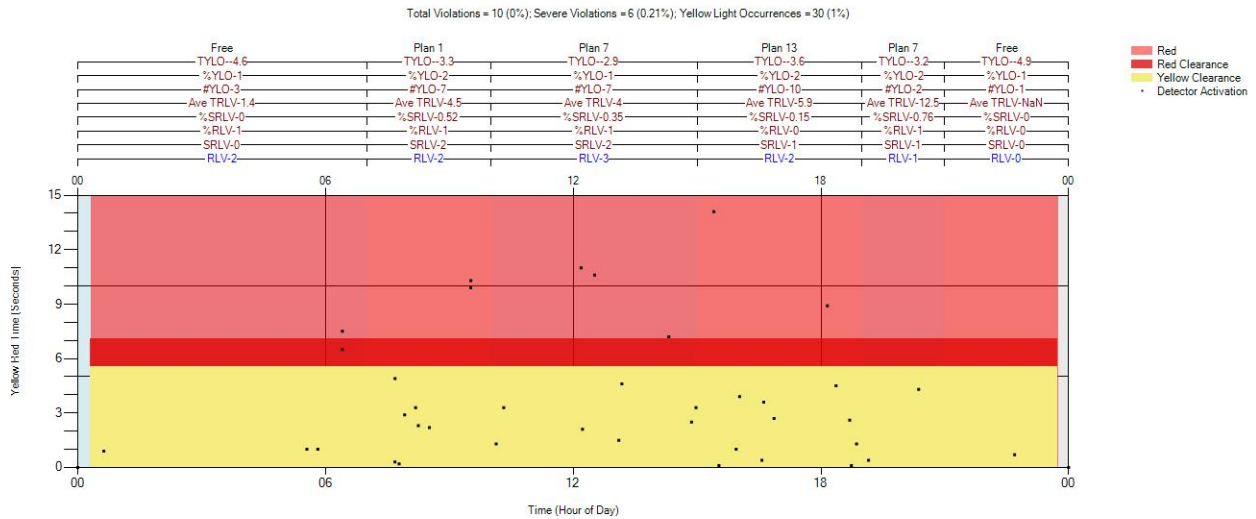


Figure 29: Yellow and Red Actuations

1.2.11. Purdue Split Failure

Purdue Split Failure relies on stop bar presence detection, either by lane group or lane-by-lane. This metric calculates the percent of time that stop bar detectors are occupied during the green phase and then during the first five seconds of red. These values are the green occupancy ratio (GOR) and red occupancy ratio (ROR).

Plots will be generated for each phase supporting the metric. The GOR and ROR are calculated and plotted when both gap out and force off occur. When the occupancy ratios both exceed 80 percent, that phase is considered a split failure in the cycle.

Figure 30 shows the options available for generating the plot when the Purdue Split Failure is selected.

Purdue Split Fail Options

First Seconds Of Red

5

Show Fail Lines

Show Average Lines

Show Percent Fail Lines

Figure 30: Purdue Split Fail Options

- **First Seconds of Red:** The number of seconds into red for calculating the ROR. Default is 5 (from Purdue research).
- **Show Fail Lines:** Displays yellow vertical lines to indicate split failure.
- **Show Average Lines:** Displays the mean GOR and ROR over 15-minute increments.
- **Show Percent Fail Lines:** Displays the percentage of cycles experiencing split failure, averaged over 15 minute increments. By default, this is not selected.

Click **Create Chart** to generate the plot.

Figure 31 is an example Purdue Split Failure diagram, shown for both southbound through and eastbound turn phases. Gap outs and force offs are both depicted. Further, for the duration of each signal plan the total number and percentage of cycles with split failures are both calculated. Finally, the total number of split fails for the analysis period is reported in the top header.

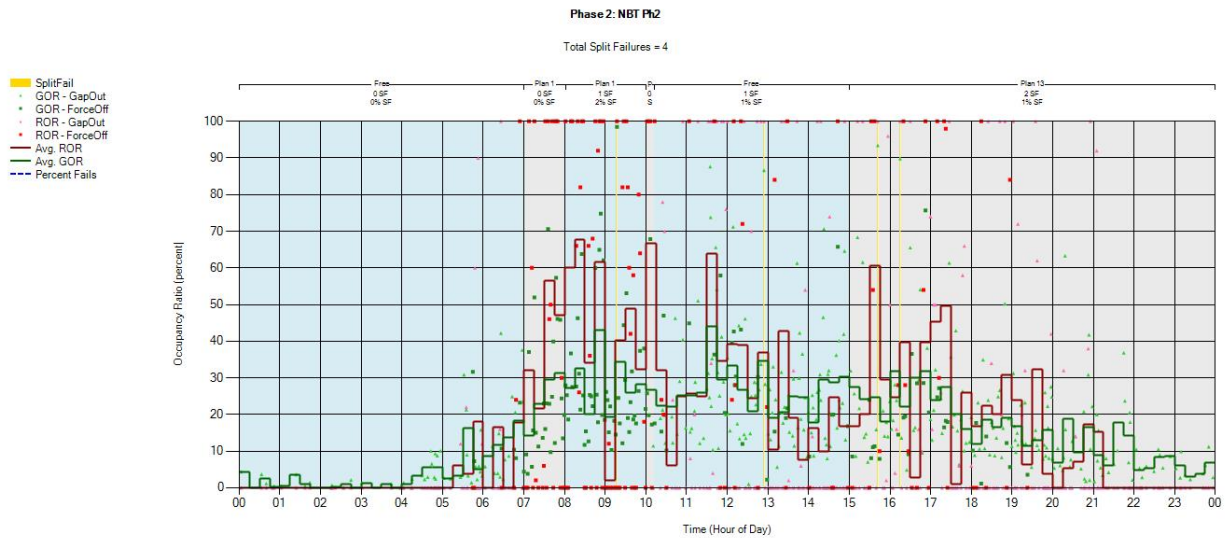


Figure 31: Purdue Split Failure

1.2.12. Timing and Actuation

This metric generates separate plots for each phase on the controller. Each plot depicts a detailed view of the vehicle and pedestrian cycles for each phase overlaid with detection actuations. In addition, this metric allows for custom enumeration codes to be plotted for further analysis. This metric is most useful for mesoscopic level (≈ 60 minutes) of detail. Since mesoscopic level of analysis will most likely be used with this metric, the algorithm will look back a user specified period of time (5.0 minutes default) for cycle (green, yellow, red) data behind the specified start time. If no enumerations are found, it will show white or gray. The time frame can be increased to find the last time the phase came on so the proper colors will show, however, increasing the time will cause the program to run longer. In addition, the algorithm will look both behind and in front of the specified start and end time for detector enumerations (2.0 minutes default).

Figure 32 shows the options available for generating the plot when **Timing and Actuation** is selected.

Figure 32: Timing and Actuation Options

Timing and Actuation Options

- **Legend:** Displays the legend for the Timing and Actuation metric, shows the colors used with a description and event code. By default, this is unchecked.
- **Header For Each Phase:** If checked, a header displaying the name of the metric with the address, signal ID #, time and date range will display on top of each phase. By default, this is unchecked.
- **Combine Lanes for Phase:** This will combine the detector events for each lane category together into one event per category.
- **Dot and Marker Size:** The size of black lines, triangles and gray squares depicting detector activations (Default is 6)
- **Phase Filter:** Allows to select a phase or phases by using comma and/or dash.

Phase & Global Custom Codes

- **Phase Event Codes:** Will display phase event code enumerations under each phase.
- **Global Event Codes:** Will display event code enumerations on a separate chart.
- **Global Event Params:** Will display event code parameters on the chart with the global event codes.

Chart Options

- **All Lane for Each Phase:** This will display all lane detection events that are configured in the Configuration Setup, regardless if data exists for the detectors during the time of analysis. If this is unchecked, then only the lanes will appear under each phase that has actuations during the analysis period.
- **On/Off Lines:** Displays a line connecting detector on (Code 82) to detector off (code 81) for added clarity.
- **Event Start Stop Pairs:** If checked, this will only show detectors where an 82 (detector on) and 81 (detector off) code pair is found for each detector event. Otherwise, the actuation is not displayed. By default, this is off.
- **Raw Data Display:** If checked, this will ignore the ATSPM configuration setup of “Phase/Direction” (and all of the detectors) and display each phase and overlap data where data exists in the raw data files. The program will search the raw data for phases 1-16 and overlaps 1-16 and display data for the vehicle and pedestrian signal display and will look back 6 minutes for enumerations. Since vehicle detectors have to be mapped in the configuration setup, vehicle actuation data will not be shown. By default, this is unchecked.

Vehicle Signal Display Options

- **Extend Search (left) Minutes.decimal:** The value will look back a user specified period of time (5.0 minutes default) for cycle (green, yellow, red) & pedestrian (walk, flashing don’t walk, solid don’t walk) data behind the specified start time. If no enumerations are found, it will show white or gray for the vehicle signal display and the pedestrian intervals. The time frame can be increased to find the last time the phase came on so the proper colors will show, however, increasing the time will cause the program to run longer.
- **Vehicle Signal Display:** Displays the minimum green (dark green), green (light green), yellow (yellow), red clearance (dark red), red (light red) vehicle and overlap signal indications.
- **Pedestrian Intervals:** Displays the walk (blue), pedestrian clearance (light blue) and don’t walk (gray) intervals.
- **Extend Start/Stop Search Minutes.decimal:** The value will look back and forward a user specified period of time (2.0 minutes default) for vehicle and pedestrian detection actuations.**Pedestrian Actuators:** Displays the pedestrian actuators (on & off) each time the pushbutton is activated.**Stop Bar Presence:** Displays the Stop bar Presence actuators as mapped in the Signal Configuration.
- **Lane-by-lane count:** Displays the lane-by-lane count actuators as mapped in the Signal Configuration.
- **Advanced Presence:** Displays the Advanced Presence actuators as mapped in the Signal Configuration.
- **Advanced Count:** Displays the Advanced Count actuators as mapped in the Signal Configuration. Since advanced count actuators are in advance of the stop bar, this feature was added if it was desired to offset the actuators to compare stop bar actuators.
- **__ Advd Count Offset:** In seconds (carried out to as many decimals as desired) will time offset the Advanced Count actuators for each phase as mapped in the Signal configuration. If any amount of time is entered in here (other than zero), on the graphs, the triangle will be purple.

Click **Create Chart** to generate the plot.

Figure 33 shows an example Timing and Actuation plot with all options in their default settings. The vehicle signal display colors (green, yellow, red) are shown in the background with the pedestrian intervals and detection actuations. The program will look back 6 minutes from the start time for vehicle signal timing data to graph, if it can't find any data within 6 minutes, it looks back 60 minutes and then 24 hours. For pedestrian intervals, it only looks back 6 minutes from the start time for data.

The x-axis time scale will dynamically adjust, depending on the time frame being analyzed. The x-axis time scales from start time to end time are as follows:

- 1 hour: >2 hours
- 5 minute: 2 hours > 1 hour
- 2 minute: 1 hour > 10 minutes
- 30 seconds: 10 minutes > 5 minutes
- 15 seconds: 5 minutes > 3 minutes
- 3 seconds: 3 minutes > 1 minute
- 2 seconds: 1 minute or less

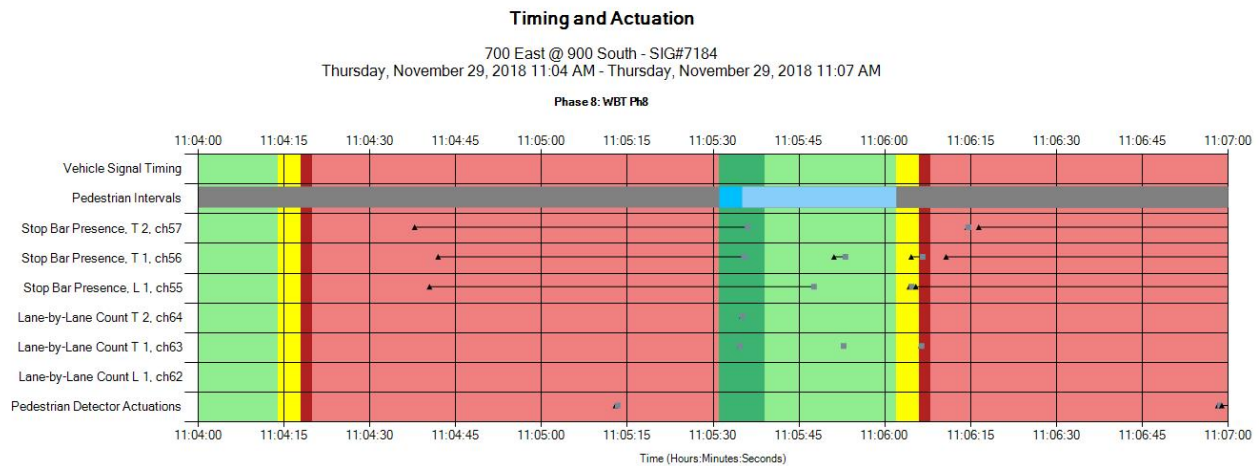


Figure 33: Timing and Actuation

The Timing and Actuation metric has a legend that can be toggled on and off (by default it is off) that if turned on, resides at the very bottom of the charts. The legend defines the colors and symbols used, as well as the enumeration event code and brief description. See Figure 34 below.

