Georgia Department of Transportation

Automated Traffic Signal Performance Measures

Component Details

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1/23/2023

Document Control Panel	
File Name:	ATSPM_Component_Details.docx
Version No.:	
Created By:	David Bremer, Atkins
Date of First Submission:	
Updated By:	
Client Comments Received:	

Revision History Control Panel		
CREATED BY:	Philip Blaiklock, Atkins	
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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.

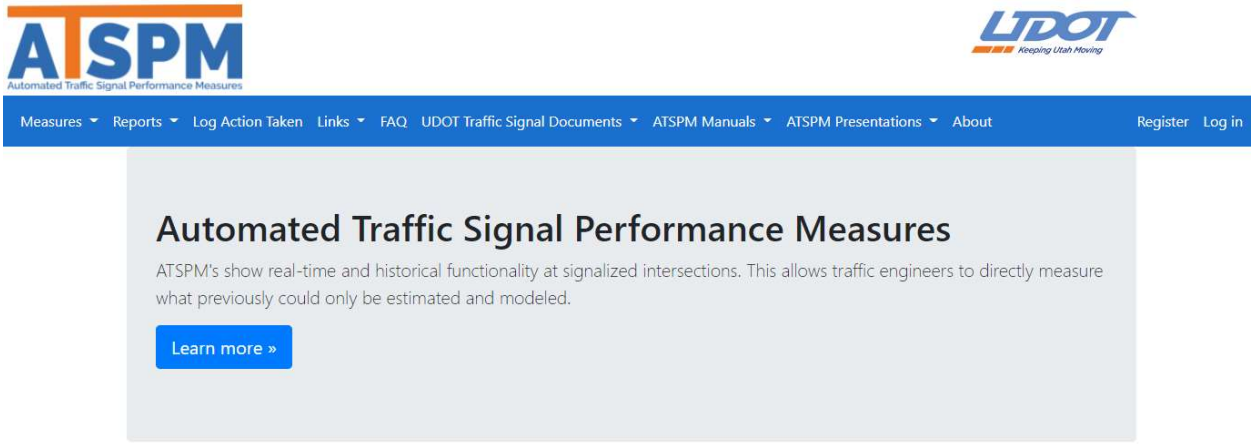


Figure 1: Automated Traffic Signal Performance Measures 4.3 About Tab

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.

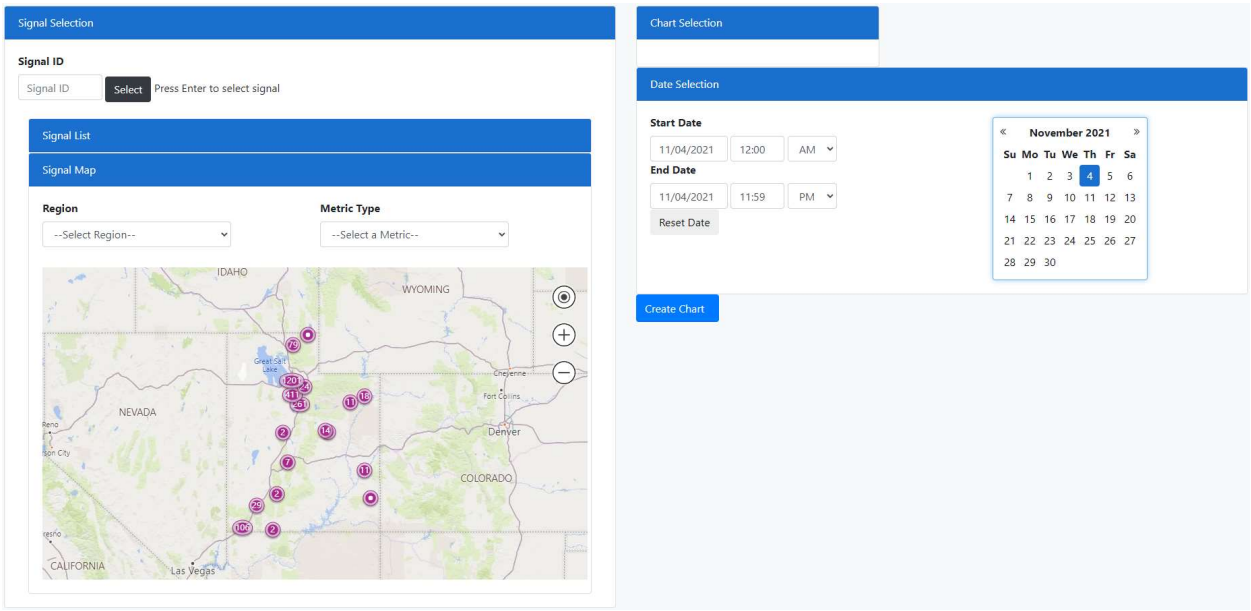


Figure 2: Default Signal Website

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.

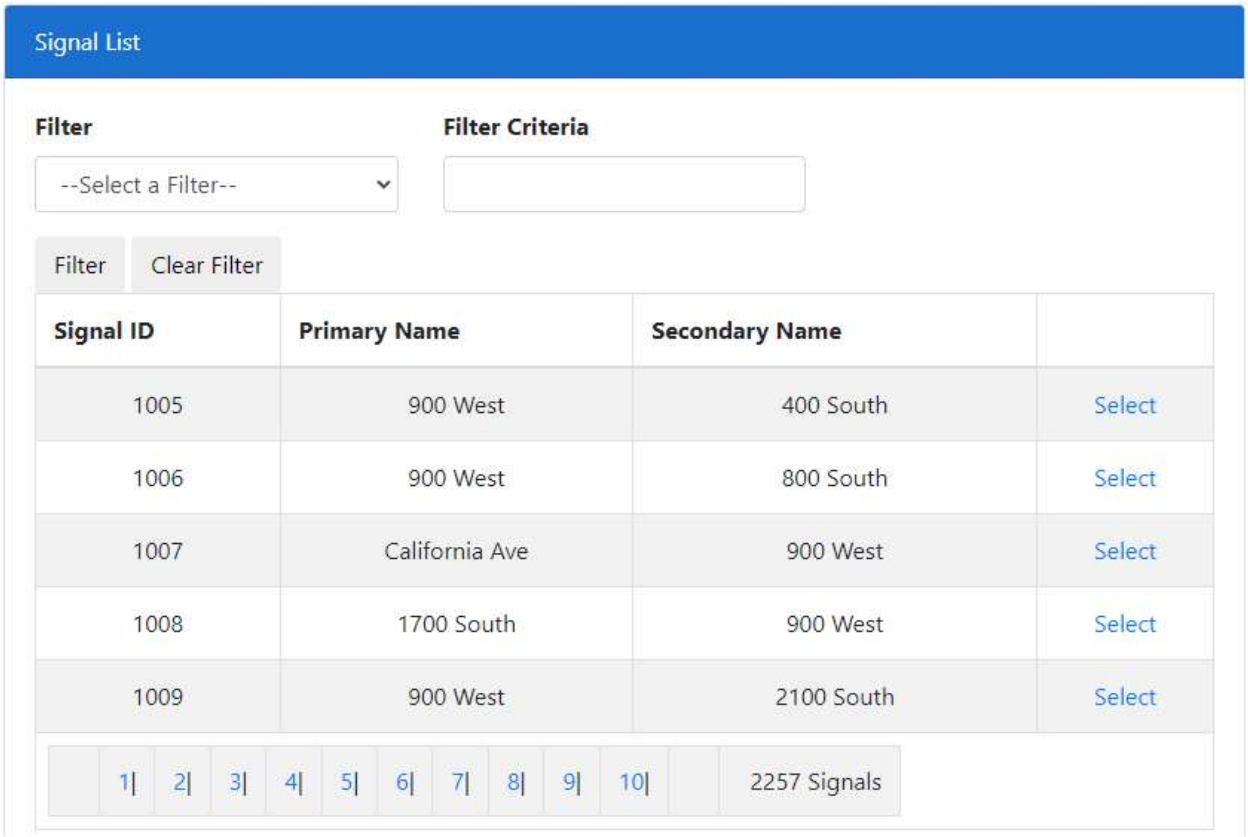


Figure 3: Signal List

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 **Area**, **Jurisdiction**, **Region**, and **Metric Type**. Choosing an **Area**, **Jurisdiction**, or **Region** displays only signals which are of that area, jurisdiction, or region. Selecting a **Metric Type** from the dropdown menu filters the map view so that it only displays signals supporting the selection. Selecting a combination of **Area**, **Jurisdiction**, **Region**, and **Metric Type** will filter the signals on the map so that a signal will only be displayed if it meets all the selected criteria. 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).

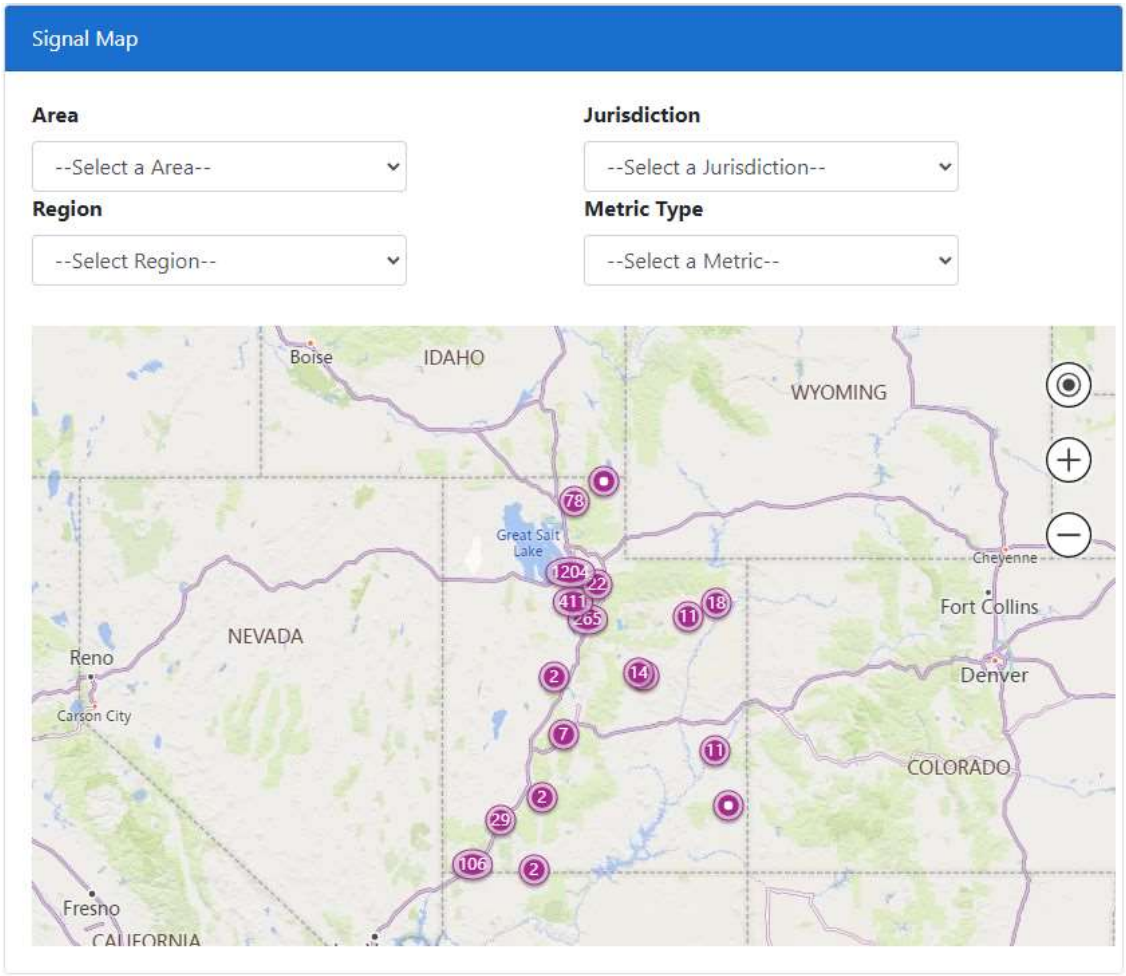


Figure 4: Signal Map

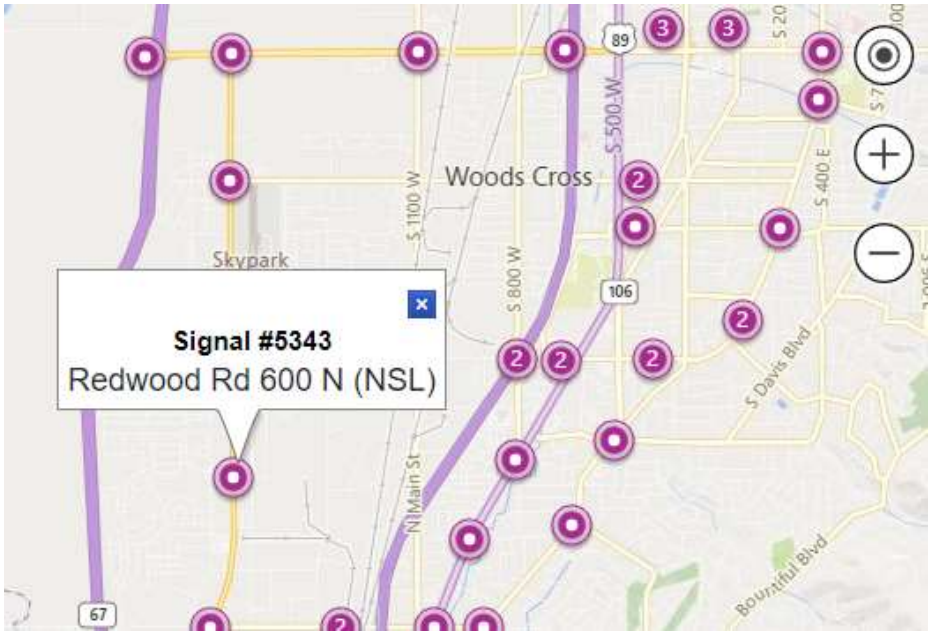


Figure 5: Signal Selected from Map

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 measures 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 measure.