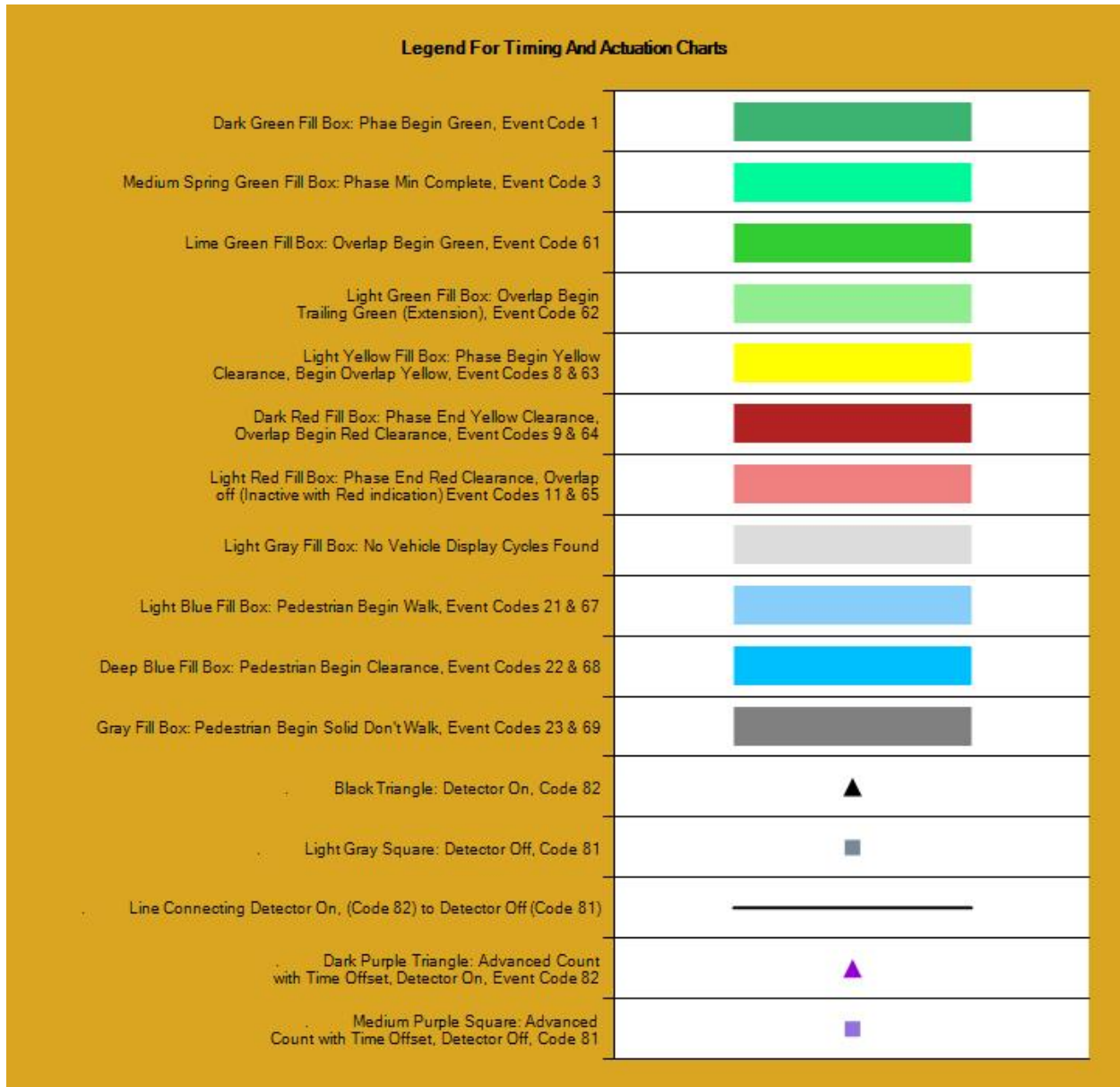


Figure 34: Legend for Timing and Actuation Charts

1.2.13. Left Turn Gap Analysis

This metric is used to evaluate available gaps in opposing traffic for a left turn to make a permissive movement. The metric looks at opposing through detector actuations, relative to the left turn under evaluation, to provide insight to the availability of permissive left turn movements. There are two components to this metric: bar graphs in user defined bins that count the number of opposing through gaps by their duration; and a representation of a percent of green time where available gaps are over a user defined threshold. The Left Turn Gap Analysis report will only appear in the available metrics list if an intersection has lane-by-lane count or stop bar presence detection on an approach. For each

approach, the report will use lane-by-lane detection over stop bar presence if that’s an option. Lastly, the report will say in the title which detection type was used for the calculations.

The gap analysis has four gap groups with a secondary Y-axis trend line gap threshold that can be adjusted as needed. The user defined gap groups are:

- Gap 1 Range: Red (Default: 1.0 to 3.3 seconds)
- Gap 2 Range: Light green (Default: 3.3 to 3.7 seconds)
- Gap 3 Range: Dark green (Default: 3.7 to 7.4 seconds)
- Gap 4 Range: Turquoise (Default: >7.4 seconds)
- Trend Line Gap Threshold (secondary Y-axis) (Default: >7.4 seconds)

The gap values were determined based off of the UDOT research report titled, “An Analysis Of Decision Boundaries For Left-Turn Treatments”, Report No. UT-19.05 Submitted by Brigham Young University to UDOT, April 2019 (<https://www.udot.utah.gov/main/uconowner.gf?n=7287874107559585>).

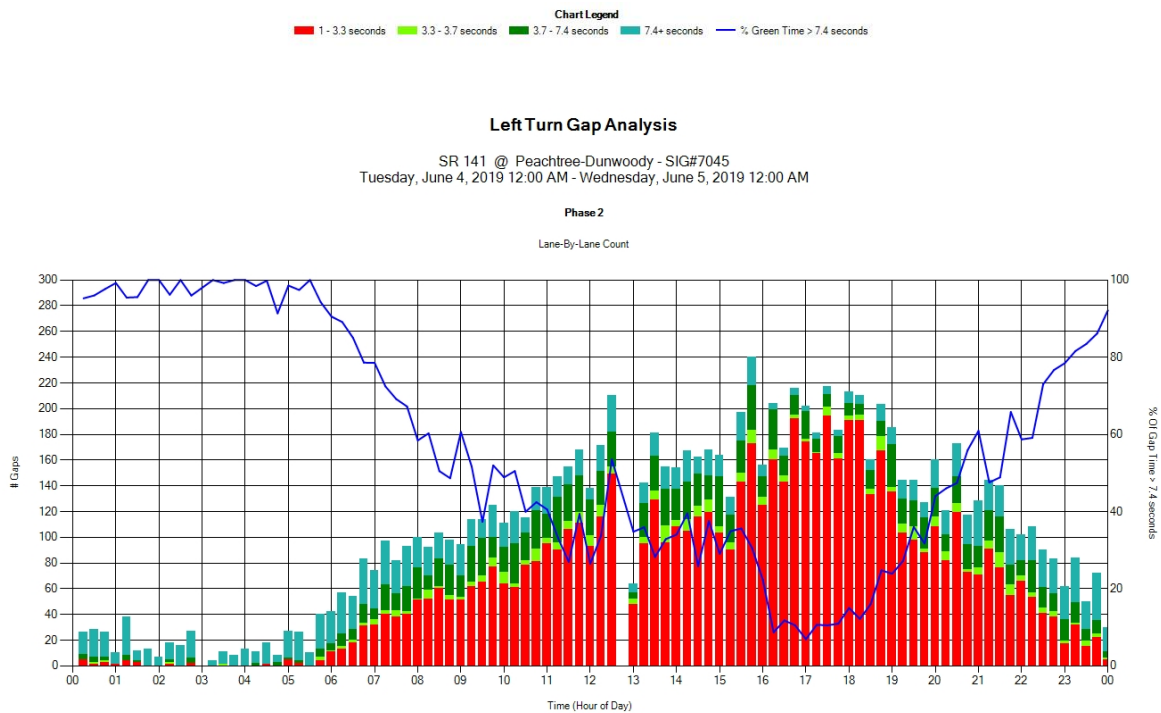


Figure 35: Left Turn Gap Analysis

1.3. Purdue Link Pivot

The Purdue Link Pivot tool generates recommended offsets for coordinated operation along a pre-defined route of consecutive signals with Purdue Coordination Diagrams configured along the route.

Selecting **Measures > Purdue Link Pivot** displays the Purdue Link Pivot Analysis page, which includes a selectable drop down list to choose the **Route**. After selecting the desired route, clicking **Signals** expands the list to display the signals within the route (see Figure 35) after which the desired metric options (see Figure 36) can be selected. These metric options are:

- **Cycle Length** MUST be match the actual Cycle Length and limits the recommended delta.
- **Start Date** selects the beginning of the metric date.
- **End Date** selects the ending of the metric date.
- **Start Time** selects the beginning of the metric time.
- **End Time** selects the ending of the metric time.

Additional options are available by clicking on **Advanced**. These options are:

- **Days to Include** (via checkbox): Default is weekdays selected and weekends not selected.
- **Starting Point** (end signal): Choices are Upstream and Downstream; default is Downstream.
- **Bias** (in percentage): Adding bias will add a multiplier to the **Bias Direction** in the **Max Arrivals On Green By Second** chart, thereby adding weight to that direction for calculating the recommended delta.
- **Bias Direction**: Chooses the selected (Upstream or Downstream) direction to add the multiplier to.

The screenshot shows the 'Purdue Link Pivot Analysis' report options form. It includes a 'Route' dropdown menu set to 'R2: Foothill Blvd', a 'Signals' button, a 'Cycle Length' input field with '90', 'Start Date' and 'End Date' input fields both set to '12/11/2016', 'Start Time' and 'End Time' dropdown menus set to '8:00 AM' and '9:00 AM' respectively, an 'Advanced' button, and a 'Run Report' button.

Figure 36: Link Pivot Analysis Options

Signals		
SignalID	Primary Name	Secondary Name
7371	Foothill Drive	Thunderbird
7223	Foothill Drive	2100 South
7222	Foothill Drive	1700 South
7221	Foothill Drive	2300 East
7220	Foothill Drive	1300 South
7503	Foothill Drive	2100 East
7219	Foothill Drive	Sunnyside
7218	Foothill Drive	Wakara Way (660 S.)
7217	Foothill Drive	Mario Capecchi Dr (1950 E.)

Figure 37: Signals along Route

After configuring the desired **Link Pivot** options, click **Run Report** to view the details of the **Adjustments** and **Approach Link Comparison**. Offset Adjustments include:

- The **Link**, a sequential numerical value for the signal within the selected route based on the Upstream/Downstream choice.
- Each **Signal** number.
- The **Location** of the signal depicted by the main street and cross street names. Link 1 in the example below (Figure 37) is Foothill Drive at Thunderbird.
- The recommended **Link Delta** for each signal. Delta is the recommended relative timing offset change for an approach on a link to optimize combined arrivals on green.
- **Edit Link Delta** allows editing to view what effect the change would have on the **Offset**.
- The recommended **Offset (+ to offset)** for each signal. The adjustment is the cumulative recommended offset change versus the cycle length. It is determined as each link’s delta is applied to the upstream approach.
- **Existing Offset** allows editing to enter existing programmed field offsets to calculate actual offsets to program into field controllers.
- **New Offset** is a calculation of the **Offset** added to the **Existing Offset**.

Adjustments

Link	Signal	Location	Link Delta	Edit Link Delta	Offset(+ to Offset)	Existing Offset	New Offset
1	7371	Foothill Drive Thunderbird	0	<input type="text" value="0"/>	45	<input type="text" value="0"/>	45
2	7223	Foothill Drive 2100 South	6	<input type="text" value="6"/>	45	<input type="text" value="0"/>	45
3	7222	Foothill Drive 1700 South	69	<input type="text" value="69"/>	39	<input type="text" value="0"/>	39
4	7221	Foothill Drive 2300 East	2	<input type="text" value="2"/>	60	<input type="text" value="0"/>	60
5	7220	Foothill Drive 1300 South	1	<input type="text" value="1"/>	58	<input type="text" value="0"/>	58
6	7503	Foothill Drive 2100 East	90	<input type="text" value="90"/>	57	<input type="text" value="0"/>	57
7	7219	Foothill Drive Sunnyside	57	<input type="text" value="57"/>	57	<input type="text" value="0"/>	57
8	7218	Foothill Drive Wakara Way (660 S.)	0	<input type="text" value="0"/>	0	<input type="text" value="0"/>	0
9	7217	Foothill Drive Mario Capecchi Dr (1950 E.)	0	<input type="text" value="0"/>	0	<input type="text" value="0"/>	0

Figure 38: Link Pivot Adjustments

The **Approach Link Comparison** table (see Figure 38) details upstream and downstream signals, upstream and downstream direction, information regarding percentages, and number of vehicles for

arrival on green (AOG), and includes a link to the respective Max Arrivals On Green By Second (**AOG Chart**) graph (see Figure 39).

Approach Link Comparison

Link	Approaches		Upstream AOG			Downstream AOG			Total Link AOG			Delta	AOG Chart
	Upstream	Downstream	Existing	Predicted	Change	Existing	Predicted	Change	Existing	Predicted	Change		
1	7371 Southbound	7223 Northbound	601	601		383	383		984	984		0	
	Foothill Drive Thunderbird	Foothill Drive 2100 South	87%	87%		90%	90%		88%	88%			

Figure 39: Approach Link Comparison

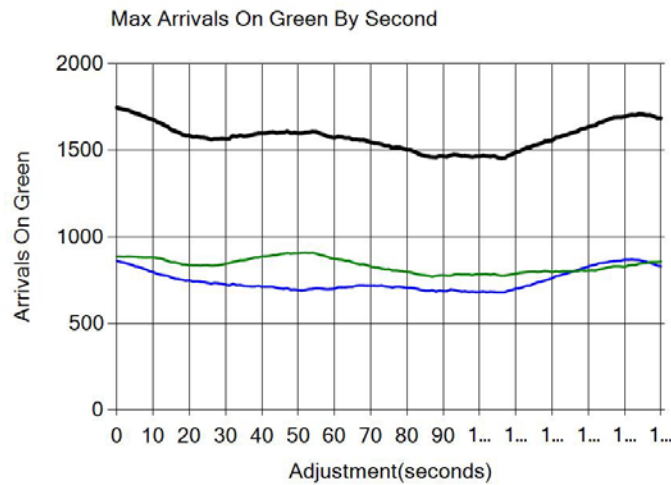


Figure 40: Max Arrivals on Green by Second

Within each link of the **Approach Link Comparison** table, a **PCD Options** button is displayed in the **AOG Chart** column. Clicking this button will add PCD Options (Figure 40) on the left pane below the Link Pivot **Run Report** button. The choices are:

- **Dates:** displays all dates within the range as determined in the **Link Pivot Analysis** options.
- **Y-Axis:** sets the Y-axis range limit. Default is 150.
- **Delta:** sets the **Link Delta** between the **Existing** and **Predicted** metrics for the **PCD Chart** to display. Defaults to the **Link Delta** from the **Adjustments** table, but can be modified to predict various outcomes.

After choosing the desired criteria, click the “View PCDs” button. The PCD charts for both the **Existing** and **Predicted** AoG will display.

Run Report

PCD Options

Dates

11/4/2016 8:00:00 AM

11/5/2016 8:00:00 AM

11/6/2016 8:00:00 AM

11/7/2016 8:00:00 AM

Y-Axis

300

Delta

77

View PCDs

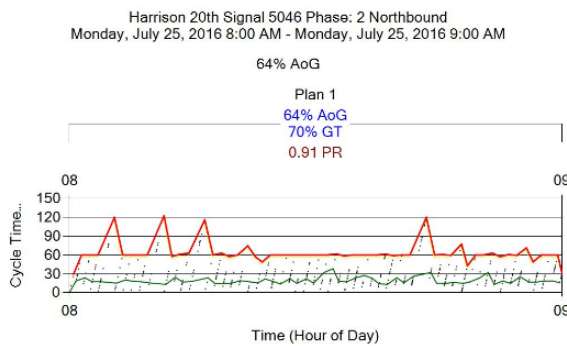
Figure 41: Link Pivot PCD Options

For the selected intersection and time period, the number and percentage of AOG are shown – for both existing and optimized conditions (see Figure 41).

See the [Purdue Coordination Diagram](#) for additional information on this metric.

Existing

Total # AOG - 1027
Total % AOG - 77



Predicted

Total # AOG - 1084
Total % AOG - 82

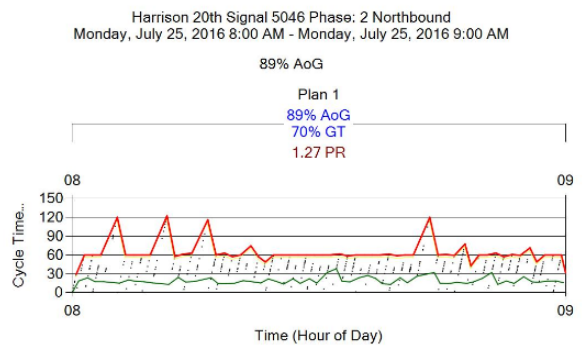


Figure 42: Purdue Coordination Diagram for Purdue Link Pivot

2. Reports

ATSPM incorporates **Reports** as a method to review data logs of which agency is accessing and entering information using the **Log Action Taken** command on the top menu. In addition, the **Reports** tab will also show the traffic signal **configuration** (view only) and **aggregate data** reports.

2.1. Chart Usage

Selecting **Reports > Chart Usage** navigates to the **Chart Usage Report** date selection page where there are two blank fields, one for the StartDate and one for the EndDate. StartDate auto populates with the first calendar date of the year and EndDate auto populates to the current date. These can be modified to the desired date range. After entering the desired range, click **Run Report** to load the usage reports for the prescribed period.

- **Chart Usage** – This is a pie chart displaying the usage or changes (in percent) of the ATSPM data for Purdue Phase Termination, Split Monitor, Pedestrian Delay, Preemption Details, Turning Movement Counts, Purdue Coordination Diagram, Approach Volume, Approach Delay, Arrivals on Red, Approach Speed, Yellow and Red Actuations, Purdue Split Failure, Purdue Link Pivot, Preempt Service Request, and Preempt Service. The chart is aggregated from user-input data through **Log Action Taken**.
- **Agency Usage** – This is a pie chart (see Figure 42) displaying the users or the agencies logging information. The users are Academics, City Government, Consultant, County Government, Federal Government, MPO (metropolitan planning organization), State Government, and Other. This is based on user-input data through **Log Action Taken**.
- **Reports Run** – This is a bar graph (see Figure 43) displaying the number of times each measure was run, based on self-reporting through **Log Action Taken**.
- **Actions By Metric** – This is a bar graph displaying the number of times actions based on each measure were taken. This is based off of user-input data through **Log Action Taken**.

The remaining charts are bar charts where the data represents the number of times and the type of actions taken regarding the metrics.

- **Purdue Phase Termination**
- **Split Monitor**
- **Pedestrian Delay**
- **Preemption Details**
- **Turning Movement Counts**
- **Purdue Coordination Diagram**
- **Approach Volume**
- **Approach Delay**
- **Arrivals On Red**
- **Approach Speed**
- **Yellow and Red Actuations**

- **Purdue Split Failure**
- **Timing and Actuation**

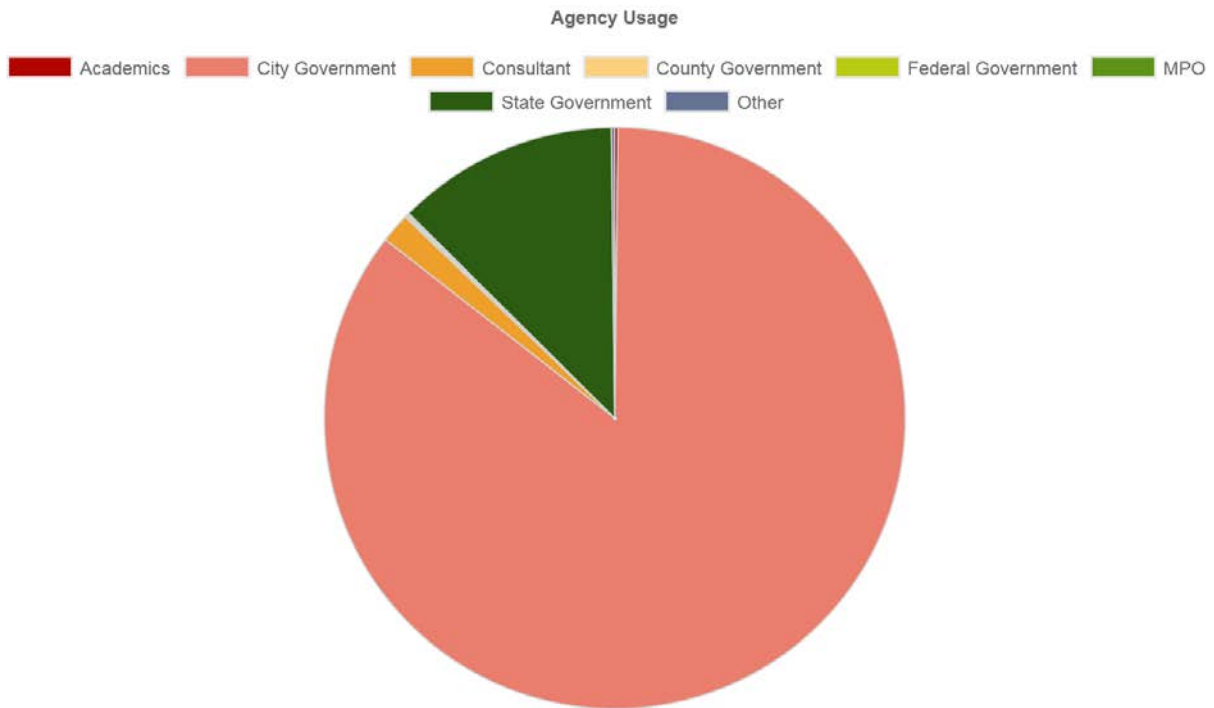


Figure 43: Agency Usage chart (pie example)

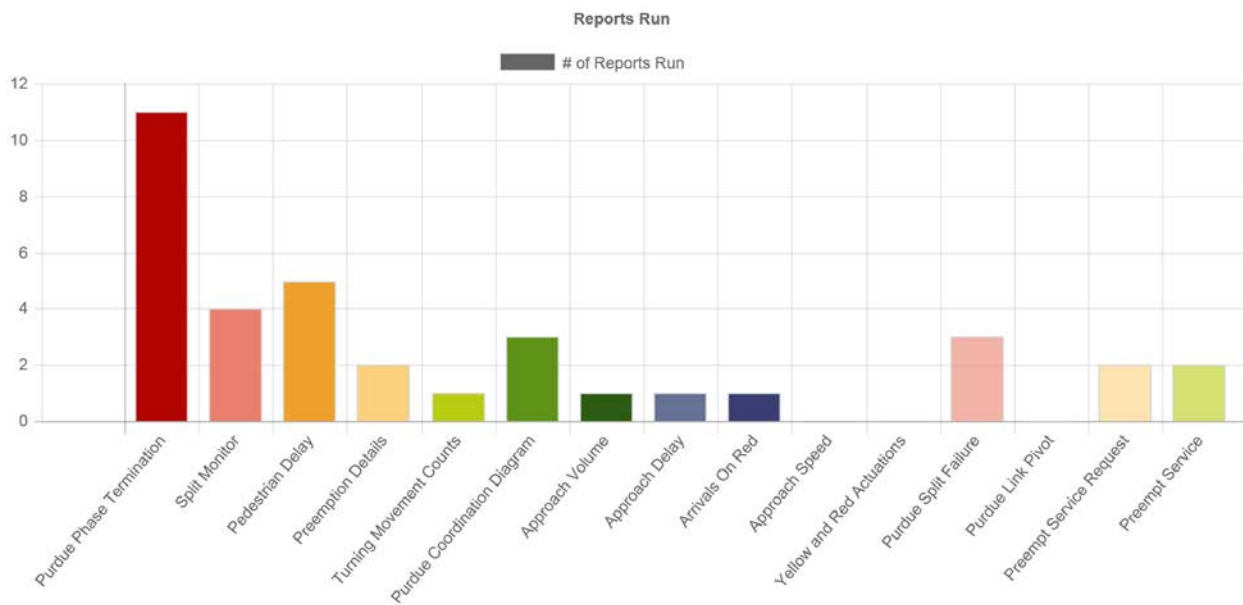


Figure 44: Reports Run chart (bar example)

2.2. Configuration

Selecting **Reports > Configuration** navigates to the **Signal Configuration** page where there is a blank field to enter the signal ID or two dropdown options to select a signal from the list or map. Once you click on the list or map or click enter after entering the signal ID manually, a read only of the configuration setup (from **Admin > Signal Configuration**), the phase assignments and detector channels for the signal will display (except for the IP address).

2.3. Aggregate Data

Selecting **Reports > Aggregate Data** navigates to the **Aggregate Data** page where there are several options in generating reports. The Raw data aggregation takes the raw data files (1/10th second data logs) and aggregates data tables to 15-minute bins by post-processing the 1/10th second data through the metric algorithms. See Figure 44 below.