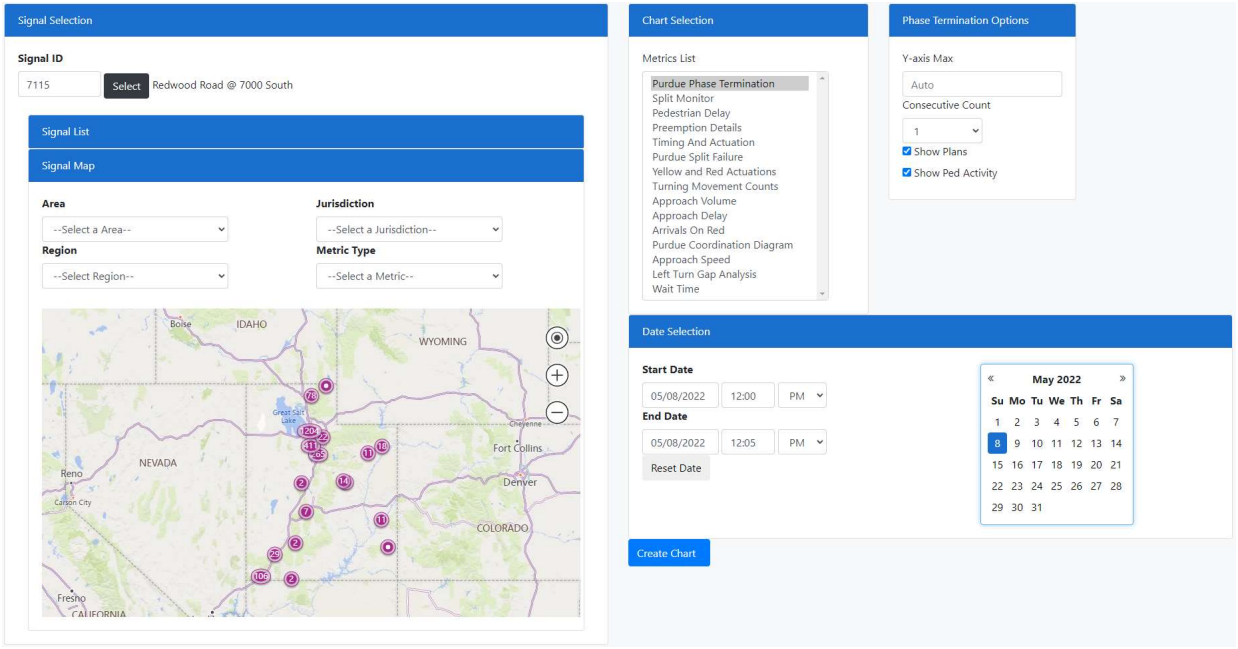


Figure 6: Chart Selection

1.1.5. Date Selection

Figure 7 shows the pane in which a time and date range may be selected for the measure. The span can be minutes, hours, days, or years. Click a day in the calendar to generate measures 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**.

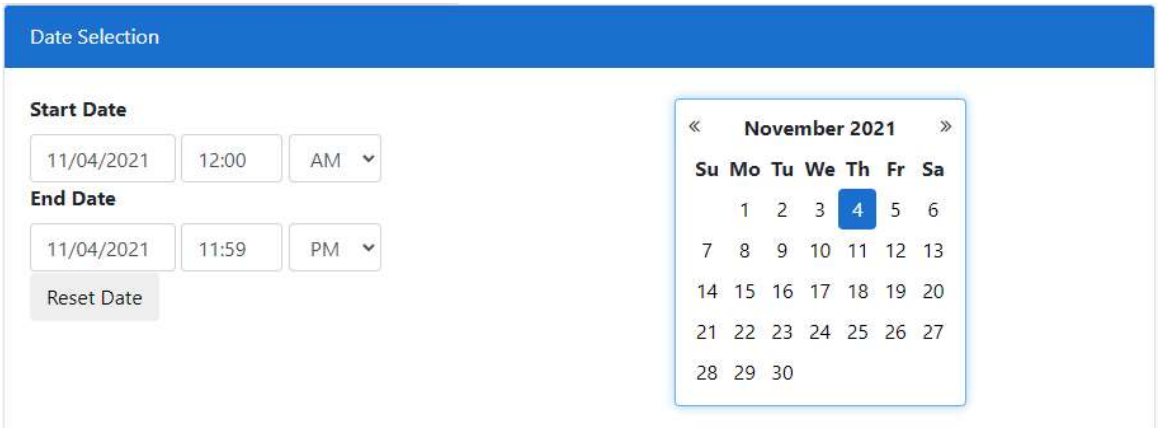


Figure 7: Date Selection

1.2. Signal Measure Types

The following is a list of Signal Measure 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
- Left Turn Gap Analysis
- Wait Time

1.2.1. Purdue Phase Termination

This measure plots the controller's phases and the reason the phase terminated. The measure 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 it 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).

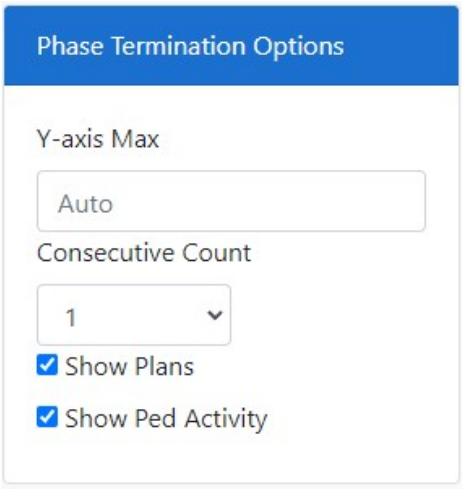


Figure 8: Phase Termination Options

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

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

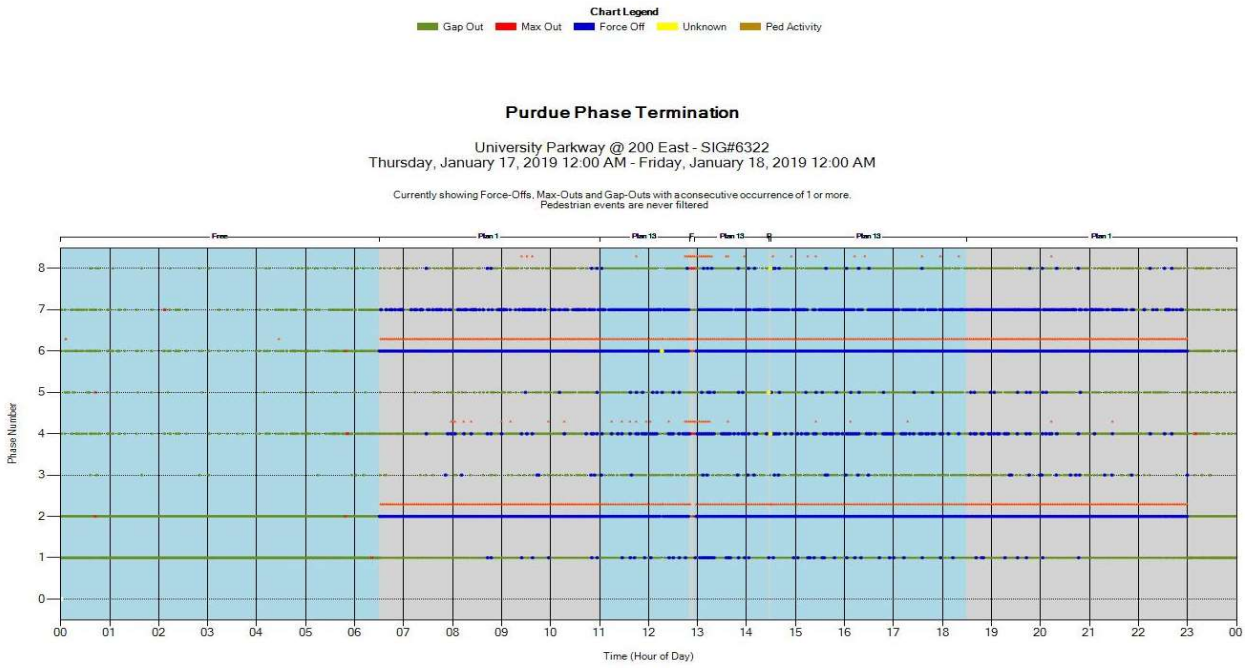


Figure 9: Purdue Phase Termination

1.2.2. Split Monitor

This measure 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.

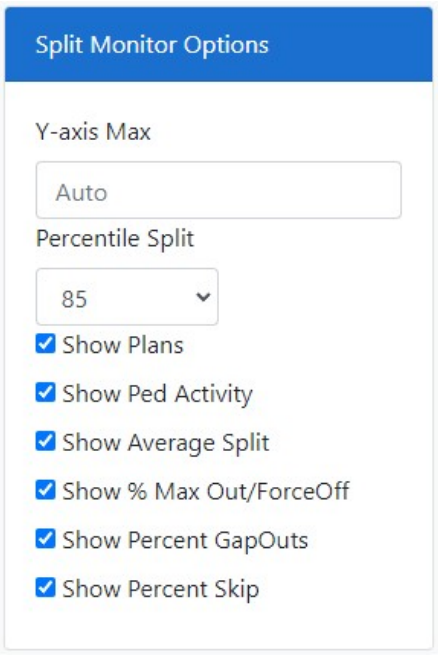


Figure 10: Split Monitor Options

- **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.

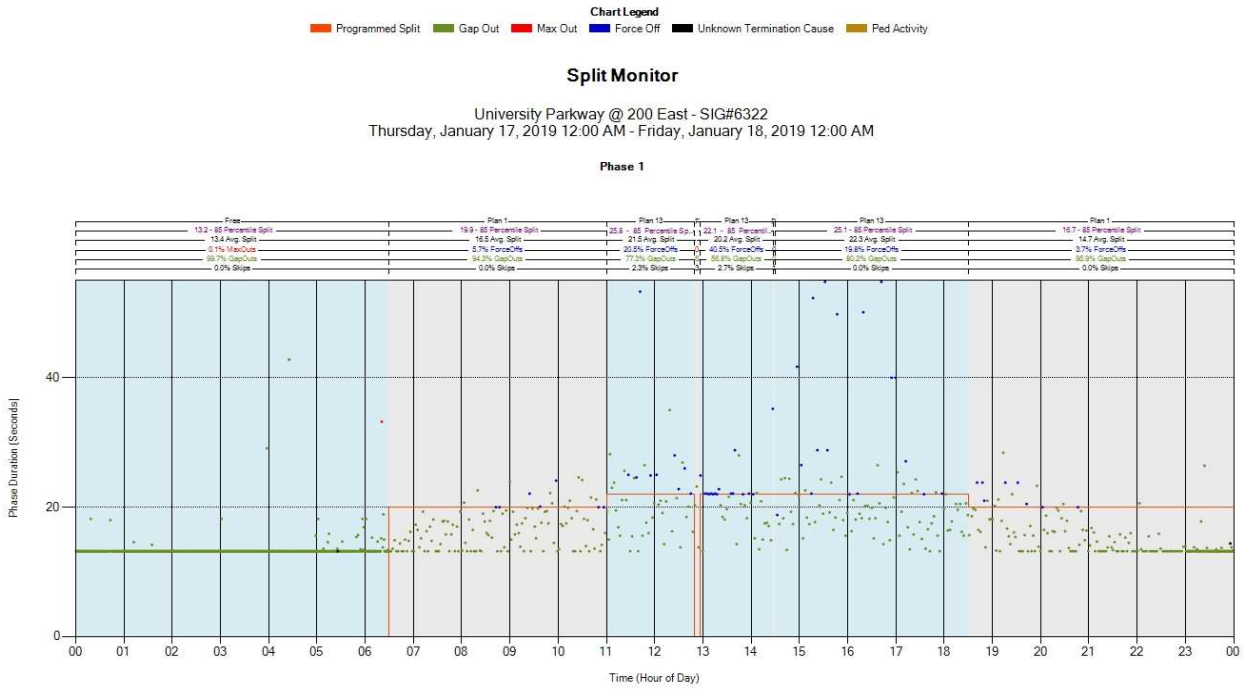


Figure 11: Split Monitor

1.2.3. Pedestrian Delay

This measure depicts the delay, in seconds, associated with each pedestrian actuation. Note that these are actual pedestrian button actuations and will show even if the coordinated phase is programmed to cycle for the pedestrian.

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

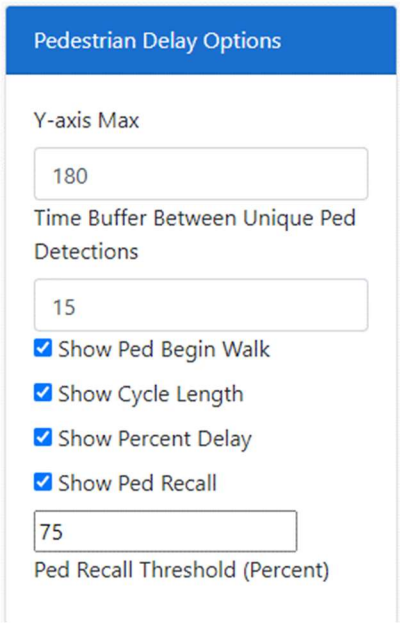


Figure 12: Pedestrian Delay Options

- **Y-axis Max:** The maximum height in seconds of the primary (pedestrian delay and cycle length) vertical axis. The default is 180 seconds.
- **Time Buffer Between Unique Ped Detections:** The duration in seconds of the time buffer to be used in calculating the time buffered presses. Any pedestrian actuations (presses) that occur within this duration of another actuation is only counted as a single press. Default is 15 seconds based on research at Utah State University in correlating push button presses to the number of pedestrians present at the signal.
- **Show Ped Begin Walk:** Plots a dot on the chart depicting the start of each begin walk interval.
- **Show Cycle Length:** Plots the cycle length on the chart.
- **Show Percent Delay:** Plots the pedestrian delay as a percent of cycle length on the chart. This option will introduce a secondary axis to the chart (percent delay by cycle length). This value is averaged by 30 minutes.
- **Show Ped Recall:** Adds a "Ped Recall On" note to the chart for any timing plan that includes the pedestrian walk interval in the number of cycles in percent as defined in the "Ped Recall Threshold (Percent).
- **Ped Recall Threshold (Percent):** The threshold to use to define what percent of cycles must have included the pedestrian walk interval to trigger the "Ped Recall On" note. Default is 75.

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

Figure 13 is an example of a Pedestrian Delay plot with a default delay axis of 180 seconds. Each dark blue bar represents the delay associated with each pedestrian actuation. Each dot represents the start of the begin walk interval. The cycle length is plotted in red, and the percent delay by cycle length is plotted on the dotted light blue line. The signal plans are color-coded and the summary information are provided above the chart for the phase and for each timing plan.

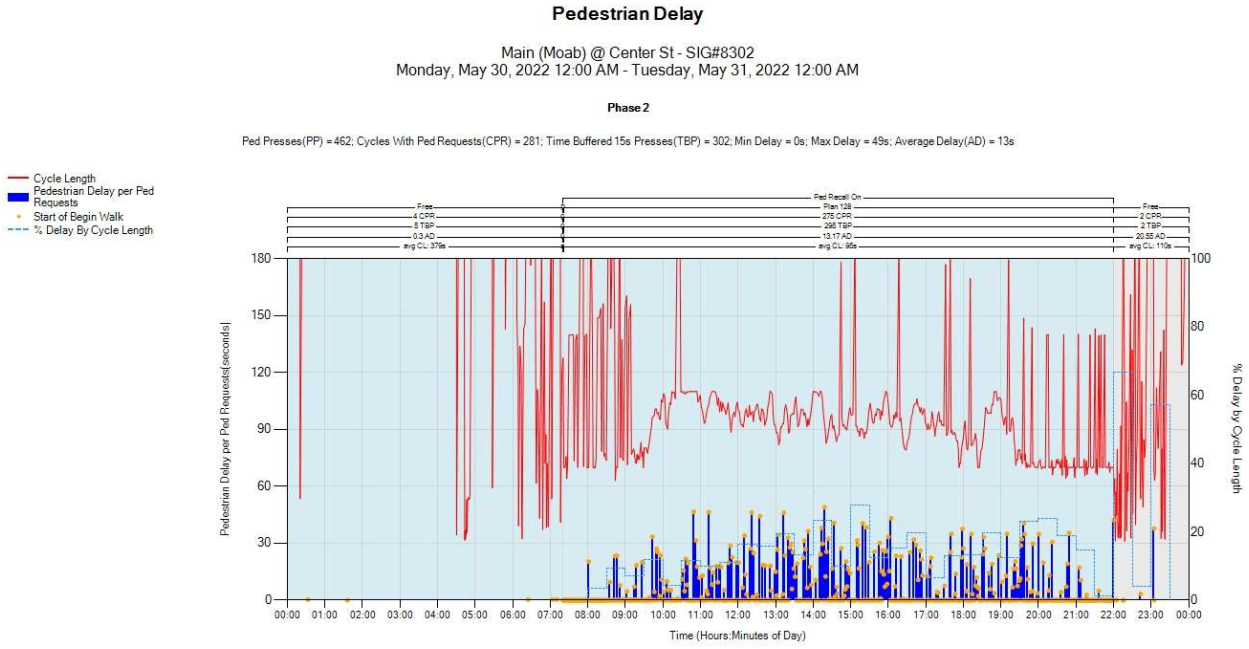


Figure 13: Pedestrian Delay

1.2.4. Preemption Details

This measure details the preemption events at the signal. This measure 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.

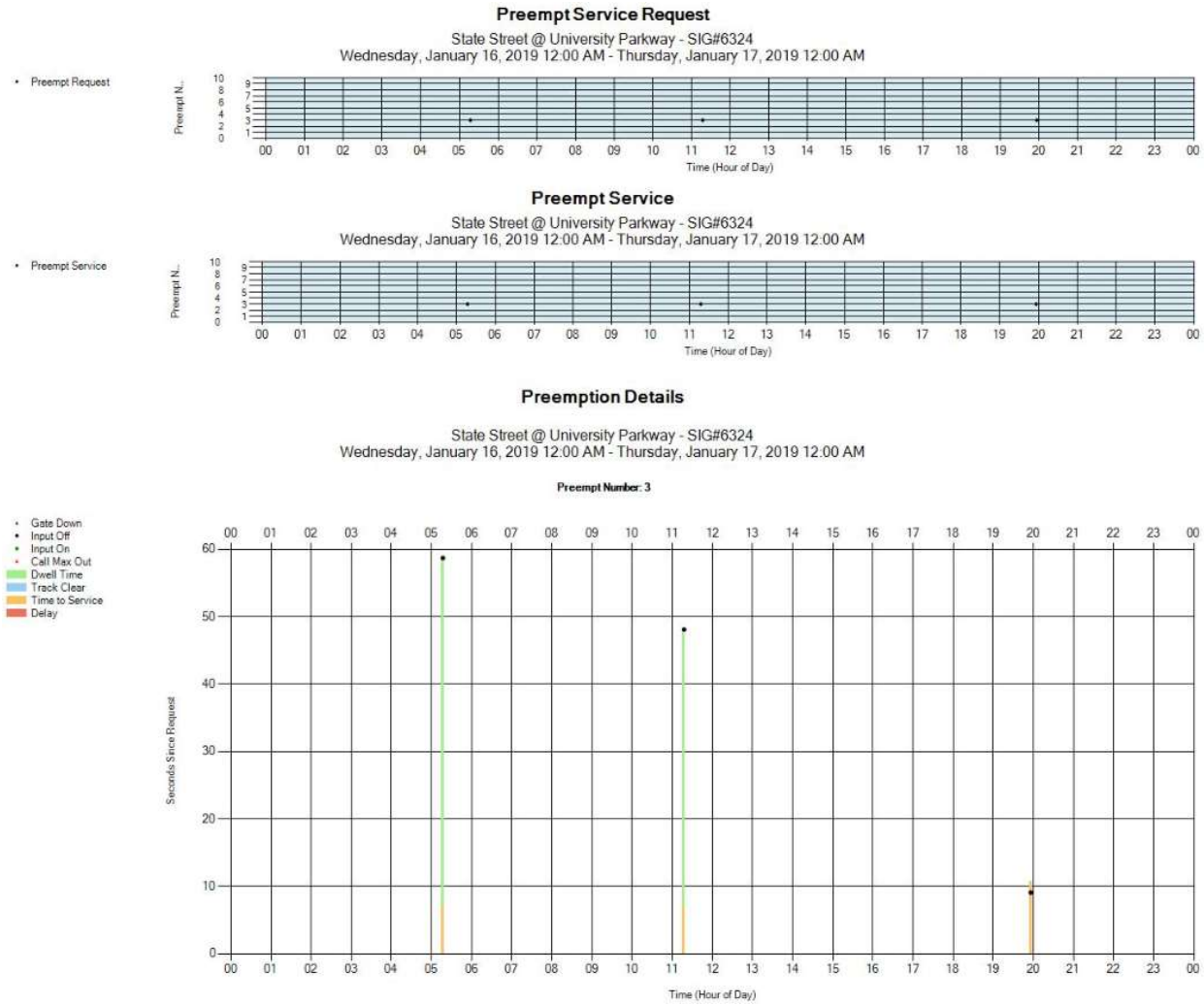


Figure 14: Preemption Details

1.2.5. Turning Movement Counts

This measure shows counts for each movement at each approach of an intersection (i.e., left, thru, right).

Figure 15 shows the options available for generating a plot when **Turning Movement Counts** is selected.

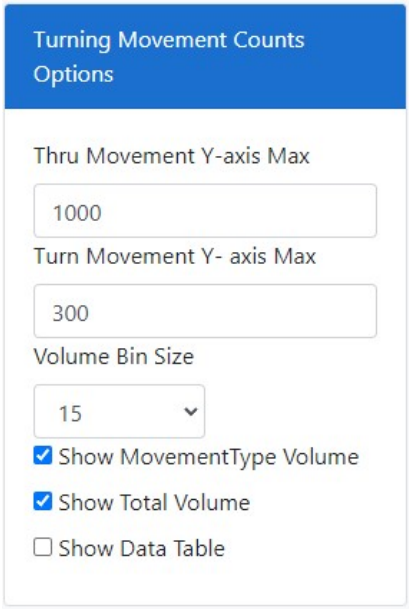


Figure 15: Turning Movement Counts Options

- **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 (i.e., two left turns are shown individually as Lane 1 and Lane 2).
- **Show Total Volume**: This is the sum of all movement type volume
- **Show Data Table**: This displays a table of the volume for each direction and lane group

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.

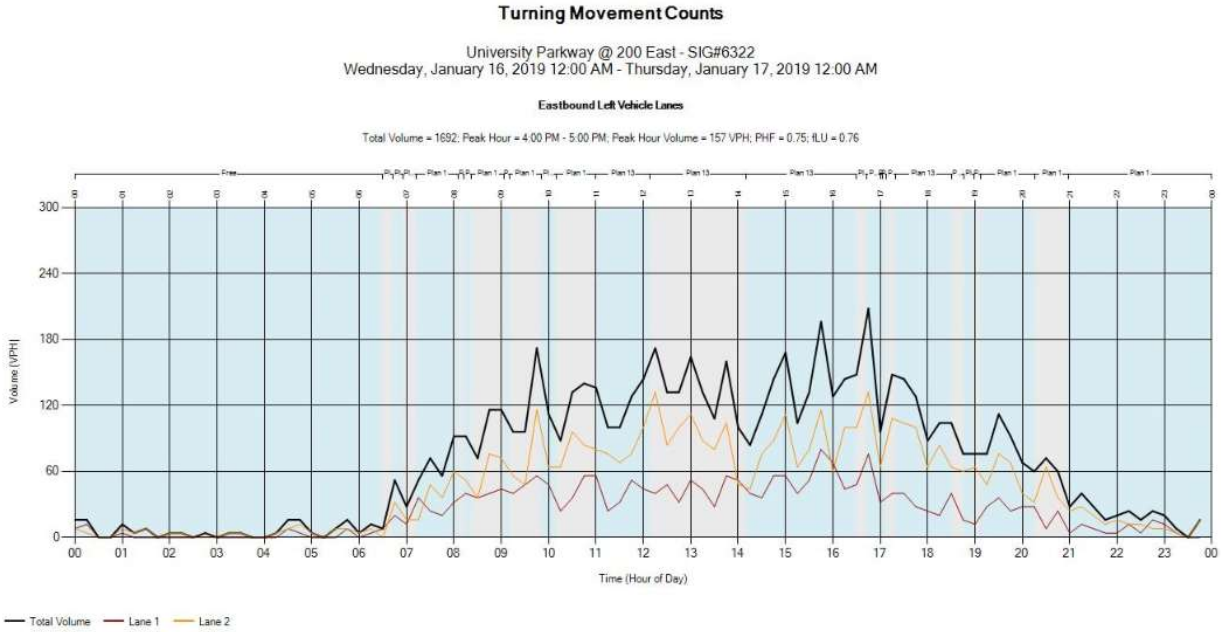


Figure 16: Turning Movement Counts

1.2.6. Purdue Coordination Diagram

The Purdue Coordinate Diagram is a powerful spatial measure. 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.

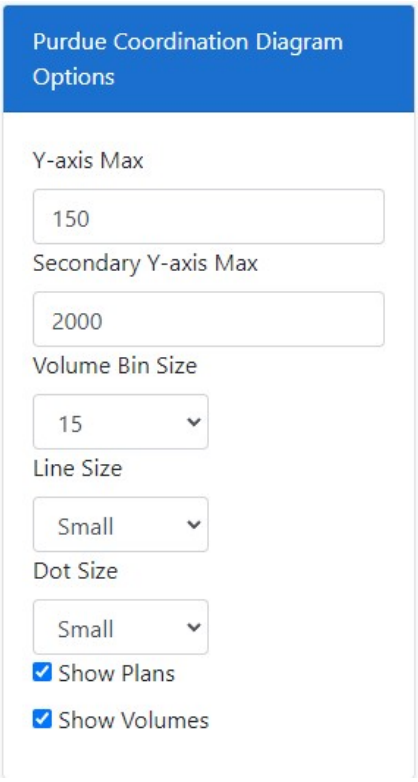


Figure 17: Purdue Coordination Diagram Options

- **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 interval, the next cycle restarts at the X-axis for the start of the red interval. 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.

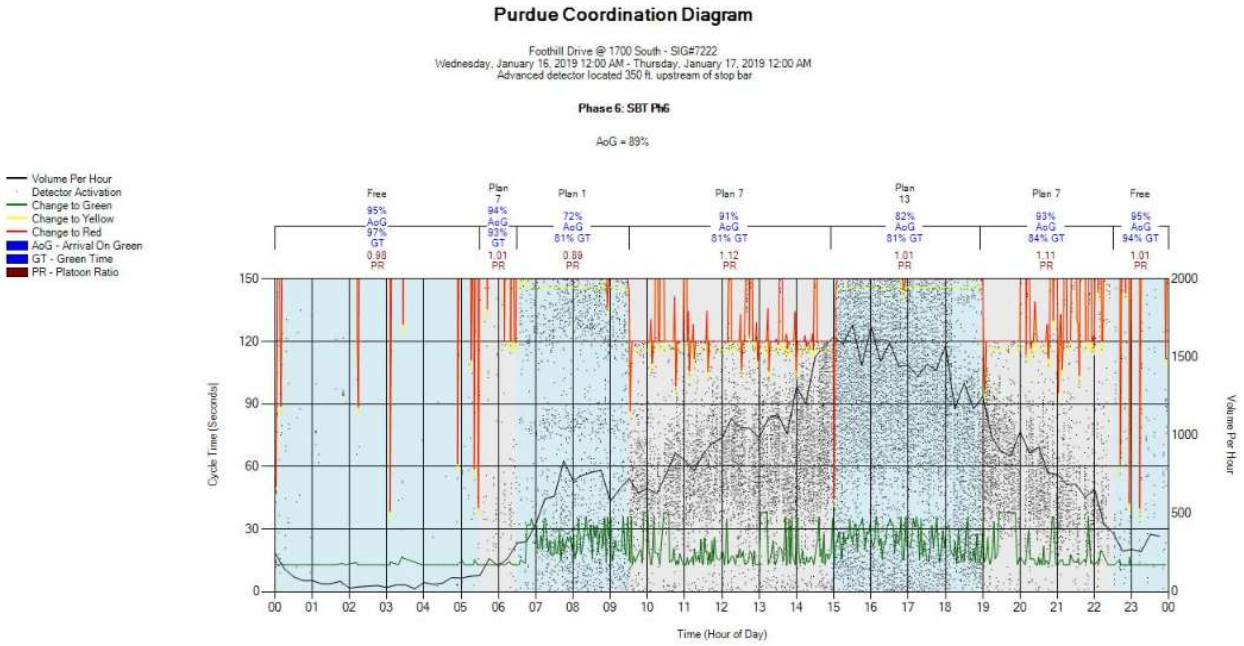


Figure 18: Purdue Coordination Diagram

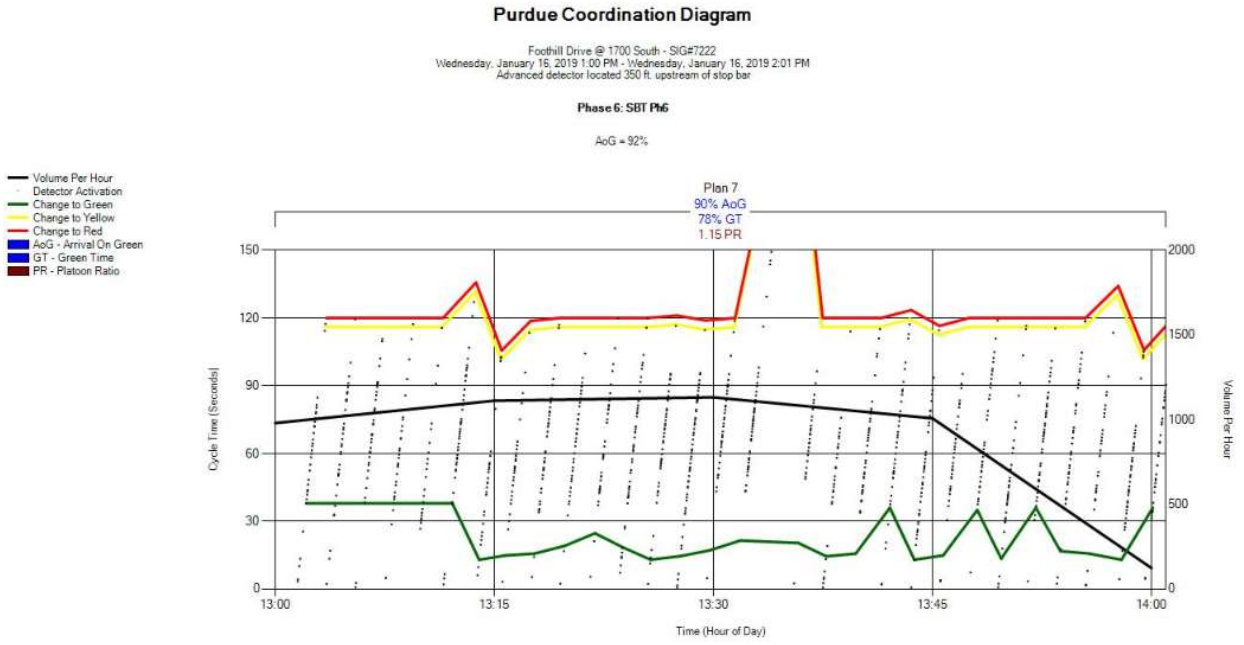


Figure 19: PCD Zoomed for Detail

1.2.7. Approach Volume

This measure 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.