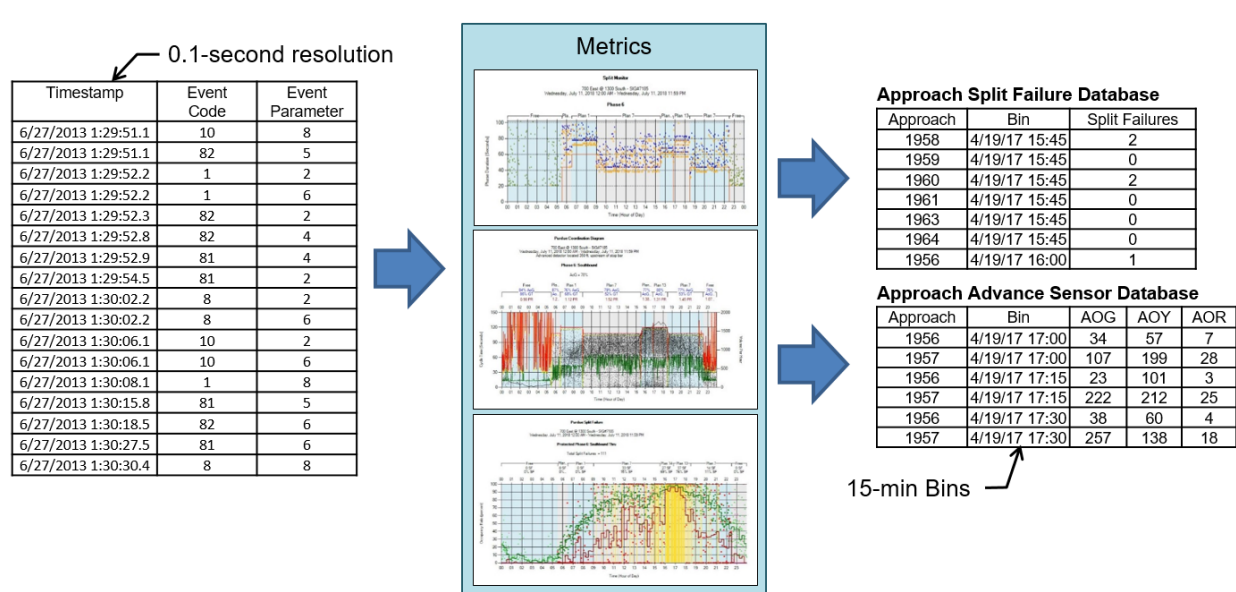


Figure 45: Raw Data Aggregation of ATSPMs

Aggregate data tables are in 15-minute bins and the metric types are:

- Detector Activation Count
- Approach PCD
- Approach Cycle
- Approach Split Fail
- Signal Preemption
- Signal Priority
- Approach Speed
- Approach Yellow Red Activations

- Signal Event Count
- Approach Event Count
- Phase Termination
- Phase Pedestrian Delay

The Series Types are:

- Signal
- Phase Number
- Direction
- Route
- Detector

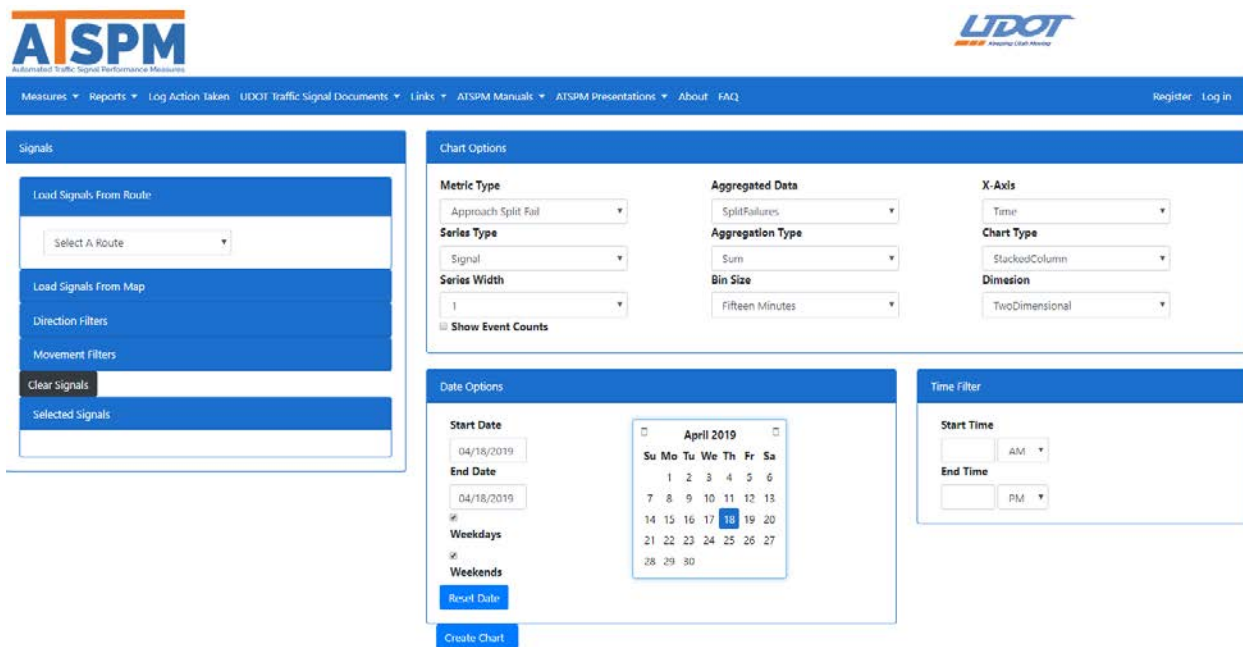


Figure 46: Aggregate Data Report

The chart options will vary, dependent on the Metric Type selected (See Figure 46 below).

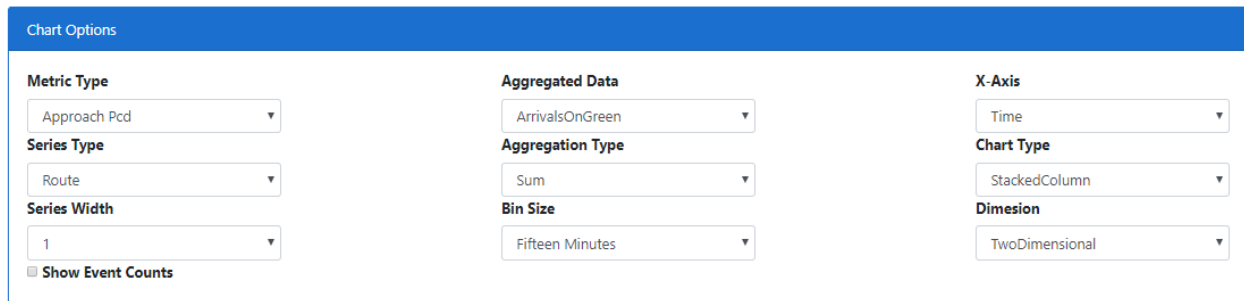


Figure 47: Aggregate Data Chart Options

An aggregate hourly volume report is shown in Figure 47.

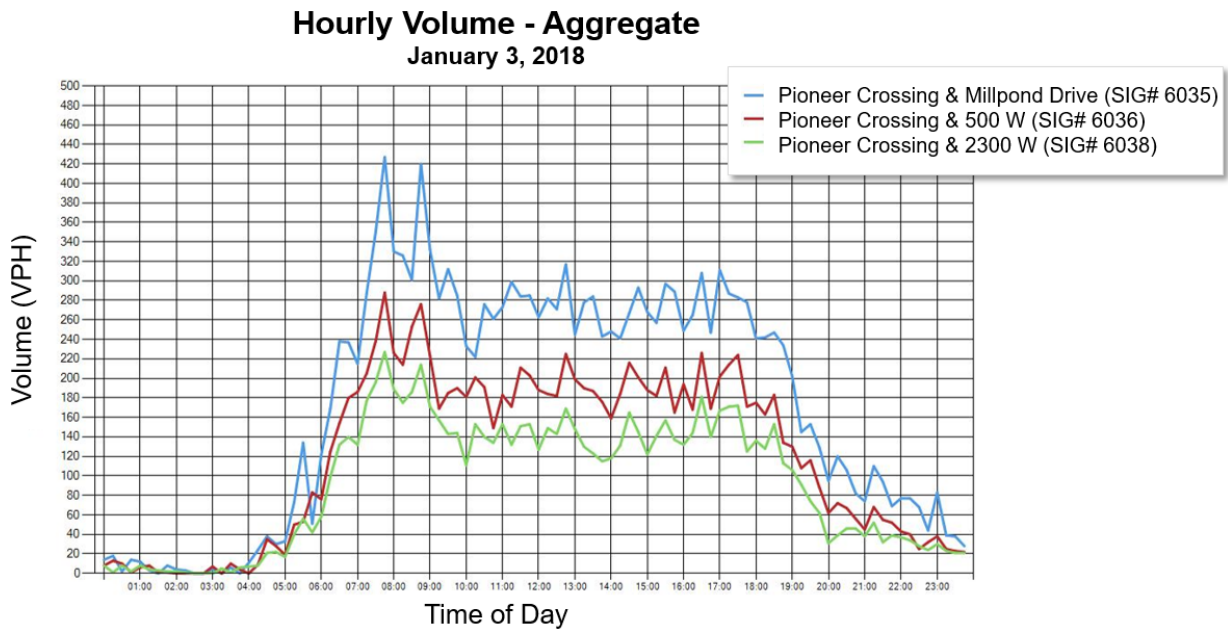


Figure 48: Aggregate Report - Hourly Volume

The 15-minute bin files of the aggregate data take up much less storage space than the raw 1/10th second data files and allow the user to evaluate performance on a much larger scale, including intersection, corridor, city and system wide analysis. For example, UDOT averages approximately 1 TB/month on the 2000 traffic signals bringing back data raw 1/10th second data logs. The aggregation data tables are approximately an extra 6 GB/month of data.

3. Log Action Taken

Selecting **Log Action Taken** displays a data entry form for the Create Action Log as shown in Figure 48.

Create
ActionLog

Name

Date

Signal ▼

Agency ▼

Actions

- Actuated Coord. All-Red Interval
- Coord On/Off Modeling
- Cycle Length Traffic Study
- Detector Issue Yellow Interval
- Offset Force Off Type
- Sequence Split Adjustment
- Time Of Day Manual Command
- Other

MetricTypes

- Purdue Phase Termination Arrivals On Red
- Split Monitor Approach Speed
- Pedestrian Delay Yellow and Red Actuations
- Preemption Details Purdue Split Failure
- Turning Movement Counts Purdue Link Pivot
- Purdue Coordination Diagram Preempt Service Request
- Approach Volume Preempt Service
- Approach Delay

Comment

Figure 49: Create Action Log Form

This entry only form allows a user – for example, an agency employee – to record activities performed in response to ATSPM information. Actions can include signal retiming, a traffic study, and more. These actions will then be used to populate a Usage report. There are seven areas to complete during the process of logging actions. All fields except Comment are required. These fields are:

- **Name:** The name of the person entering the action.
- **Date:** Auto-populated with the current date, which can be modified if the action is not being logged on the date it was taken.
- **Signal:** A dropdown list with all signal IDs and location. Select the corresponding signal ID and location for the logged action.
- **Agency:** A dropdown list for the type of entity that performed the action. The choices are:
 - Academics
 - City Government
 - Consultant
 - County Government
 - Federal Government
 - MPO

- State Government
- Other
- **MetricTypes:** A group of Check Boxes for each metric. Select the applicable metric or metrics that motivated the action.
- **Comment:** A text box to enter comments about the action.

After all appropriate fields are completed, click the **Create** button to complete the log of the action taken.

4. Agency Traffic Signal Documents

The **Agency Traffic Signal Documents** link provides access to various documents for information desired by the agency. The title “Agency Traffic Signal Documents” can be changed under **ADMIN** and **Menu CONFIGURATION**. UDOT has several documents in this menu, including such documents as **Traffic Signal Management Plan (TSMP)**, the **Emergency Response Plan for UDOT’s Traffic Signals**, **Detector Accuracy Information**, **Wavetronix Matrix Latency Information**, **Signal Ops QIT Final Report**, **NEMA Phase # Convention at UDOT**, **UDOT Detection Form 2019-04-09**, **UDOT Detection Form Printable Tables 2019-04-09**, **AWS LFT and Detection Worksheets 2019-04-10**, and **AWS LFT, Detection Worksheets Printable, and Examples of Detector Setup DZ**. In essence, this dropdown menu can be a repository for agency traffic signal documents. Due to enhancements with Bootstrap (CSS framework directed at responsive, mobile-first front-end web development) to better fit mobile apps, only one submenu is allowed in all menus.

5. Links

The **Links** tab on the ATSPM menu bar provides hyperlink access to various documents, presentations, and ATSPM sites from other states. These links can be used for implementation possibilities and information related to ATSPM. Each state’s ATSPM links will vary. Links available at the UDOT ATSPM site are described herein.