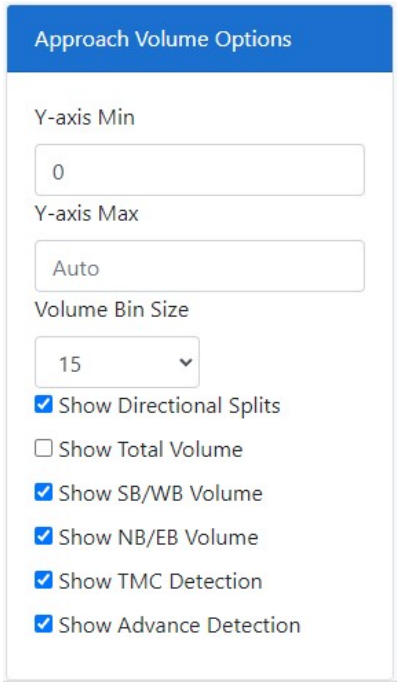


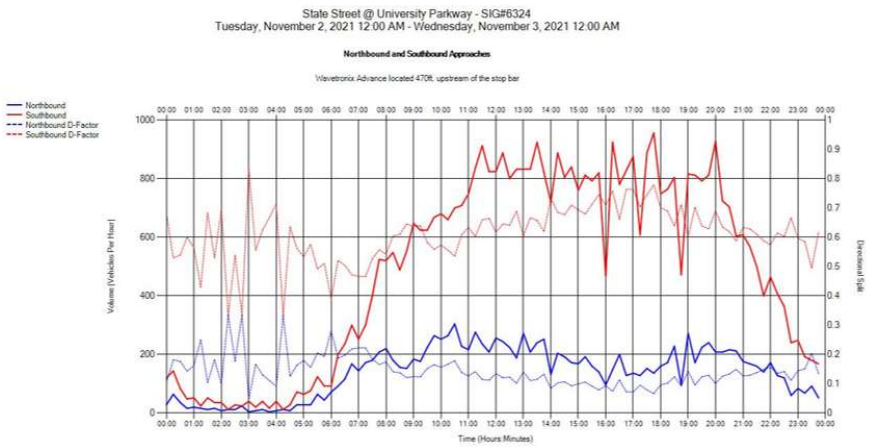
Figure 20: Approach Volume Options

- **Y-axis Min:** Constrains the minimum extent of the Y-axis of all plots to this value in vehicles per hour. Default value is **0**.
- **Y-axis Max:** Constrains the maximum extent of the Y-axis of all plots to this value in vehicles per hour. Otherwise, the plots will auto-expand to the maximum height. Default value is **Auto**.
- **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.
- **Show Total Volume:** Displays an additional line showing the sum of both directions. Default is not selected.
- **Show SB/WB Volume:** Displays the southbound and westbound volumes.
- **Show NB/EB Volume:** Displays the northbound and eastbound 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 peak hour, peak hour K factor, peak hour volume, peak hour factor, and total volume for the analysis period. These metrics are also available for each travel direction along with the D Factor for the peak hour.



Metric	Value
Peak Hour	11:30 AM - 12:30 PM
K Factor	0.073
Peak Hour Volume	1098
Peak Hour Factor	0.956
Total Volume	15141
-	-
Northbound Peak Hour	9:45 AM - 10:45 AM
Northbound Peak Hour D Factor	0.286
Northbound Peak Hour K Factor	0.063
Northbound Peak Hour Volume	271
Northbound Peak Hour Factor	0.891
Northbound Total Volume	3350
-	-
Southbound Peak Hour	11:30 AM - 12:30 PM
Southbound Peak Hour D Factor	0.785
Southbound Peak Hour K Factor	0.073
Southbound Peak Hour Volume	862
Southbound Peak Hour Factor	0.945
Southbound Total Volume	11791

Figure 21: Approach Volume

1.2.8. Approach Delay

This measure plots the 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** measure is selected.

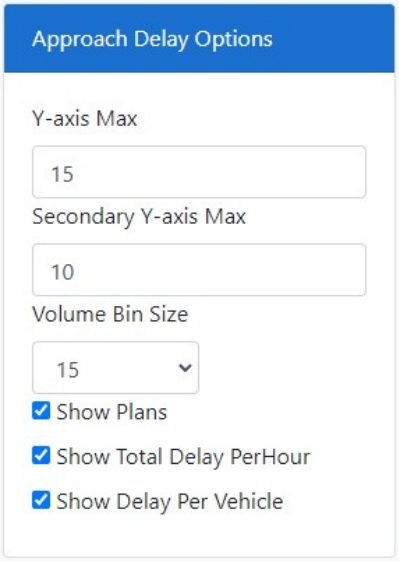


Figure 22: Approach Delay Options

- **Y-axis Max (Delay Per Vehicle):** The maximum Y-axis extent for Delay Per Vehicle, given in seconds and 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, given in hours and 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 Plans:** Located above the plot; displays average delay and total delay for each signal plan.
- **Show Total Delay PerHour:** 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.

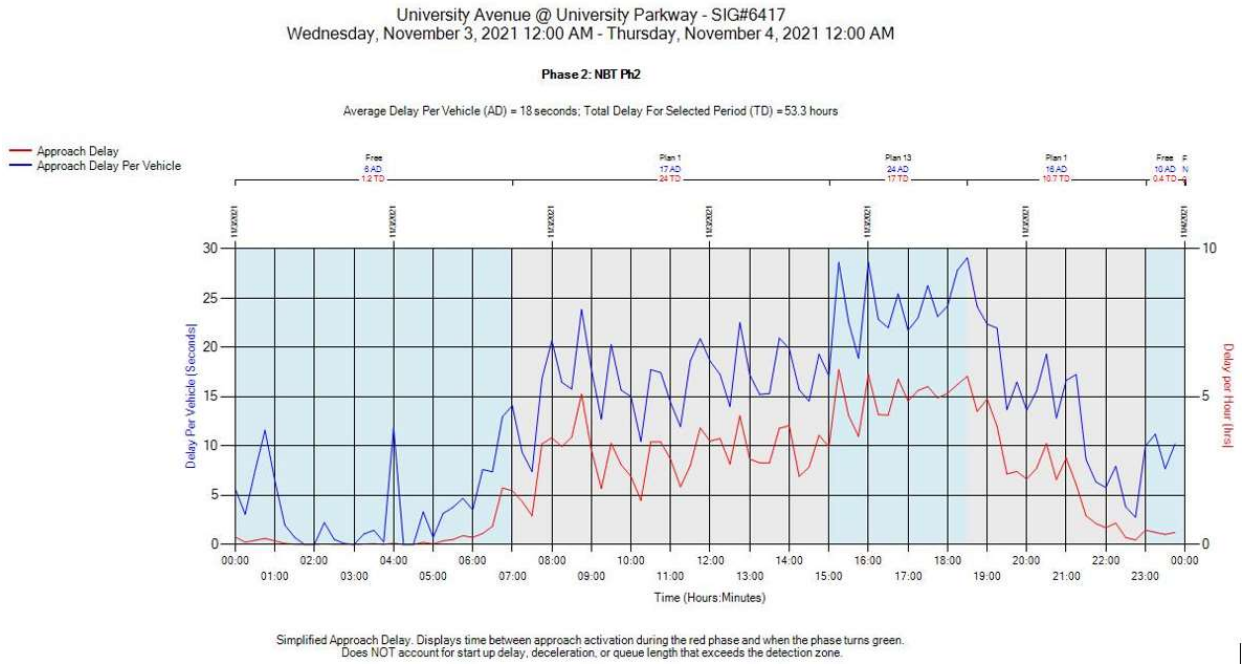


Figure 23: Approach Delay

1.2.9. Arrivals on Red

This measure 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.

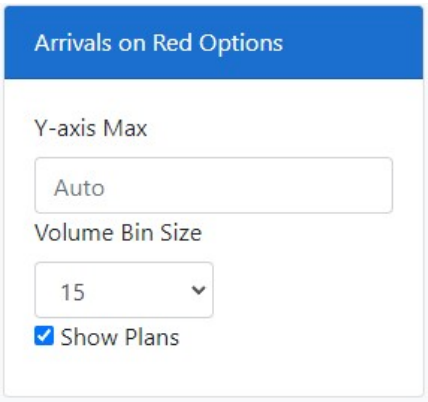


Figure 24: Arrivals on Red Options

- **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.

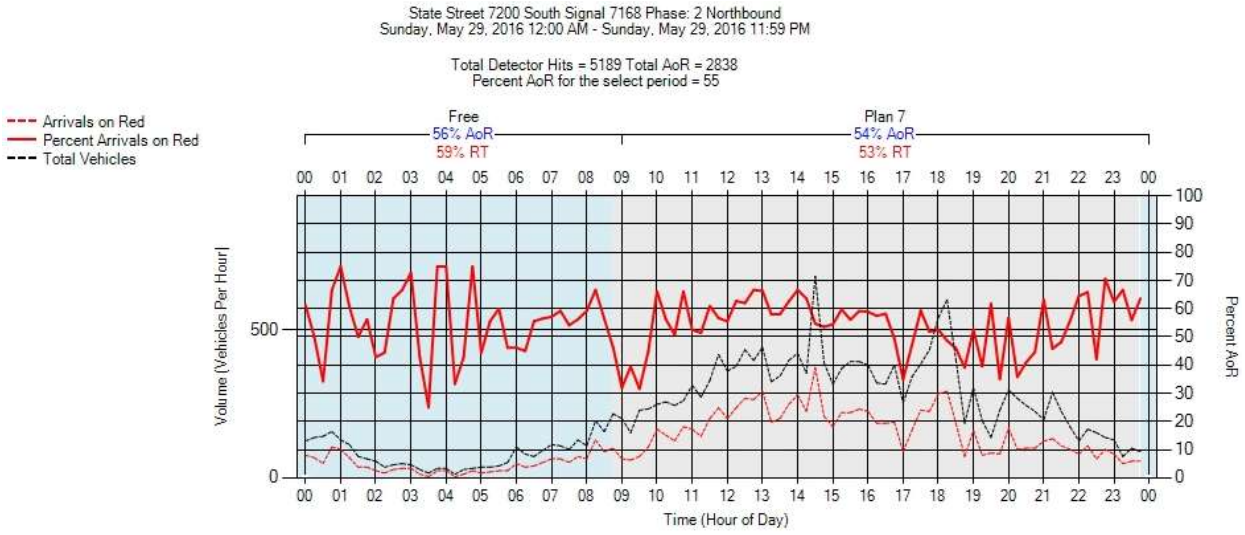


Figure 25: Arrivals on Red

1.2.10. Approach Speed

This measure tracks the speed of vehicles approaching a signalized intersection. Phases where this data are available will be plotted. This measure 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** measure is selected.

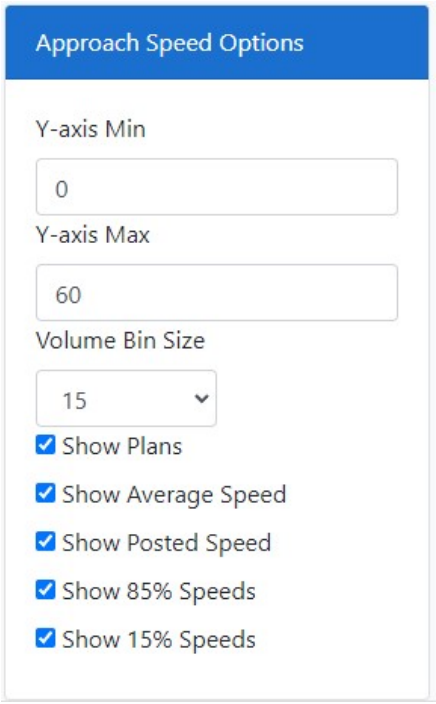


Figure 26: Approach Speed Options

- **Y-axis Min:** Defines a minimum speed extent in MPH on the Y-axis. Default is 0.
- **Y-axis Max:** Defines a maximum speed extent in MPH on the Y-axis. Default is 60.
- **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 also toggles background shading that denotes different signal plans.
- **Show Average Speed:** Displays the plotted line for average speed of approaching vehicles.
- **Show Posted Speed:** Displays a horizontal line for the posted speed limit.
- **Show 85% Speeds:** Displays the plotted line for the 85th percentile speed of approaching vehicles.
- **Show 15% Speeds:** Displays the plotted line for the 15th 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, standard deviation of speed, and 15th percentile speed for each signal timing plan within the analysis period.