5.1. Indiana Hi Resolution Data Logger Enumerations

The **Indiana Hi Resolution Data Logger Enumerations** link accesses the Purdue University document of the same title in the Purdue e-Pubs library. “This document [created by industry representatives and Purdue staff] defines the enumerations used to encode events that occur on traffic signal controllers with high resolution data loggers.”

5.2. Florida ATSPM

The **Florida ATSPM** link (<https://atspm.cflsmartroads.com/ATSPM>) accesses another ATSPM site for the State of Florida.

5.3. FAST (Southern Nevada)

The Freeway and Arterial System of Transportation (**FAST**) link (<http://challenger.nvfast.org/spm/>) accesses another ATSPM site for Southern Nevada. This is currently an older version of the UDOT ATSPM software, but has some enhancements added by FAST.

5.4. Georgia ATSPM

The **Georgia** link (<https://traffic.dot.ga.gov/atspm>) accesses another ATSPM site for the State of Georgia.

5.5. Arizona ATSPM

The **Arizona** link (<http://spmapp01.mcdot-its.com/ATSPM>) accesses another ATSPM site for Arizona managed by AZTech Regional Information System (ARIS).

5.6. Alabama ATSPM

The **Alabama** link (<http://signalmetrics.ua.edu>) accesses another ATSPM site for Alabama Department of Transportation. This is currently an older version of the UDOT ATSPM software, but is password protected.

5.7. ATSPM Workshop 2016 SLC

The **ATSPM Workshop 2016 SLC** link (<https://docs.lib.purdue.edu/atspmw/2016/>) accesses presentations and posters from a two-day workshop hosted in Salt Lake City that included 170 attendees from across the country and featured several presentations and discussions. The August 2016 ITE Journal article entitled "*Implementation of Automated Traffic Signal Performance Measures*" highlighted the extent that ATSPMs and this workshop has had across the country.

5.8. Train the Trainer Webinars

The **Train the Trainer workshop** links (<https://connectdot.connectsolutions.com/p75dwqefphk?proto=true>, <https://connectdot.connectsolutions.com/p6l6jaoy3gj?proto=true>, <https://connectdot.connectsolutions.com/p6mlkvekogo/?proto=true>, <https://connectdot.connectsolutions.com/p3ua8gtj09r/?proto=true>) will access an Adobe Connect application that will show a video of how to install the UDOT ATSPM system conducted in January 2017 in Salt Lake City.

6. ATSPM Manuals

Three ATSPM manuals have been created by Atkins for GDOT and modified by UDOT for ATSPMs, including the **Installation Manual**, **Component Details**, and **Reporting Details**.

6.1. GDOT ATSPM Installation Manual

The GDOT ATSPM Installation Manual is an Atkins publication modified by UDOT and developed in collaboration with UDOT for Georgia. It is a detailed manual depicting step-by-step instructions on how to install and configure the ATSPM.

6.2. GDOT ATSPM Component Details

The GDOT ATSPM Component Details is an Atkins publication modified by UDOT and developed in collaboration with UDOT for Georgia. It is a detailed description on navigating the ATSPM site and configuring reports to ensure they include the desired results.

6.3. GDOT ATSPM Reporting Details

The GDOT ATSPM Reporting Details is an Atkins publication modified by UDOT and developed in collaboration with UDOT for Georgia. It includes detailed guidance on the components necessary to provide each metric as well as how the data is gathered, displayed, and interpreted.

6.4. ATSPM Detection Suggestions

The ATSPM Detection Suggestions is a two-page PDF that shows the following:

- Page 1 (Figure 49): The left side shows detection configuration options, including none, lane-by-lane presence, lane-by-lane count and advanced count. The right side shows the various metrics that will work under each of the detection configuration options. For example, in order to use the Purdue Split Failure metric, you need presence detection at the stop bar with channels broken out lane-by-lane or grouped together.
- Page 2 (Figure 50): This shows a sample layout of a UDOT intersection and the detection requirements for various metrics. It is not uncommon for some large intersections to use 40+ channels of detection.




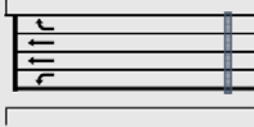
Detection	Metric
<p>None (metrics will display and show info in ATSPM without detection, however, the metrics will be more useful with detection)</p> 	<p>Purdue Phase Termination (without detection, only maxouts/forceoffs) Split Monitor (without detection, splits will be fixed time) Preemption Details (requires preemption device) Pedestrian Delay (requires pedestrian detection) Timing and Actuation (without detection, only timing will be displayed)</p>
<p>Lane-by-lane or Lane Group Presence</p> 	<p>Purdue Split Failure</p>
<p>Lane-by-lane Stop Bar Count</p> 	<p>Turning Movement Counts Yellow and Red Actuations (requires placement of detection into the intersection and beyond the stop bar OR placement of detection at the stop bar with a speed filter)</p>
<p>Advanced Count (Lane-by-lane or group)</p> 	<p>Purdue Coordination Diagram Purdue Link Pivot Offset Optimization Approach Volume Approach Delay Arrivals on Red Approach Speed (requires detection with speed service)</p>

Figure 50: ATSPM detection requirements for each metric

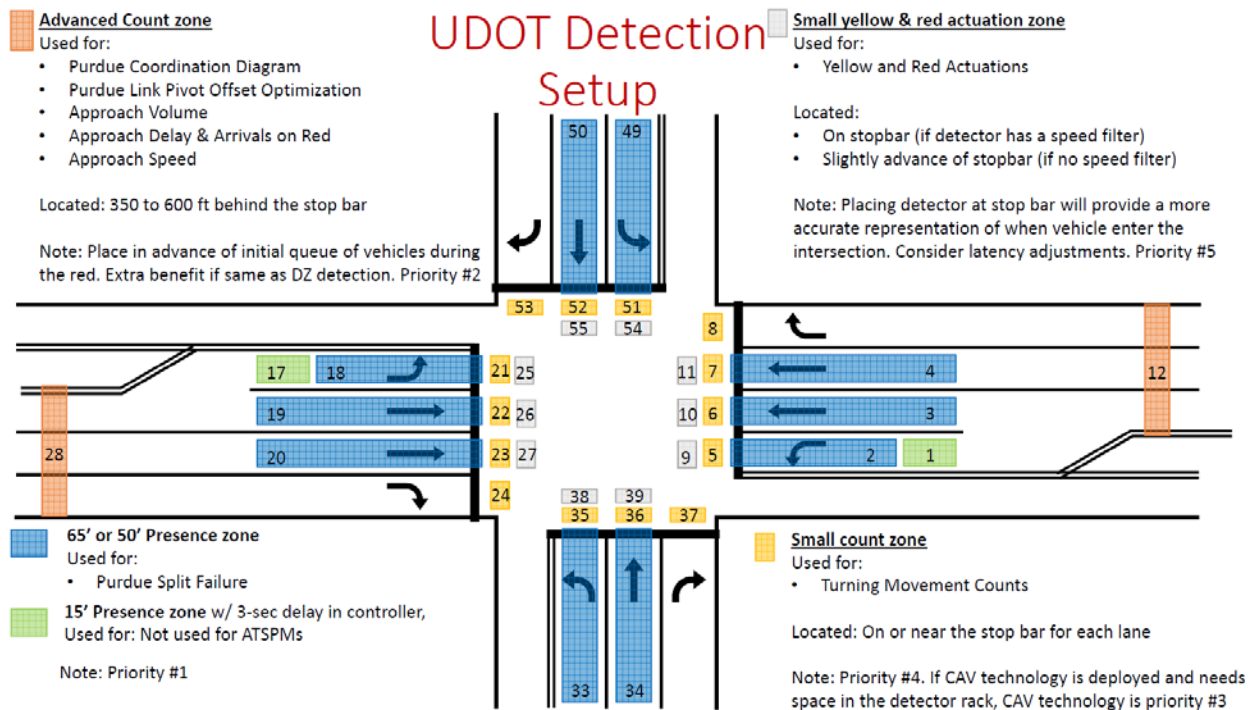


Figure 51: UDOT detection setup example

7. ATSPM Presentations

The **ATSPM Presentations** link provides users access to several presentations Utah has given on ATSPMs. Some of them are:

- ATSPM UDOT Conference 11-2-16
- ATSPM CO WY ITE & Rocky Mtn 10-20-16
- Train the Trainer - Derek Lowe & Shane Johnson
- Jamie Mackey – ATSPM Train the Trainer – Configuration Utility
- ATSPM ITS California 9-21-16
- ATSPM EDC4 Minnesota 10-25-16
- Train the Trainer - Mark Taylor
- ATSPM UDOT Conference 11-6-18

In essence, this dropdown menu can be a repository for agency ATSPM Presentations. Due to enhancements with Bootstrap (CSS framework directed at responsive, mobile-first front-end web development) to better fit mobile apps, only one submenu is allowed in all menus.

8. ADMIN

8.1. Signal Configuration (Admin Only)

Click **Admin** and then **Signal Configuration**. A login screen will appear if you are not logged in. Once logged in as an administrator, you will see the website ATSPM Configuration Tool.

The ATSPM Configuration Tool, shown in Figure 51, offers options to create a new signal or edit existing ones. To begin the process of creating a new signal, click **Create New Signal**. This will open a pop-up window, shown in Figure 52, asking for the signal ID number.

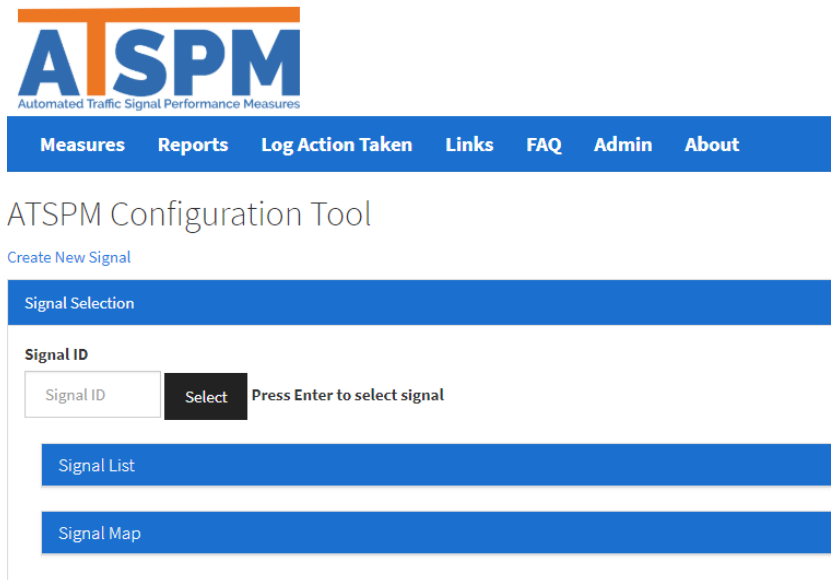


Figure 52: Admin Selection Options and ATSPM Configuration site



Figure 53: New Signal ID Prompt

Below the **Create New Signal** link is the Signal Selection pane for signal configuration editing. Use this area to edit an existing signal or a recently created one. This is like the signal selection area for choosing metrics to display. The options are to enter the Signal ID, navigate the Signal List, or choose it from the Signal Map. By default the Signal List and Signal Map are minimized.

After selecting the signal to configure, whether existing or new, the signal details will display below the Signal Map pane.

Command functions include:

- **Save:** commits any edits made in the configuration fields.
- **Delete this Signal:** Removes the signal from the database.
- **Copy Signal:** Replicates the data in the fields and presents the **Create New Signal** prompt.
- **Add New Version:** Copies the signal and changes the version label / version start date
- **Delete This Version:** Removed the version from the database.

Configuration fields are:

- **Version:** Shows the current version being worked on

- **Version Start:** Date the current version was created
- **Version Label:** User created version name
- **Primary Name:** the name of the main road at the intersection
- **Secondary Name:** the name of the secondary road at the intersection.
- **IP Address:** the Internet Protocol (IP) address for communication to the controller.
- **Latitude:** the geographical latitude location for mapping purposes.
- **Longitude:** the geographical longitude location for mapping purposes.
- **Region:** the regional name for mapping purposes.
- **Controller Type:** the controller type.
- **Display on Map:** a checkbox to choose whether the signal is displayed on the map.
- **Chart Notes:** the notes relative to the intersection. These will show up at the top of the metric page. Only the newest comment will show. A space can be saved to effectively erase the note.
- **Configuration Table:** an expandable link (see Figure 53) that once clicked displays all detector information including the Detector ID, Detector Channel, Phase, and other detector settings.