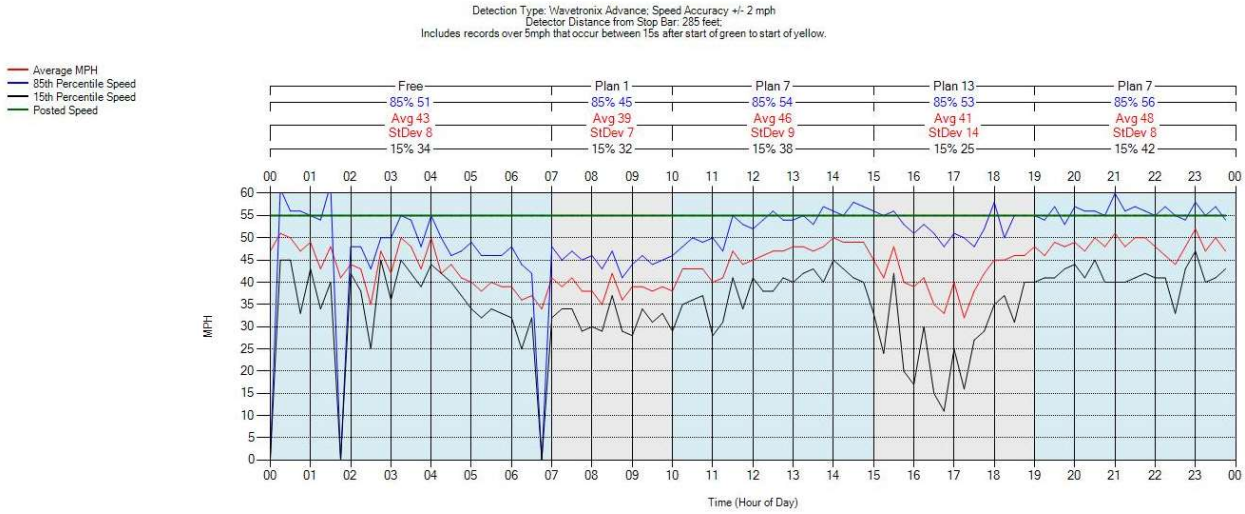


Figure 27: Approach Speed

1.2.11. Yellow and Red Actuations

This measure 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 help identify engineering countermeasures to deal with red light running.

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

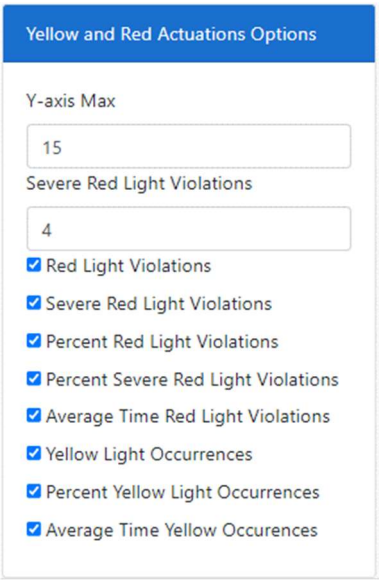


Figure 28: Yellow and Red Actuations Options

- **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 threshold number of seconds since the start of the red clearance after which a vehicle actuation is considered to be a severe red light violation. The default value is 4 (estimated from the average summation of red clearance time plus start-up loss time). As of 9/2021, the value 4 is hard-coded and changing the value in the entry field will not change the calculations or plots.
- **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 red light violations 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 severe 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 red light violation occurs (relative to the end of the yellow clearance interval) 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 vehicles passing through the yellow light 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 number and percentage of red light violations relative to total flow.
- **Severe Violations:** Over the entire analysis period, the number and percentage of severe red light violations relative to total flow.
- **Yellow Light Occurrences:** Over the entire analysis period, the number and percentage of yellow light violations relative to total flow.

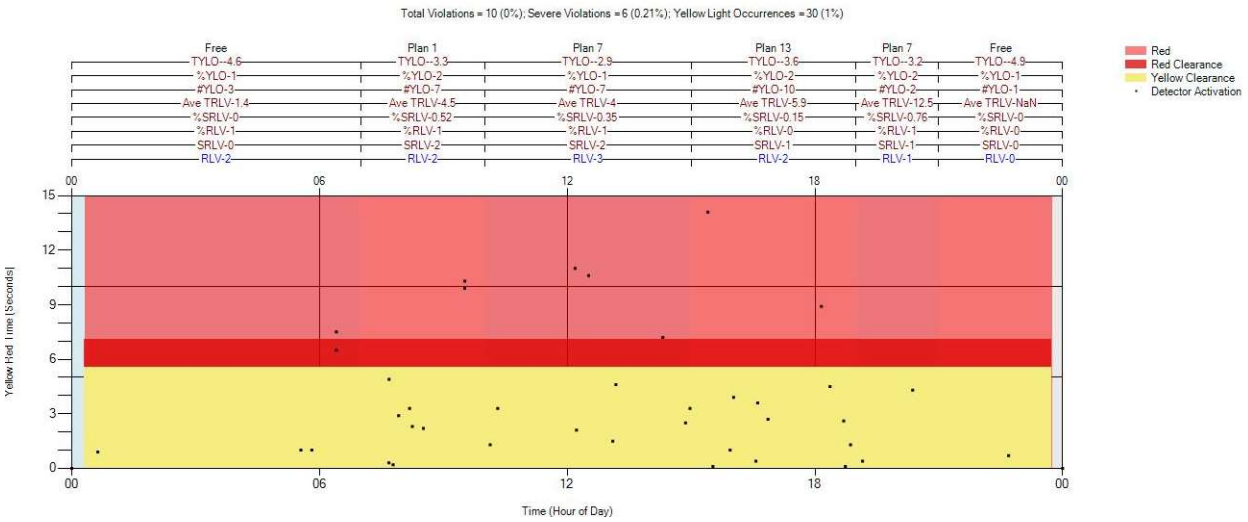


Figure 29: Yellow and Red Actuations

1.2.12. Purdue Split Failure

Purdue Split Failure relies on stop bar presence detection, either by lane group or lane-by-lane. This measure 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 measure. The GOR and ROR are calculated and plotted when both gap out and force off occur. When the occupancy ratios both exceed 79 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** measure is selected.

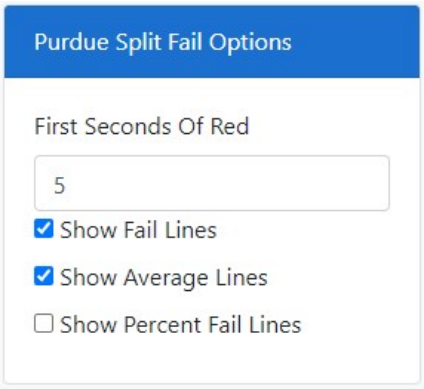


Figure 30: Purdue Split Fail Options

- **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 failures.
- **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 the northbound through phase. The GOR and ROR for gap outs and force offs are depicted with green and red points. Split failures are depicted with vertical yellow lines. Further, for the duration of each signal plan the total number and percentage of cycles with split failures are calculated. Finally, the total number of split fails for the analysis period is reported in the top header.

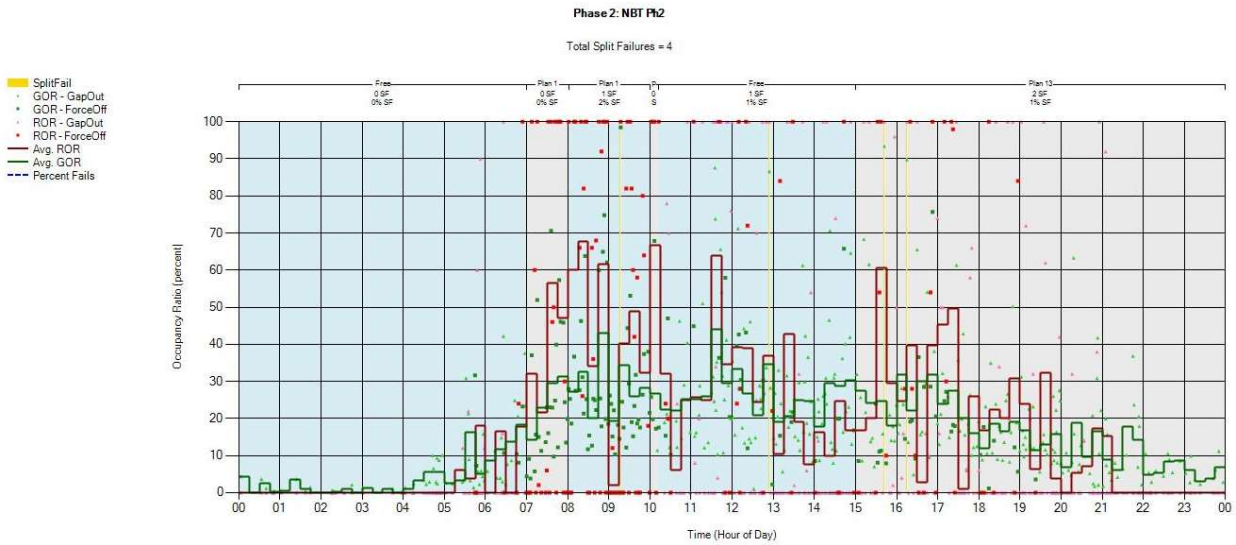


Figure 31: Purdue Split Failure

1.2.13. Timing and Actuation

This measure 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 measure allows for custom enumeration codes to be plotted for further analysis. This measure is most useful for mesoscopic level (approximately 60 minutes or less) of detail. Since mesoscopic level of analysis will most likely be used with this measure, 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.

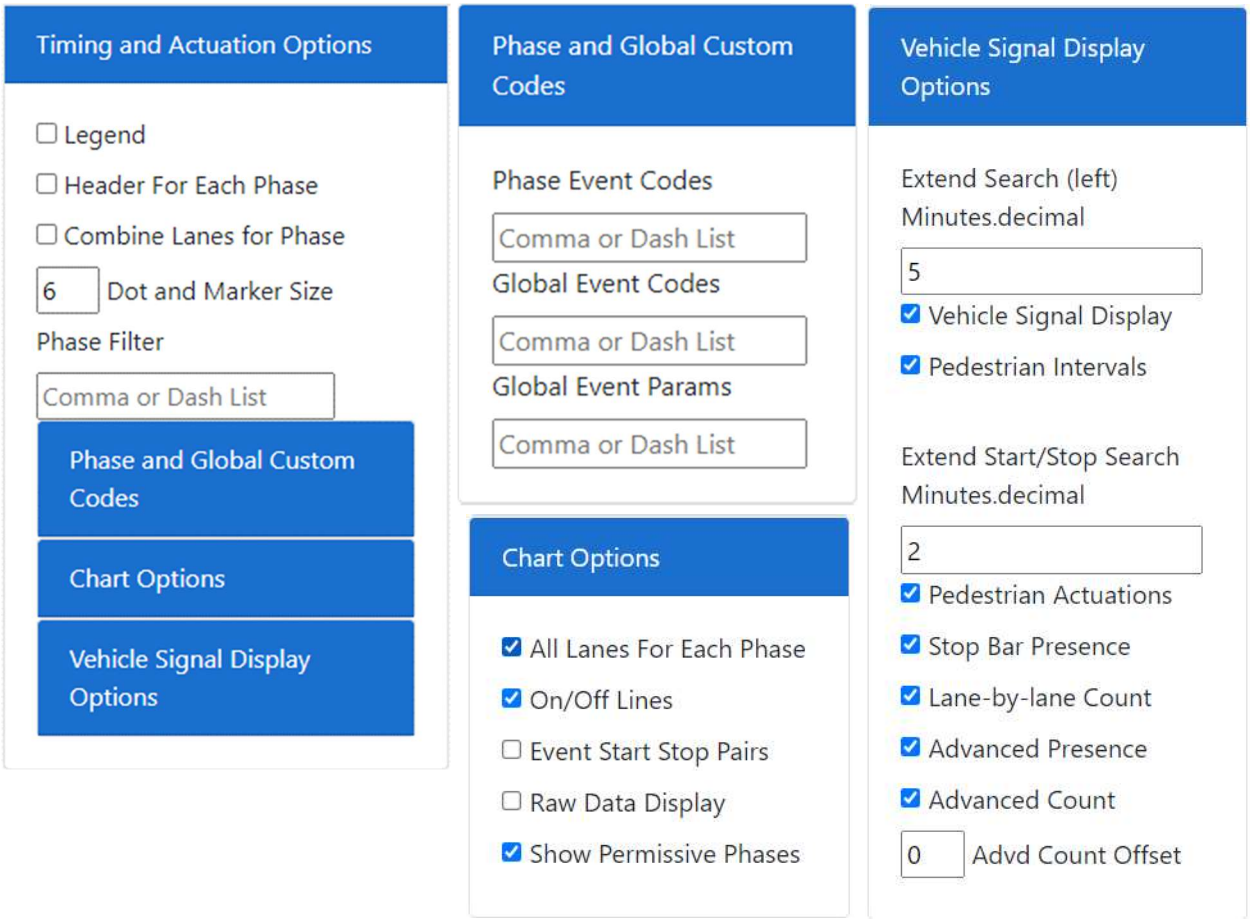


Figure 32: Timing and Actuation Options

Timing and Actuation Options

- **Legend:** Displays the legend for the Timing and Actuation measure, showing 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 measure with the location description, signal ID number, and time and date range will be shown above each phase chart. 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. By default, this is unchecked.
- **Dot and Marker Size:** The size of black lines, triangles, and gray squares depicting detector activations. Default is 6.
- **Phase Filter:** Displays only the selected phase or phases (listed using commas and/or dashes to separate multiple phases).

Phase & Global Custom Codes

- **Phase Event Codes:** Will display the listed phase event code enumerations under each phase.

- **Global Event Codes:** Will display the listed global event code enumerations on a separate chart.
- **Global Event Params:** Will display the listed 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, 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.
- **Show Permissive Phases:** Displays charts for all configured phases (while still adhering to any other specifications in the analysis options). If unchecked, then the analysis will be omitted for any permissive phases and only protected phases (including throughs) will be shown.

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), and 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) beyond the analysis time range for vehicle and pedestrian detection actuations used to help the context of the beginning and end of the analysis range to be accurate.
- **Pedestrian Actuations**: Displays the pedestrian actuations (on & off) each time the pushbutton is activated.
- **Stop Bar Presence:** Displays the Stop Bar Presence actuations as mapped in the Signal Configuration.

- **Lane-by-lane count:** Displays the lane-by-lane count actuations as mapped in the Signal Configuration.
- **Advanced Presence:** Displays the Advanced Presence actuations as mapped in the Signal Configuration.
- **Advanced Count:** Displays the Advanced Count actuations as mapped in the Signal Configuration. Since advanced count actuations are in advance of the stop bar, this feature was added so the advanced count actuations can be compared to the stop bar actuations.
- **Advd Count Offset:** This will offset the Advanced Count actuations for each phase as mapped in the Signal configuration by the specified number of seconds (carried out to as many decimals as desired). If any amount of time is entered in here (other than zero), the triangles on the graphs 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 up to 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:

- Every 1 hour for analysis periods >2 hours
- Every 5 minutes for analysis periods > 1 hour to 2 hours
- Every 2 minutes for analysis periods > 10 minutes to 1 hour
- Every 30 seconds for analysis periods > 5 minutes to 10 minutes
- Every 15 seconds for analysis periods > 3 minutes to 5 minutes
- Every 3 seconds for analysis periods > 1 minute to 3 minutes
- Every 2 seconds for analysis periods 1 minute or less

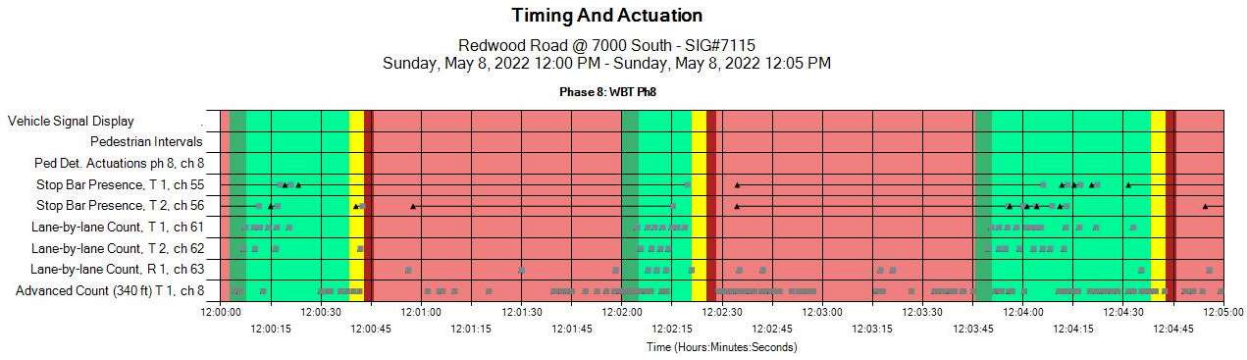


Figure 33: Timing and Actuation

The Timing and Actuation measure 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.

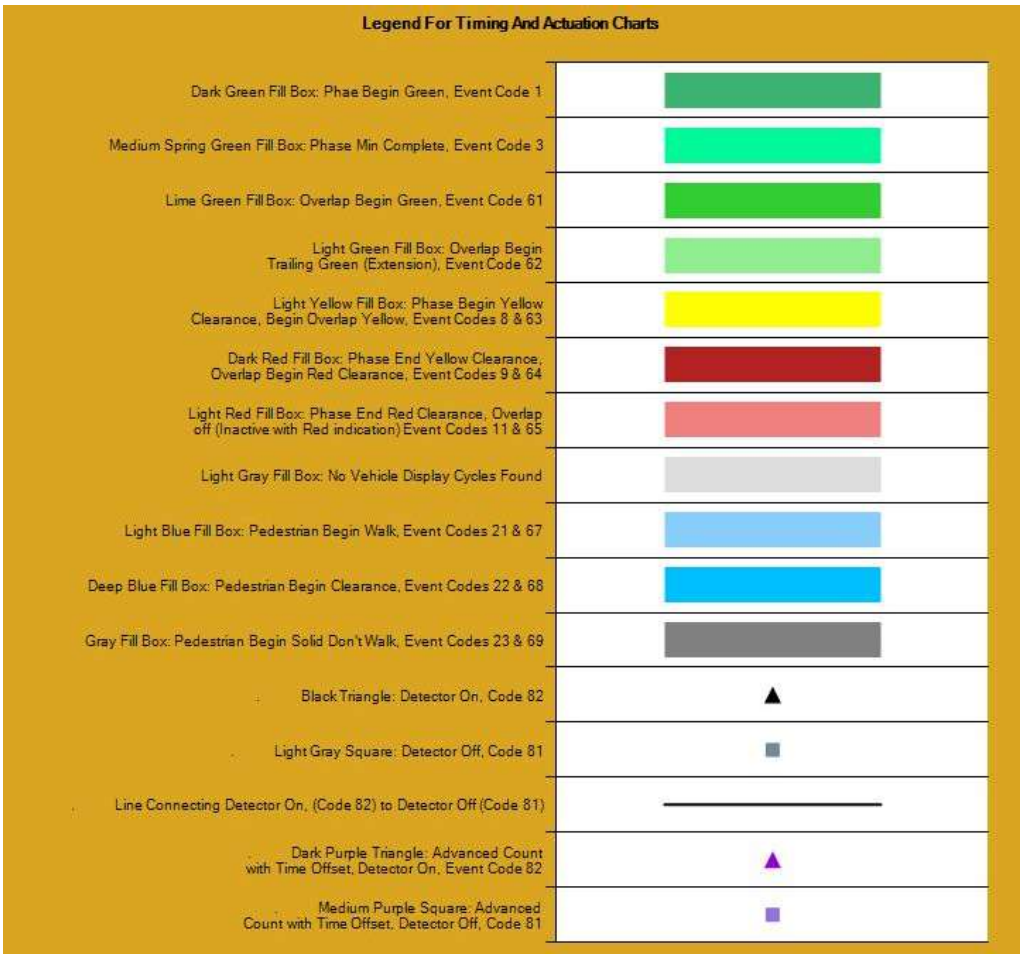


Figure 34: Legend for Timing and Actuation Charts

1.2.14. Left Turn Gap Analysis

This measure is used to evaluate available gaps in opposing traffic for a left turn to make a permissive movement. The measure 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 measure: 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 measure 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 measure 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.

Figure 35 shows the options available for generating the plot when the **Left Turn Gap Analysis** measure is selected.

Figure 35 Left Turn Gap Analysis Options

- **Gap 1 Range:** This is the range of gap sizes in seconds that will be displayed in red on the chart. The lower threshold is exclusive, and the upper threshold is inclusive. Default is 1.0 to 3.3.
- **Gap 2 Range:** This is the range of gap sizes in seconds that will be displayed in light green on the chart. The lower threshold is exclusive, and the upper threshold is inclusive. Default is 3.3 to 3.7.
- **Gap 3 Range:** This is the range of gap sizes in seconds that will be displayed in dark green on the chart. The lower threshold is exclusive, and the upper threshold is inclusive. Default is 3.7 to 7.4.
- **Gap 4 Range:** This is the lower bound of gap sizes in seconds that will be displayed in turquoise on the chart. This lower threshold is exclusive. Default is 7.4.
- **Trend Line Gap Threshold:** This is the lower bound of gap sizes in seconds that will be displayed as a line showing the percent of gaps exceeding this threshold (plotted using the secondary Y-axis). Default is 7.4.
- **Bin Size:** This is the resolution in minutes to which the left turn gap analysis trends will be analyzed and displayed. Default is 15.

The default 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 36 shows an example Left Turn Gap Analysis plot with all options in their default settings. The red, light green, dark green, and turquoise bars show the number of gaps in each bin size that fit in the threshold ranges for each gap group. The blue line shows the percent of gaps that are larger than the specified trend line gap threshold. A legend is given at the top of the chart, defining the bounds of the colored bars and trend line threshold. The chart also displays the permissive phase number of the left turn for which gaps in the opposing through traffic are analyzed.

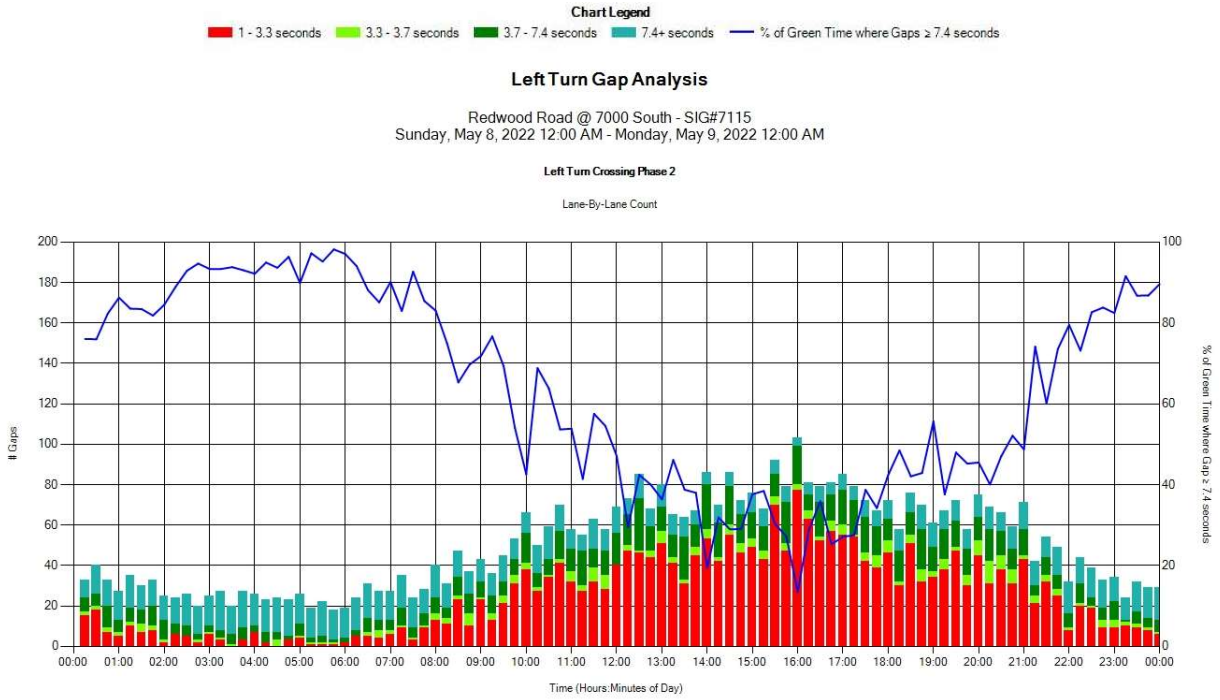


Figure 36: Left Turn Gap Analysis

1.2.15. Wait Time

This measure plots the wait time for each phase, defined as the time duration (in seconds) between when a call is placed on the phase by the controller and the following time when the indication for that phase turns green.

Figure 37 shows options available for generating a plot when the **Wait Time** measure is selected.

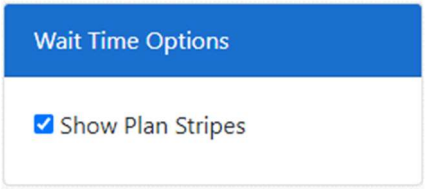


Figure 37: Wait Time Options

- **Show Plan Stripes:** Toggles the chart timing plan sections which (if toggled on) are shown above the plot and display the average and maximum wait time for each signal plan.

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

Figure 38 is a sample Wait Time plot. The pink line represents the average wait time delay associated with each time interval, and the orange line represents the programmed split for the phase. The blue line represents the vehicular volume per hour of the movement for each time interval. The dots on the chart represent individual wait times (one per phase) and are color-coded to match the termination type of the previous phase. A green dot represents a gap out, a red dot represents a max out, a blue dot represents a force off, and a black dot represents any unknown reason for termination. The chart also shows the average wait time and maximum wait time delay in seconds for the duration of each timing plan.

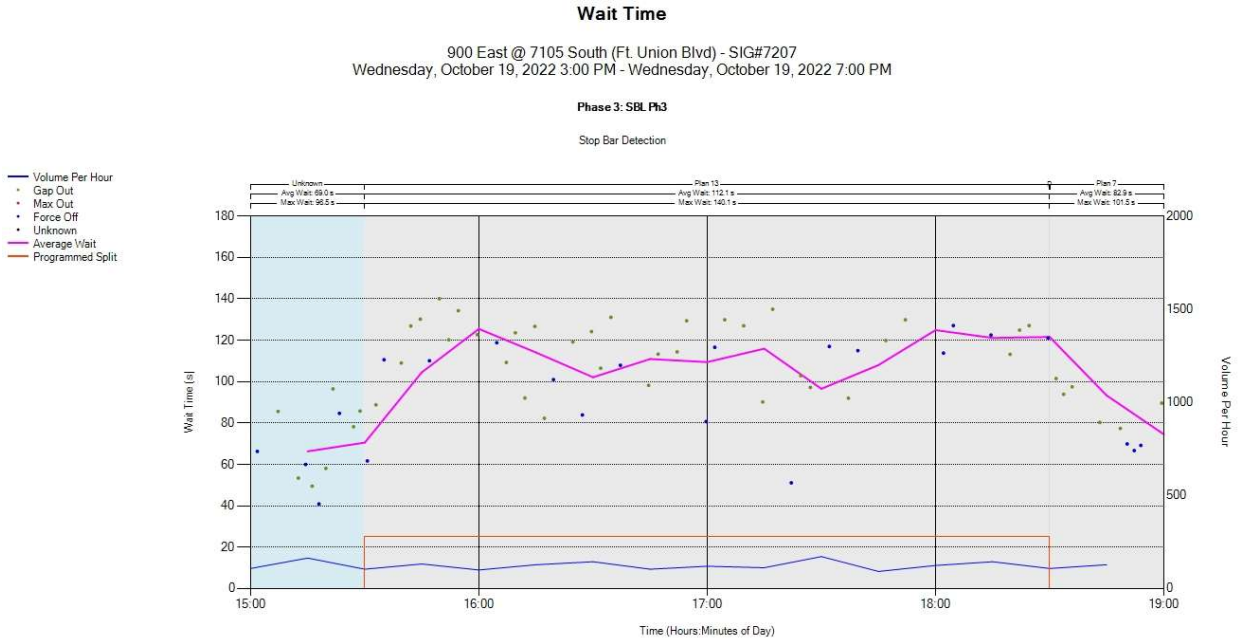


Figure 38: Wait Time

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 39) after which the desired metric options (see Figure 40) can be selected. These metric options are:

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

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 39: Signals along Route

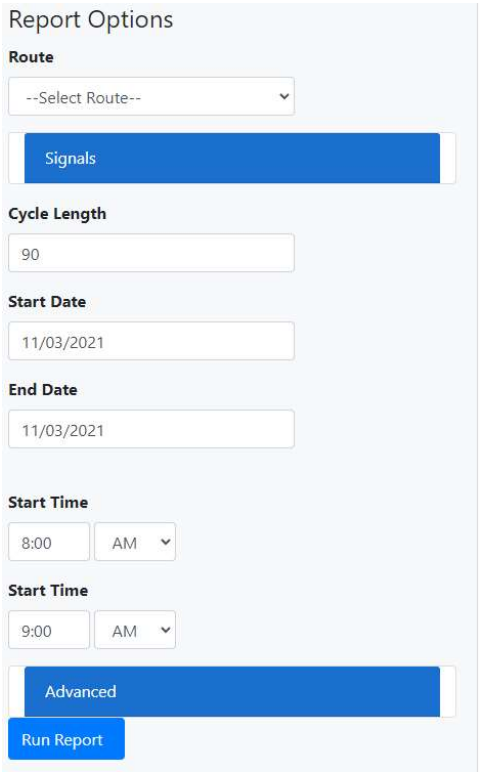


Figure 40: Link Pivot Analysis Options

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 described by the main street and cross street names. Link 1 in the example below (Figure 41) is Foothill Drive at Thunderbird.
- The recommended **Link Delta** for each signal. The Link 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	0	45	0	45
2	7223	Foothill Drive 2100 South	6	6	45	0	45
3	7222	Foothill Drive 1700 South	69	69	39	0	39
4	7221	Foothill Drive 2300 East	2	2	60	0	60
5	7220	Foothill Drive 1300 South	1	1	58	0	58
6	7503	Foothill Drive 2100 East	90	90	57	0	57
7	7219	Foothill Drive Sunnyside	57	57	57	0	57
8	7218	Foothill Drive Wakara Way (660 S.)	0	0	0	0	0
9	7217	Foothill Drive Mario Capecchi Dr (1950 E.)	0	0	0	0	0

Figure 41: Link Pivot Adjustments

The **Approach Link Comparison** table (see Figure 42) details upstream and downstream signals, upstream and downstream directions, 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 43).