Detector ID	Det. Channel	Direction	Phase	Perm. Phase	Overlap	Enabled	Detection Types	Detection Hardware	Latency Correction	Movement Type	Lane Number	Lane Type	MPH	Dist. From Stop Bar	Decision Point	Move. Delay	Min Speed Filter	Comment
S34101	1	WB	0	8	False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Left	1	Vehicle						Lane group - thru & left
S34102	2	WB	8		False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Thru	1	Vehicle						
S34103	3	EB	0	4	False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Left	1	Vehicle						Lane group - thru & left
S34104	4	EB	4		False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Thru	1	Vehicle						
S34106	6	NB	2		False	True	Advanced Count Advanced Speed	Wavetronix Advance	0	Thru	1	Vehicle	50	350		15	5	
S34108	8	SB	6		False	True	Advanced Count Advanced Speed	Wavetronix Advance	0	Thru	1	Vehicle	50	350		15	5	

Figure 54: Detector Configuration Table expanded

Below the **Configuration Table** is a list of all approaches (Phase/Direction). Clicking on an approach expands the detectors for that approach. Each **Detector** can also be expanded (see Figure 54) to display the configuration for a **Detector**. The **Phase/Direction** and **Detector** configuration options are:

- **Phase/Direction**
 - **Direction:** a dropdown list of the directions **NB, SB, EB, WB, NE, NW, SE, and SW**.
 - **Description:** the header bar text for the approach. The recommendation is direction and phase, for example, "NBT Ph2."
 - **Protected Phase:** the number associated with the phase.
 - **Permissive Phase:** if applicable, the number of any permissive phase.
 - **Protected Phase Overlap:** a checkbox to select if the phase is a protected overlap.
 - **Perm. Phase Overlap:** a checkbox to select if the phase is a permissive overlap
- **Detectors (expand):**
 - **Det Channel:** the channel number associated with the detector.
 - **Detector Types:** a group of selectable boxes for types of detection, including:
 - Advanced Count

- Advanced Speed
- Lane-by-lane Count
- Lane-by-lane with Speed Restriction
- Stop Bar Presence
- Advance Presence
- **Detection Hardware:**
 - Unknown
 - Wavetronix Matrix
 - Wavetronix Advance
 - Inductive Loops
 - Sensys
 - Video
- **Latency Correction:** Correction for lag in sensor data. Typically 1.2 for Stop Bar Presence and Lane-by-lane with Speed Restriction (if using the Wavetronix Matrix detectors). 0 for everything else, unless the latency is known.
- **Lane Number (Lane-by-lane Count):** the lane number, if detector(s) are assigned to individual lanes. This is available for all detection types but only required for Lane-by-lane Counts.
- **Movement Type (Lane-by-lane Count):** a dropdown list for the type of direction of travel for the lane. The choices are **Thru, Right, Left, Thru-Right, and Thru-Left**. This is available for all detection types but only required for Lane-by-lane Counts.
- **Lane Type (Lane-by-lane Count):** a dropdown list for the type of direction of travel for the lane. The choices are **Vehicle, Bike, Pedestrian, Exit, Light Rail Transit, Bus, and High Occupancy Vehicle**. This is available for all detection types but only required for Lane-by-lane Counts.
- **MPH (Advanced Count, Advanced Speed):** to enter the speed limit for the approach.
- **Distance To Stop Bar (Advanced Count):** enters the distance to the stop bar for Purdue Coordination.
- **Min Speed Filter (Advanced Speed):** any speeds below this value will not be included in the calculation of average or percentile speeds. (Usually 5 mph)
- **Decision Point (Advanced Count):** blank for the Utah ATSPM, but incorporated if other agencies wish to move the timestamp earlier (in seconds) e.g. 3 seconds before the stop bar.
- **Movement Delay (Advanced Speed):** the approximate time in seconds needed to clear the queue to the sensor. (Usually 15 seconds)
- **Date Added:** a calendar field for date & time selection.
- **Detector Comment:** internal comments not pushed to public site
 - **New Comment:** to enter a new comment, press the blue circle with a white plus; this opens a new **Comment Text** field and a **Create** button.

Figure 55: Approach Configuration

8.2. Route Configuration – Link Pivot & Aggregate Data (Admin Only)

To access the Link Pivot & Aggregate Data Route Configuration, the user account logged into the system must have Admin Privileges. Click **Admin** and then **Route Configuration**.

Route Configuration

Create New

RouteName	Edit/Delete
RL: 1000 W (SR 252)	Edit Delete
RL: 12th St	Edit Delete
RL: 21st St	Edit Delete
RL: 2700 N (N Ogden)	Edit Delete

Figure 56: Route Configuration page

The route configuration page, shown in Figure 55, displays all existing **RouteName** and links to edit, view details on, or delete. There is also a link to **Create New** in the upper left corner.

- **Create New:** Starts a new route
- **Edit:** Opens the route for configuration

Edit: ApproachRouteID is a dropdown list of all existing routes.

- **ApproachOrder** is a number for sequencing the signals.
- **ApproachID** is a dropdown list of all existing intersections and phases.
- **Details** – Selecting **Details** opens a webpage that displays the signal’s ID, the RouteName, and the ApproachOrder. This page also includes an edit link that brings the user to the **Details Edit** screen.

- **Delete** – Selecting **Delete** opens a website asking “are sure you want to delete this?” Clicking OK deletes the intersection from the route and removes the selected route from the table.
- **Delete:** Selecting **Delete** opens a website asking “are sure you want to delete this?” Clicking OK deletes the route from the list of routes returns the user to the Index.

Index

[Create New](#)

ApproachRouteDescription	RouteName	ApproachOrder	
5004 - Riverdale Road 1500 West Eastbound Phase 6	R1: Riverdale Rd	1	Edit Details Delete
5003 - Riverdale Road I-84 SPUJ Eastbound Phase 6	R1: Riverdale Rd	2	Edit Details Delete
5002 - Riverdale Road 1050 West Eastbound Phase 6	R1: Riverdale Rd	3	Edit Details Delete

Figure 57: Route Details page

8.3. Menu Configuration (Admin Only)

To access the Menu Configuration, the user account logged into the system must have Admin Privileges. Click **Admin** and then **Menu Configuration**. At this location, you’re able to configure and change the display order of the toolbar and submenus.

MenuId	MenuName	ParentId	DisplayOrder	Controller	Action	Application	
1	Measures	0	1	#	#	SignalPerformanceMetrics	Edit Details Delete
2	Reports	0	2	#	#	SignalPerformanceMetrics	Edit Details Delete
3	Log Action Taken	0	3	ActionLogs	Create	SignalPerformanceMetrics	Edit Details Delete
4	Links	0	4	#	#	SignalPerformanceMetrics	Edit Details Delete
5	FAQ	0	10	FAQs	Display	SignalPerformanceMetrics	Edit Details Delete
6	ATSPM Manuals	0	6	#	#	SignalPerformanceMetrics	Edit Details Delete
7	ATSPM Presentations	0	7	#	#	SignalPerformanceMetrics	Edit Details Delete
8	Chart Usage	2	1	ActionLogs	Usage	SignalPerformanceMetrics	Edit Details Delete
9	Signal	1	1	DefaultCharts	Index	SignalPerformanceMetrics	Edit Details Delete
10	Purdue Link Pivot	1	2	LinkPivot	Analysis	SignalPerformanceMetrics	Edit Details Delete

Figure 58: Menu Configuration Details page

The menu configuration page, shown in Figure 57, displays all existing **menus** and links to edit, view details on, or delete. There is also a link to **Create New** in the upper left corner. Files need to be placed in the Images directory of the code base for the website. Due to enhancements with Bootstrap (CSS framework directed at responsive, mobile-first front-end web development) to better fit mobile apps, only one submenu is allowed in all menus.

8.4. Raw Data Export (Requires registration and privileges)

To access the Raw Data Export, the user account logged into the system must have Admin Privileges, however, data privileges to the raw data export are usually granted to those who desire access to the raw data logs for research or evaluation purposes. To receive raw data export privileges, first register and create a new account (Email and Password). Then, email an ATSPM administrator, justify your

reason and request that the Administrator add you to the “Data” role. Once the ATSPM administrator grants privileges and you’re logged in, click **Admin** and then **Raw Data Export**. Follow the instructions on the raw data export page (Figure 58).

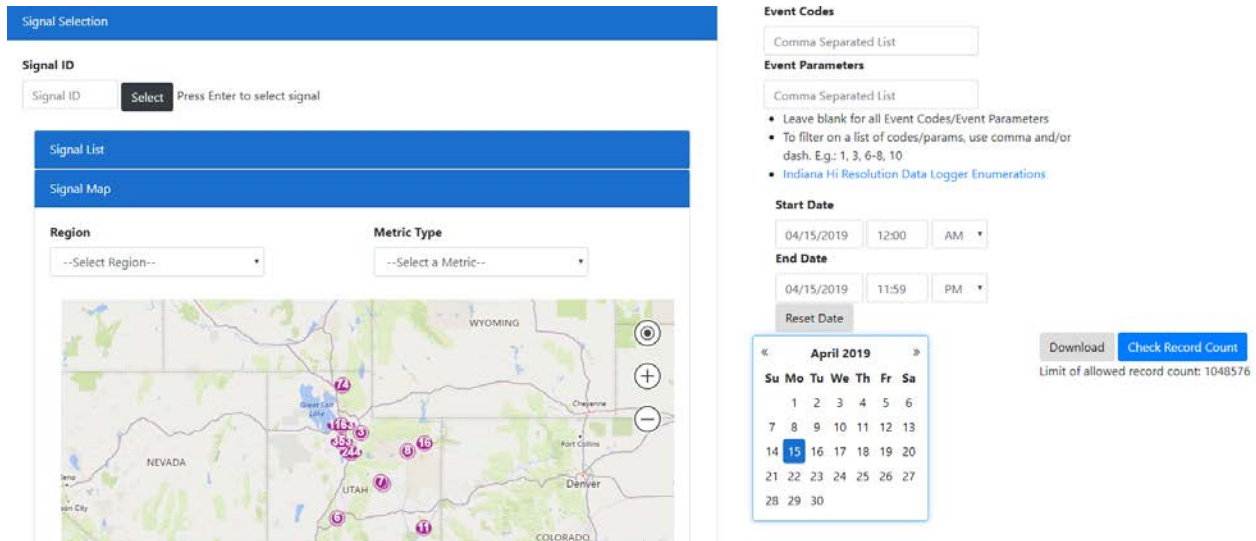


Figure 59: Raw Data Export page

8.5. FAQs (Admin Only)

To access the FAQs, the user account logged into the system must have Admin Privileges. Click **Admin** and then **FAQs**. At this location, you’re able to configure and change the display order, modify, add or delete the information.

The FAQ Editor page, shown in Figure 59, displays all existing FAQs and links to edit, view details on, or delete. There is also a link to **Create New** in the upper left corner.

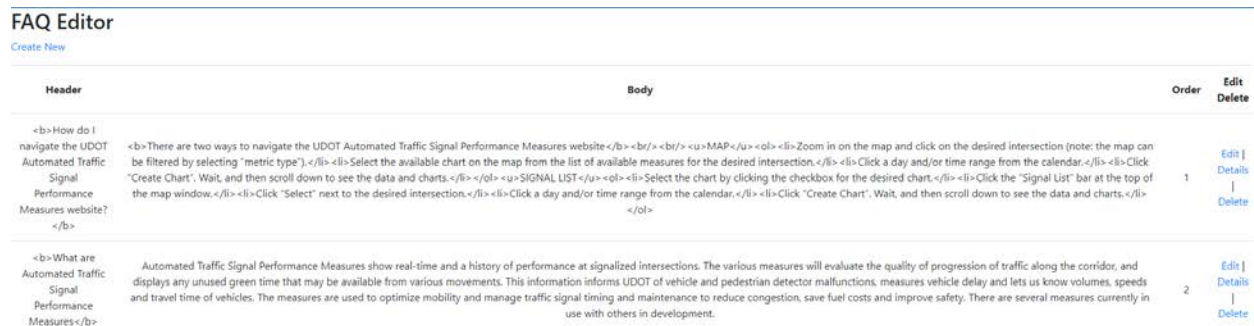


Figure 60: FAQs Editor page

8.6. Watch Dog (Admin Only)

The ATSPM Watchdog is a scheduled executable and is discussed in more detail in Section 12.4. To access the Watch Dog application settings, the user account logged into the system must have Admin Privileges. Click **Admin** and then **Watch Dog**. At this location, you’re able to configure and change the Watch Dog application settings, including:

- Minimum Record Threshold (Low Detector Count Alarm): Default 500.
- Consecutive Event Count (Max Out and Force Off Alarms): Default 3.
- Min Phase Termination Threshold (Max Out and Force Off Alarms): Default 50.
- Percent Threshold (Max Out and Force Off Alarms): Default 0.9.
- Ped Actuations Threshold (Ped Alarm): Default 200.
- Minimum Count Threshold (Low Detector Count Alarm): Default 50.
- Current Day Evaluation Start Hour (Max Out, Force Off, & Ped Alarms): Default 1.
- Current Day Evaluation End Hour (MaxOut, Force Off, & Ped Alarms): Default 5.
- Previous Day Evaluation Start Hour (Low Detector Count Alarm): Default 17.
- Previous Day Evaluation End Hour (Low Detector Count Alarm): Default 18.
- Checkbox for “weekday Only”: Default is to have this enabled.
- Checkbox for “Email All Watch Dog Errors”: Default is to not have this enabled.
- Maximum # of processor threads: Default 10.
- Default Email Address:
- From Email Address: UDOT created a special email titled, SPMWatchdog@utah.gov and is the “from” email the system sends out each day.
- Email Server: The email server DTS needs to connect to send out the daily email.