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	PCD Options
	Foothill Drive Thunderbird	Foothill Drive 2100 South	87%	87%		90%	90%		**88%**	**88%**			

Figure 42: Approach Link Comparison

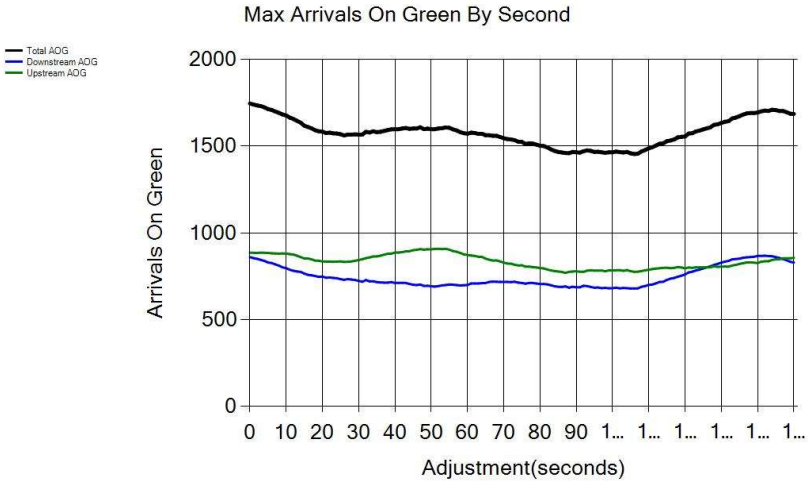


Figure 43: Max Arrivals on Green by Second

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 44) 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 are 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.

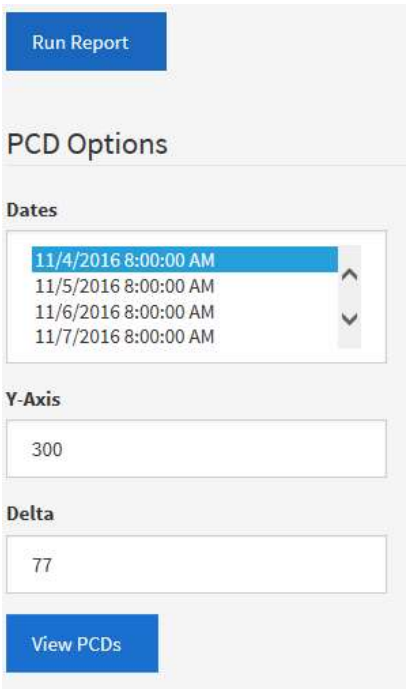


Figure 44: Link Pivot PCD Options

For the selected intersection and time period, the number and percentage of AOG are shown – for both existing and optimized conditions (see Figure 45).

See the Purdue Coordination Diagram for additional information on this metric.

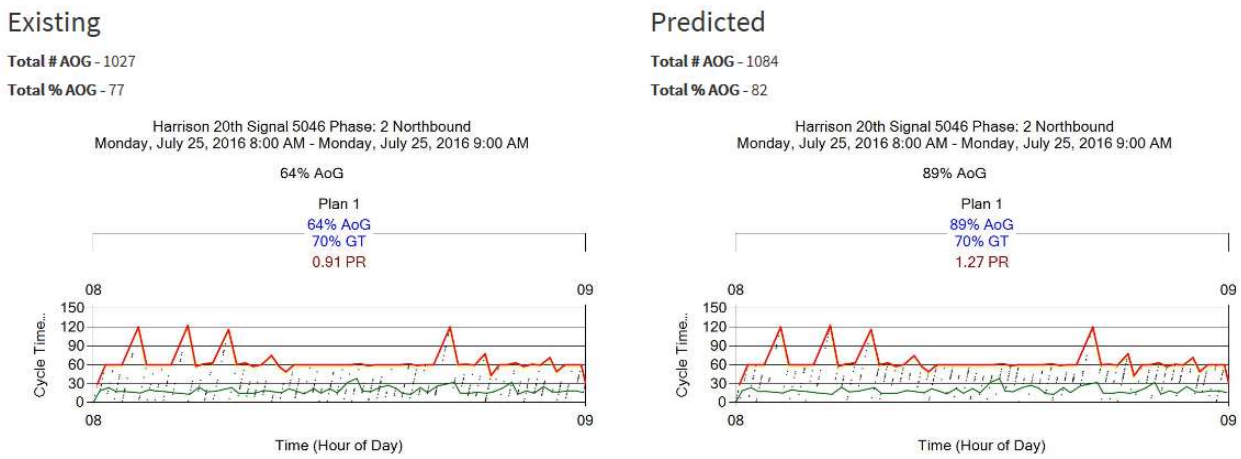


Figure 45: Purdue Coordination Diagram for Purdue Link Pivot

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 also shows 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. 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 46) 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 47) displaying the number of times each measure was run. This graph is based on all reports ran by all users; the ATSPM website counts them automatically and the data are reported in this chart.
- **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 measures.

- **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**

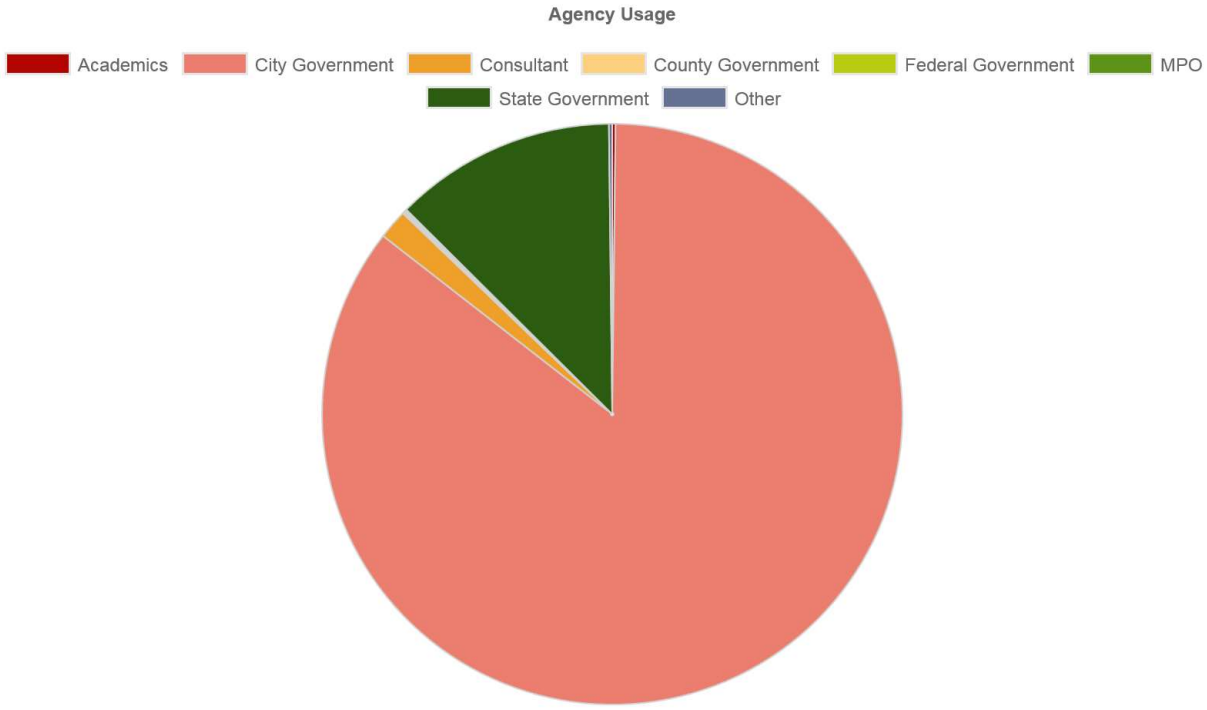


Figure 46: Agency Usage chart (pie example)

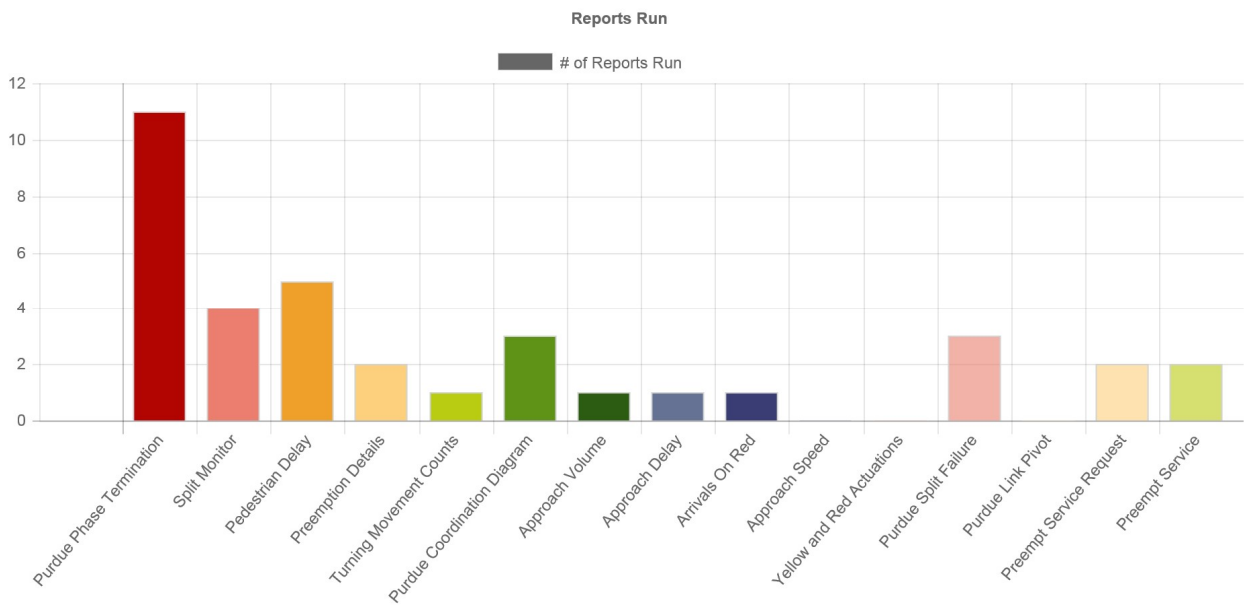


Figure 47: Reports Run chart (bar example)

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 table of the configuration setup (from **Admin > Signal Configuration**), the phase assignments by approach, and the detector channels for the signal are displayed. IP addresses are not displayed.

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 measure algorithms. See Figure 48 below.

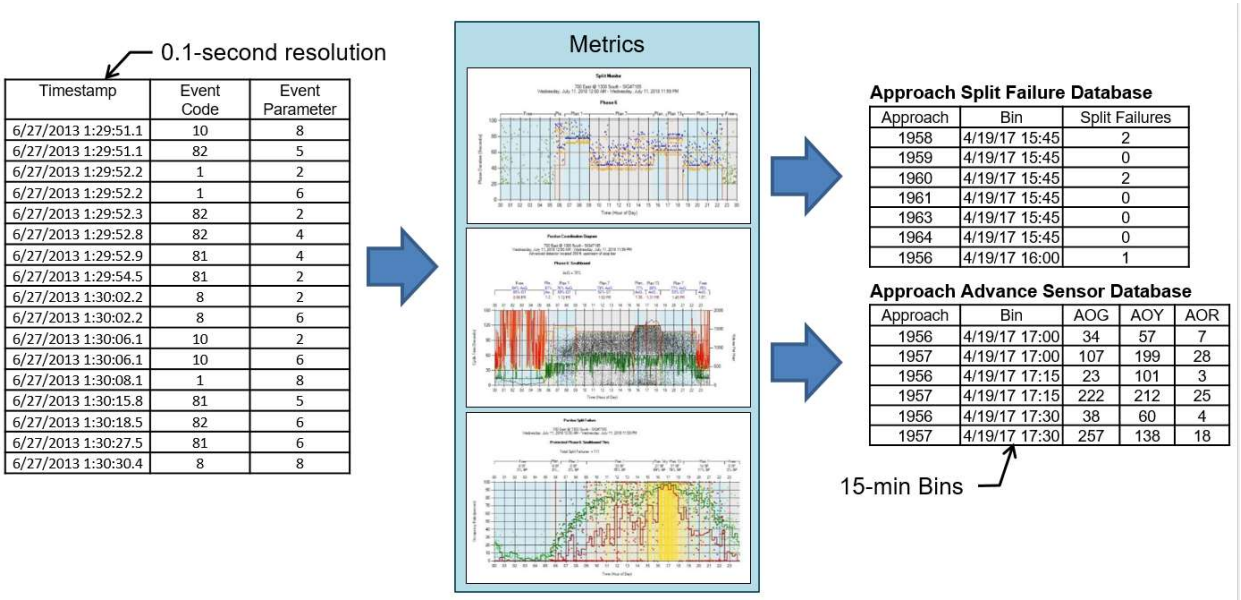


Figure 48: Raw Data Aggregation of ATSPMs

The Aggregate Data report has four sections: Signals, Chart Options, Date Options, and Time Filter (see Figure 49).