8.7. Database Archive Settings (Admin Only)

The Database Archive settings page was designed to automatically allow the user to archive the raw data log enumerations (does not include the aggregate data files) after a predefined time period to flat files for cold storage (See Figure 60). Partition databases are needed for this to work and there is some adjustments to the scripts that will need to be made specific for each agency.

Edit
Database Archive Settings

Enable Database Archive

Move/Remove data after how many months:

Figure 61: Database Archive Settings

At some intersections, it is desired to keep raw data log enumerations indefinitely. To exempt traffic signal raw data files from automatically being removed and archived, you can select the traffic signals either by entering the signal ID and clicking “select” or from the signal list or signal map. To access the Database Archive Settings, the user account logged into the system must have Admin Privileges. Click **Admin** and then **Database Archive Settings**. At this location, you’re able to configure and change the

8.8. General Settings (Admin Only)

To access the General Settings, the user account logged into the system must have Admin Privileges. Click **Admin** and then **General Settings**. At this location, you’re able to configure various general settings, including:

- Raw Data Count Limit: Default 1048576 – limits the amount of data to download on the Raw Data Export page.
- Image Path: Directs the Service of where to access the chart images for all metrics.
- Image URL: Directs the Website of where to access the chart images for all metrics.
- ReCaptcha Public Key: Currently not used. It’s a future placeholder if additional security is desired for the **Register** menu.
- ReCaptcha Secret Key: Currently not used. It’s a future placeholder if additional security is desired for the **Register** menu.

8.9. Roles (Admin Only)

To access the Roles, the user account logged into the system must have Admin Privileges. Click **Admin** and then **Roles**. At this location, you’re able to add roles to users, remove user roles and list the roles for each user. The following roles are available:

- User – No privileges are granted.
- Data – Privileges are granted to the **Admin** menu to access the **Raw Data Export** page.
- Technician – Read only privileges are granted to the **Signal Configuration** and **Route Configuration** pages under **Admin**.
- Configuration – Privileges (edit) are granted to the **Signal Configuration** and **Route Configuration** pages under **Admin**.
- Admin – All privileges are granted as described for the Data, Technician & Configuration users, including access to **Menu Configuration, FAQs, Watch Dog, Database Archive Settings, General Settings, Roles, & Users**.

[Create New Role](#) | [Roles](#)

Add role to user

Username :

Role Name:

Remove role from user

Username :

Role Name:

List roles for user

Username :

Roles for this user

1. Data
2. Configuration
3. Admin
4. Technician
5. User

Figure 62: Adding Roles to ATSPM Users

8.10. Users (Admin Only)

To access the Users, the user account logged into the system must have Admin Privileges. Click **Admin** and then **Users**. At this location, you’re able to edit roles or delete users. The users can also be assigned to receive alerts, such as the watch dog email.

9. ABOUT

The ATSPM website About tab, shown in Figure 1, displays a brief description of the version notes and recognizes the contributors to the open source ATSPMs. There is also a link to download the open source software at the FHWA’s open source portal at: <https://www.itsforge.net/>.

10. FAQ

The **FAQ** tab on the ATSPM menu bar, shown in Figure 62, includes questions that, when selected, expand to show the answer to each question. These include questions and answers for the public, such

as navigation tips and a description of what ATSPMs are, as well as detailed information regarding server, data storage, and system requirements. A question regarding whom to contact for additional information is also provided. Questions and answers can be modified for each agency as needed.

Who uses the Signal Performance Metrics data?

The data has been useful for some of the following users in Utah:

- [Signal engineers](#) in optimize and fine-tuning signal timing.
- [Maintenance signal technicians](#) in identifying broken detector problems and investigating trouble calls.
- [Traffic engineers](#) in conducting various traffic studies, such as speed studies, turning movement studies, modeling studies, and optimizing the intersection operations.
- [Consultants](#) in improving traffic signal operations, as UDOT outsources some of the signal operations, design and planning to consultants.
- [UDOT Traffic & Safety](#), [UDOT Traffic Engineers](#), [UDOT Resident Construction Engineers](#) in conducting various traffic studies and/or in determining the time-of-day where construction or maintenance activities would be least disruptive to the traveling motorists.
- [Metropolitan Planning Organizations](#) (MPO's) in calibrating the regional traffic models.
- [Academia](#) in conducting various research studies, such as evaluating the effectiveness of operations during adverse weather, evaluating the optimum signal timing for innovative intersections such as DDI's, CFI's and Thru-Turns, etc.
- [City and County](#) Government in using the data in similar manner to UDOT.

What are the detection requirements for each metric?

Figure 63: FAQ site with a question expanded

11. Additional Website Components

11.1. Generate Add Data Script

This is an application tool supporting the website. It generates JavaScript code based on the traffic controllers currently configured in the database. The output JavaScript file, in turn, places controller location pins on navigation map (as shown in Figure 63). The number on the circle shows the number of signals under that cluster group. For example, if you click on "3", it will zoom into the cluster of three signals.

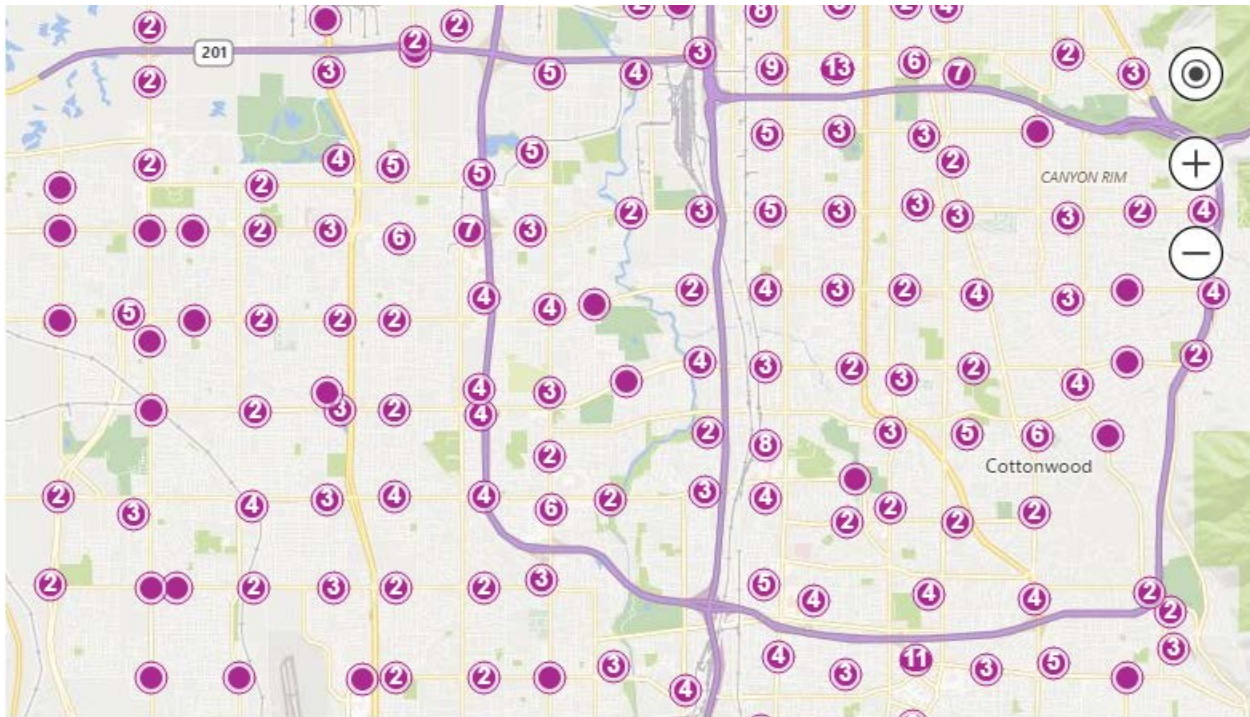


Figure 64: Map pins generated by JavaScript

The **GenerateAddDataScript** executable is invoked by the Windows scheduler on a timer. Typically, the timer is scheduled hourly, so it can pick up new traffic signals that have been added to the system. A copy of the *MOE.Common.DLL.Config* file should be placed in the same folder as the script generator, so the application can pick up the database location and connection strings.

The **GenerateAddDataScript.config** file sets configuration keys for this executable. The most relevant key is:

- **PathN**: The physical or network path where the javascript will be saved. Multiple output paths may be specified, where **N** is numeric starting at 1. The path must end with the javascript filename, typically *AddData.js*.

11.2. Speed Listener

This component, **WavetronicsSpeedListener.exe**, receives data packets from Wavetronix Advance Detectors via a Digi PortServer®. The Digi PortServer must be configured to send to the IP address and port of the speed listener service. Other serial to Ethernet converters will likely function, but the instructions provided are specifically for the PortServer. When the speed listener receives a new packet, it creates a timestamp, pairs it with the data, and inserts the detector ID, miles per hour, kilometers per hour, and timestamp into the Speed Events table in the database.

The database connection information is contained in the speed listener configuration file, **WavetronicsSpeedListener.exe.config**.

12. Data Collection Components

12.1. FTP from All Controllers

ATSPM uses the **FTPfromAllControllers** executable as a background task managed by Windows Scheduler. This component fetches logs via file transfer protocol (FTP). Once the logs are retrieved, Decode and Import processes (described in the following section) will decode the files and ingest them to the system database.

The **FTPfromAllControllers.exe.config** file sets configuration keys for this executable. The most relevant keys are:

- **HostDir:** Denotes the path where the downloaded signal logs (.DAT) will be stored. The path can be any network path or local disk. Downloaded files are written to a subdirectory corresponding to the signal controller. These subdirectories are keyed according to the website's internal, 4-digit signal ID.
- **DeleteFiles:** This true/false flag controls whether logs are deleted on the signal controller after being retrieved.

12.2. Decode and Import

ATSPM invokes several different processes to decode signal controller logs and ingest the data into the system database. The process used depends on the signal controller vendor. These processes are background tasks managed by the Windows scheduler, and are described in the following subsections.

12.2.1. ASC/3

The **NewDecodeAndImportASC3Logs** executable decodes and imports logs from the Econolite ASC/3 signal controller.

The **NewDecodeAndImportASC3Logs.exe.config** file sets configuration keys for this executable. The most relevant keys are:

- **ASC3LogsPath:** Denotes the path of the downloaded signal logs (.DAT) from the controller. Normally this is the same path as **FTPfromAllControllers.exe.config (HostDir)**.
- **CSVOutPath:** Denotes the output folder where decoded CSV files are placed.
- **DeleteFiles:** Specifies whether the importer deletes the .DAT files after ingesting them into the database.

12.2.2. Siemens

The **DecodeSiemensLogs** executable decodes and imports logs from Siemens signal controllers.

The **DecodeSiemensLogs.exe.config** sets configuration keys for this executable. The most relevant keys are:

- **LogPath:** Denotes the path of the downloaded signal logs (.DAT) from the controller. Normally this is the same path as **FTPfromAllControllers.exe.config <HostDir>**.
- **DeleteFile:** Specifies whether the importer deletes the .DAT files after ingesting them into the database.
- **CSVOutPath:** Denotes the output folder where decoded CSV files are placed.
- **DecoderPath:** Specifies the full path to the SiemensDecoder.exe, a proprietary Siemens component required for the Siemens decoder to run.

12.2.3. TrafficWare

The **DecodeTrafficwareLogs** executable decodes and imports logs from TrafficWare signal controllers.

The **DecodeTrafficwareLogs.exe.config** sets configuration keys for this executable. The most relevant keys are:

- **TWLogsPath:** Denotes the path of the downloaded signal logs (.DAT) from the controller. Normally this is the same path as **FTPfromAllControllers.exe.config (HostDir)**.
- **DeleteFile:** Specifies whether the importer deletes the .DAT files after ingesting them into the database.
- **CSVOutPath:** Denotes the output folder where decoded CSV files are placed.
- **DecoderPath:** Specifies the full path to the SiemensDecoder.exe, a proprietary Siemens component required for the Siemens decoder to run.

12.2.4. Peek

Retrieval and ingestion of information from Peek is configured on a case-by-case deployment. The Peek representative should be consulted during ATSPM deployment with this hardware.

12.2.5. Intelight MaxTime

Retrieval and ingestion of information from Intelight MaxTime is handled differently from all other signal vendors. Since the MaxTime interface is entirely web based, ATSPM employs a web service to communicate with this hardware.

The **GetMaxTimeRecords** executable handles retrieval of controller events and ingestion into the database. Windows scheduler runs this at regular intervals as a scheduled task (typically every five minutes). Events are retrieved in XML format and ingested directly into the database. No FTP is necessary.

12.3. Archive Metric Data

This tool pre-processes traffic signal data. Data for every intersection in the system is processed. It supports the creation of Executive Reports when requested by the user, and allows them to be generated in a timely manner. It saves off data in configurable bins (time chunks).

The executable is **ArchiveMetricData.exe** and is typically scheduled to run each evening (as a background task via Windows Scheduler). Its settings are configured in **ArchiveMetricData.exe.config**. Relevant keys in this configuration file include:

- **<BinSize>**: The size of time chunk, in minutes, in which data are grouped. Default is 15 minutes.
- **<ErrorRecipients>**: A comma-separated list of email addresses that are notified, should an archiving error occur.
- **<MaxThreads>**: The maximum number of central processing unit (CPU) threads the executable process will use.
- **<ConnectionStrings>**: Connection string(s) for the target database(s).

The processed information and statistics are stored in the *Archived_Metrics* table in the system database. For each time bin, the volume, speed, cumulate delay, cumulative AoR, and cumulative [green time](#) are tabulated.

12.4. ATSPM Watchdog

The ATSPM Watchdog is a scheduled executable. It sends out email alerts when it detects one or more of the following conditions (based on defaults in the configuration file):

- **No data**: report phases with less than 500 records in the database between midnight and midnight the previous day.
- **Force offs**: report phases with more than 90% force offs in at least 50 activations between 1 a.m. and 5 a.m. the same day.
- **Max outs**: report signals with more than 90% max outs in at least 50 activations between 1 a.m. and 5 a.m. the same day.
- **Low advanced detector counts**: report phases with PCD detectors that have less than 100 vehicles counted between 5 p.m. and 6 p.m. the previous day.
- **Stuck ped**: report phases with more than 200 pedestrian activations between 1 a.m. and 5 a.m. the same day.

Watchdog is intended to run daily. Normally, only the first occurrence of each error will be reported. But if a day or more is skipped, previous occurrences will be reported as new errors the next time watchdog runs. For example, if watchdog is not run Monday but resumes Tuesday, then the Tuesday run will report new errors from both the Monday and Tuesday periods. This should be rare, but does provide a means to catch problems that may have been missed.

The “AspNetUsers” database table contains the list of email recipients. If the “ReceiveAlerts” column value is set to one, the user will receive emails generated by the ATSPM Watchdog. If the value is set to zero, the user will not receive any emails.

The executable is **ATSPMWatchDogNew.exe** and is typically scheduled to run early each morning (as a background task via Windows Scheduler). Its settings are configured in **ATSPMWatchDogNew.exe.config**. Relevant keys in this configuration file include:

- **ConnectionStrings:** Connection string(s) for the target database(s). The key for the default string is "ATSPM."
- **ConsecutiveCount:** The minimum number of consecutive phase termination events for the watchdog criteria to apply.
- **StartHour** and **EndHour:** The hours of the day between which the watchdog criteria will apply. These are on a 24-hour scale; 8 corresponds to 8:00 in the morning, while 18 is 6:00 in the evening.
- **EmailServer:** The mail server that will send the Watchdog emails. If the mail server is hosted on the same machine running Watchdog, use the machine's network name.
- **ToAddress:** This field will append an email address on the outbound email to the corresponding address(s) in the database.
- **PercentThreshold:** This is the threshold percentage for max-out or force-off phases, for these data to be included in the Watchdog criteria. The percentage is expressed as a decimal; 0.9 corresponds to 90 percent.
- **MinPhaseTerminations:** The minimum number of phase termination events (max-out or force-off) for these data to be included in the Watchdog criteria. Applied in conjunction with **PercentThreshold**.
- **LowHitThreshold:** The volume threshold, tallied between **StartHour** and **EndHour**, below which the low hit count Watchdog criteria will apply.
- **MaxThreads:** The maximum number of CPU threads the executable process will use.

12.5. Web API

ATSPM version 4.2.3 and higher has had a Web API built so users can export large amounts of data on a scheduled basis. The web API is managed under ADMIN – ROLES. Once the users are granted THE Web API role, they are able to pull data on a scheduled basis. The data the users have access to pull with the API is Route Configuration. Set up the signals as routes and then the route number is needed that is defined in the SQL database (you need to look up the route number in the SQL tables).

The ATSPM system has established a website for the Udot Atspm Web API site using token-based authentication and https. You can conduct the following tests with Postman:

1) GET, <https://udottraffic.utah.gov/AtspmApi/api/data/forall>

This shall return the server time to show that you are hitting the right server, and doesn't require authentication.

2) POST <https://udottraffic.utah.gov/AtspmApi/token> with your signed up username and password in the Body, to get the access token for authentication (currently it is valid for 30 days)

3) GET <https://udottraffic.utah.gov/AtspmApi/api/data/authenticate> with Header including the KEY Authorization and the VALUE Bearer <the token you got from step 2>, and you will get "Hello *username*" to verify that your authentication process is done right.

4) GET <https://udottraffic.utah.gov/AtspmApi/api/data/SignalConfig/1001>
 (1001 represents any valid SignalId you need to query) to get signal configuration which includes all of its approaches and all the detectors of any approach.

GET:

<https://udottraffic.utah.gov/AtspmApi/api/data/ControllerType>

<https://udottraffic.utah.gov/AtspmApi/api/data/DirectionType>

<https://udottraffic.utah.gov/AtspmApi/api/data/LaneType>

<https://udottraffic.utah.gov/AtspmApi/api/data/MovementType>

to decipher what the description the corresponding Id's mean.

5) GET <https://udottraffic.utah.gov/AtspmApi/api/data/controllerEventLogs?StartTime=2019-10-01T00:00:00&EndTime=2019-10-01T00:00:10&RouteIds=1&RouteIds=2>

To query ControllerEventLogs based on RouteId's. Each Route may contain multiple signals.

GET <https://udottraffic.utah.gov/AtspmApi/api/data/speedEvents?StartTime=2019-10-01T00:00:00&EndTime=2019-10-01T00:00:10&RouteIds=1&RouteIds=55>

To query SpeedEvents based on RouteId's.

GET <https://udottraffic.utah.gov/AtspmApi/api/data/ApproachCycleAggregate?StartTime=2019-9-01T00:00:00&EndTime=2019-9-01T00:00:10&RouteIds=2&RouteIds=3>

To query ApproachCycleAggregate based on RouteId's. ApproachCycleAggregate can be replaced with [ApproachEventCountAggregate](#), [ApproachPcdAggregate](#), [ApproachSpeedAggregate](#), [ApproachSplitFailAggregate](#), [ApproachYellowRedActivationAggregate](#), [PhasePedAggregate](#), [PhaseTerminationAggregate](#), [PreemptionAggregate](#), [PriorityAggregate](#), [SignalEventCountAggregate](#) to query other aggregate tables.

Currently the result set is limited to 300,000 rows of data. If the input parameters returns result sets bigger than that, you will get the error message of: "Request returns too many records. Please shorten timespan."

13. Architectural Components

13.1. MOE WCF Library

The MOE WCF Library (MOEWcfServiceLibrary in the source code) contains Windows Communication Foundation (WCF) services. Currently, ATSPM uses the Metric Generator and Link Pivot services.

The Metric Generator service is hosted on the web server, and handles requests triggered when the user clicks “Create Chart.” The service, in turn, instantiates a “MetricOptions” object corresponding to the chart type and returns it to MOE.Common (see below). Similarly, when the user runs a Link Pivot Report, the Link Pivot Service will create a LinkPivot object and return its parameters to MOE.Common.

13.2. MOE.Common

MOE.Common represents the core, business logic of the ATSPM website. As part of the Model-View-Controller architecture, it includes the “Model” logic which scans the database and generates all charts. The “MetricOptions” object described above (and in the Reporting Details document) is housed here and contains sub-types corresponding to each chart (such as Turning Movement Counts, Arrivals on Red, Split Monitor, etc.).

Appendix A: Glossary

This Appendix lists and defines the technical terms used throughout the document.

A.1. Activation (pedestrian)

Activation of a pedestrian phase indicates the phase was served. This includes actuation by the push button or if the phase was called by a ped recall or coordination.

A.2. Actuation (pedestrian)

Actuation is another term for a pedestrian pressing the button at the crosswalk to request the crossing signal.

A.3. Approach Delay

Approach delay is defined as the time starting when the vehicle begins to decelerate at an intersection and ending when it crosses the stop bar.

On the ATSPM website, this figure is simplified as the time starting when the advance detector is actuated and ending when the phase turns green.

A.4. D (Directional) Factor

D Factor indicates the directionality of flow when comparing opposing directions (east versus west, north versus south). It can be the ratio of one direction to the other or of one direction to their sum (directional split).

A.5. Dwell Time

On signal controllers supporting preemption, dwell time is the time elapsed while the preemption is activated and servicing the emergency movement. For example, dwell time applies when the railroad gates are down and the train is present.

A.6. Entry Delay

On signal controllers supporting preemption, entry delay is a timing delaying the onset of preemption.

A.7. Force Off

Force Off occurs when the controller's split timer expires, terminating the phase. This only occurs under coordinated operation. A force-off indicates that a phase is over-capacity.

A.8. Gap Out

Gap Out occurs when the signal controller terminates the phase because its minimum time has been served, and the vehicle extension timer has expired. A gap-out can indicate that a phase has excess capacity.

A.9. Green Occupancy Ratio

GOR is the proportion of green time that a detector is occupied. On the ATSPM website, the detector is at the stop bar.

A.10. Green Time

The time, in seconds, that a phase (or overlap) has the green light.

A.11. K Factor

On the ATSPM website, the K Factor denotes the ratio of the peak hour volume to the total traffic for the day. It is non-applicable when the analysis period is shorter or longer than 24 hours.

A.12. Lane Utilization Adjustment Factor

The f_{LU} reflects the degree of variation of traffic flow between lanes in a lane group. According to the *Highway Capacity Manual 2000*, it is calculated as:

$$f_{LU} = v_g / (v_{g1} N)$$

v_g is the unadjusted demand flow rate for the lane group in vehicles/hour. v_{g1} is the unadjusted demand flow rate on the single lane in the lane group with the highest volume. A f_{LU} of 1.0 indicates that all lanes in the group have the exact same flow rate.

A.13. Max Out (phase)

Max Out occurs when, under high traffic demand, a phase has been extended to its maximum length. This only occurs under non-coordinated operation. A max-out indicates that a phase is over-capacity.

A.14. Max Out (preemption)

On signal controllers supporting preemption, max out refers to a timer that expires after initiation of the preempt call. The max out timer covers cases where the emergency movement was never actually serviced (a false alarm).

A.15. Occurrence

In Yellow and Red Actuation, Occurrence is defined as a vehicle proceeding beyond the stop bar and entering the intersection during the yellow indication.

A.16. Peak Hour

Peak Hour is the hour within a time period (typically a day) with the maximum volume. The hour is measured with a 15-minute resolution. Thus, the peak hour might be 4:15-5:15 PM.

A.17. Peak Hour Volume

Peak Hour Volume is the vehicle count recorded during the peak hour.

A.18. Peak Hour Factor

Peak Hour Factor (PHF) measures the relationship between the peak hour volume and the maximum rate of flow within that hour.

PHF for the standard 15-minute volume resolution is described as:

$$PHF = \frac{V_h}{4 \cdot V_{15\max}}$$

V_h is the peak hour volume, and $V_{15\max}$ is the highest 15-minute volume recorded during that hour. A PHF of 1.0 indicates perfectly uniform traffic flow within the peak hour.

A.19. Preemption

Preemption is a function in most signal controllers, whereby an external source sends the controller command to change operating conditions for a special event. Preemption is often used for emergency vehicles and railroad crossings.

A.20. Platoon Ratio

Platoon ratio is a metric describing the quality of vehicle progression through an intersection. Higher ratios denote higher degrees of platooning, or AoG.

Platoon ratio R_p is calculated as:

$$R_p = \frac{P}{g/C} = \frac{CP}{g}$$

P is the proportion of vehicles arriving on green, g is the length of green in the cycle, and C is the overall cycle length.

A.21. Red Occupancy Ratio

ROR is the proportion of time that a detector is occupied during the beginning of red (default, five seconds). On the ATSPM website, the detector is at the stop bar.

A.22. Split

Split is the fraction of the overall cycle time the signal controller assigns to a particular phase. It includes the green, yellow, and red intervals.

A.23. Split Failure

Split failure occurs when a signal controller is unable to serve all the demand on a phase within a cycle. Split failure imposes delay on vehicles passing through the intersection.

A.24. Time-to-Service

On signal controllers supporting preemption, time-to-service elapses between the initiation of the preempt call and the actual servicing of the emergency movement.

A.25. Violation

In Yellow and Red Actuation, Violation is defined as a vehicle proceeding beyond the stop bar and entering the intersection during the red indication.