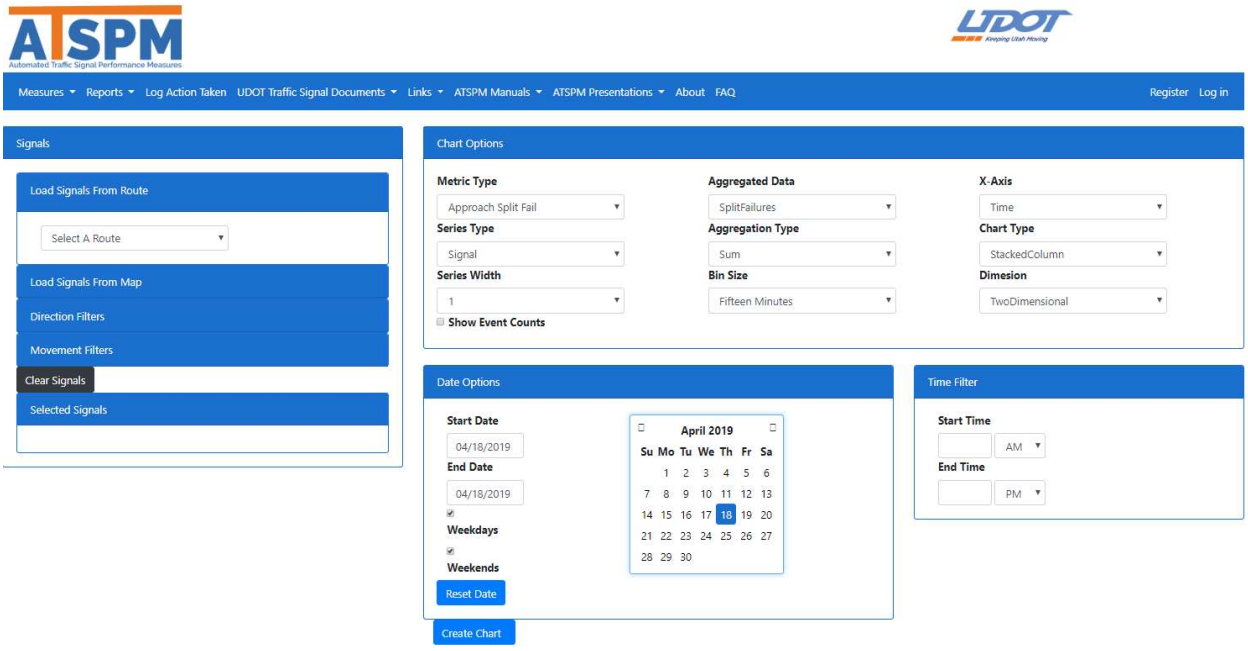


Figure 49: Aggregate Data Report

Signals can be selected on the left side using the Load Signals from Route option and/or the Load Signals from Map option (see Figure 50). More than one signal may be selected at a time. The Direction Filters option allows travel directions to be included or excluded from the aggregation by using a series of checkboxes, and the Movement Filters option allows movement types to be included or excluded from

the aggregation by using a series of checkboxes as well. By default, all directions and movements are included.

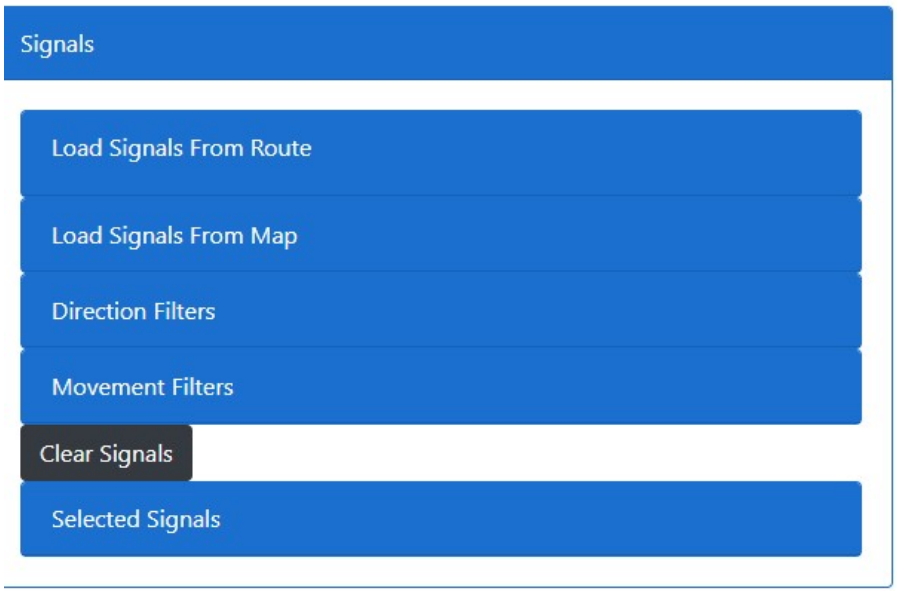


Figure 50 Select Signals for Aggregates

The Chart Options section has 10 options for customizing the aggregation (see Figure 51). The details for each option are given below:

The **Metric Type** is the measure to be aggregated. One of the following may be selected:

- 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
- Left Turn Gap
- Split Monitor

The **Series Type** is the grouping with which the output chart will be displayed. One of the following may be selected:

- Signal (default)
- Phase Number
- Direction
- Route
- Detector

The **Series Width** is the line weight used for the data display in the output charts. Numbers between 1 (thin) and 5 (thick) may be selected, with 1 as the default.

If selected, the **Show Event Counts** check box will display data values in numbers for each point in the output chart. By default, it is unchecked.

The **Aggregated Data** field is used to select the desired measure component to be aggregated. The options in the dropdown box will vary depending on the Metric Type selected. For example, the options available for the Approach PCD measure are ArrivalsOnGreen, ArrivalsOnRed, ArrivalsOnYellow, PercentArrivalsOnGreen, PlatoonRatio, and ApproachVolume.

The **Aggregation Type** is the method of aggregation to be used. Sum (default) or Average may be selected.

The **Bin Size** specifies the time duration which will be aggregated (summed or averaged). The default is 15 minutes, though 30 minutes, hour day, month, and year may also be selected.

The **X-Axis** option specifies which data will be represented by the x-axis on the chart. It can be changed from Time (the default) to TimeOfDay, Direction, Approach, Signal, or Detector.

The **Chart Type** specifies the graphical type of the report. The Default is StackedColumn, though there are 29 other options that can be selected instead.

The **Dimension** option specifies if the output chart will be shown in 2-D (default) or 3-D.

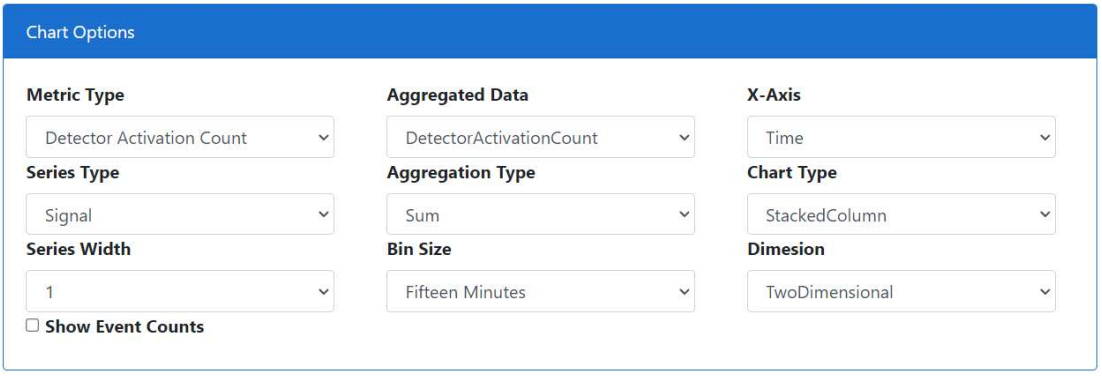


Figure 51: Aggregate Data Chart Options

The date range for the report can be selected in the Date Options section. The Start Date and End Date default to the current date but can be modified to be whatever date range is desired. Weekdays and Weekends can be included (default for both) or excluded with their respective checkboxes.

The Time Filter can be used to specify the time period of each day in the date range that will be used in the aggregation. If left blank, the aggregation will use data from all 24 hours in each day in the date range.

An aggregate hourly volume report is shown in Figure 52 for signal 7115. The options used to create this graph are: Approach Split Fail, Direction, 1, unchecked, SplitFailures, Sum, Fifteen Minutes, Time, Stacked Column, and TwoDimensional.

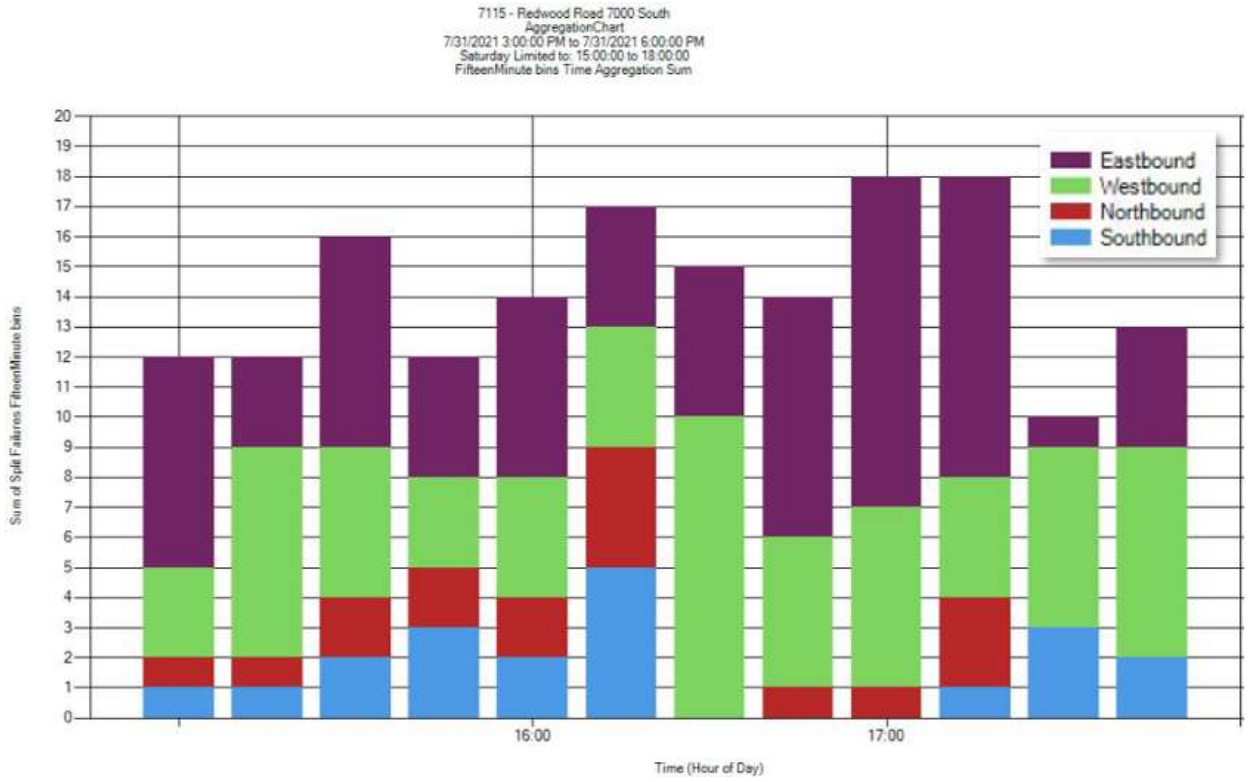


Figure 52: Aggregate Report - Hourly Volume

The 15-minute bin files of the aggregate data take up much less storage space then 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 collecting data with raw 1/10th second data logs. The aggregation data tables are approximately an extra 6 GB/month of data.

2.4. Left Turn Gap Analysis

Selecting **Reports > Left Turn Gap Analysis** navigates to the **Left Turn Gap Analysis** page where the page is set up very similar to that of a signal measure. There are several sections of report options, all of which are described below. Figure 53 shows all but the Signal Selection section.

Signal Selection: As described in detail in sections 1.1.1 - 1.1.3, a signal can be selected by typing in the signal ID number, selecting a signal from a dropdown list, or selecting a signal from an interactive map.

Left Turn Gap Options: After a signal has been selected, this section will display the left turn movements and associated phases available for the left turn gap analysis. Each option, including an option of "All Left Turns", is provided as a checkbox (default is all options checked).

Signal Data Check: This section is used to configurate the signal data checks process.

- **% Cycles with Ped Calls**: Sets the maximum expected percent of all cycles in the analysis period to have a pedestrian call. The default is 30%.
- **% Cycles with Gap Outs**: Sets the maximum expected percent of all cycles in the analysis period to end in a gap out. The default is 50%.
- **Left-turn volume (vph)**: Sets the minimum expected number of left turn volume (vph) on average over the analysis period. The default is 60 vph.

Report Information: This section is used to select the analyses and adjust the corresponding thresholds that will be run in the making of the left turn gap report.

- **Final Gap Analysis Report checkbox**: Selects the gap analysis to be run and the results of that analysis to be displayed in the report. This option is checked by default.
- **% LT Vehicles/Acceptable Gaps threshold**: (Only visible if the Final Gap Analysis Report checkbox is checked.) The maximum desired ratio of left-turning vehicles to acceptable gaps (given in percent). The default is 70%.
- **Split Fail Analysis checkbox**: Selects the split failure analysis to be run and the results of that analysis to be displayed in the report. This option is unselected by default.
- **% Cycles with Split Failure threshold**: (Only visible if the Split Fail Analysis checkbox is checked.) The maximum desired percent of all cycles in the analysis period to incur a split failure. The default is 50%.
- **Pedestrian Call Analysis checkbox**: Selects the pedestrian call analysis to be run and the results of that analysis to be displayed in the report. This option is unselected by default.
- **% Cycles with Ped Calls threshold**: (Only visible if the Pedestrian Call Analysis checkbox is checked.) The maximum desired percent of all cycles in the analysis period to incur a split failure. The default is 50%.
- **Conflicting Volumes Analysis**: Selects the conflicting volumes analysis to be run and the results of that analysis to be displayed in the report. This option is unselected by default.

Date Selection: This section is used to select the date and weekday(s) of the analysis period. The time for the analysis is not selected in this section. The date is selected as described in section 1.1.5. The

weekdays are selected via checkboxes; Monday, Tuesday, Wednesday, Thursday, and Friday, are selected by default (Sunday and Saturday are unselected by default). If a date range of more than one day is selected, data from the selected weekdays will be averaged together.

Time Options:

- **Custom**: The start and end times are selected via drop down boxes that allow for starting/ending on any 15-minute increment of any hour in the day.
- **Peak hour (AM & PM)**: The start and end time of these hours are calculated during the analysis. This option is selected by default.
- **Peak Periods (6AM-9AM & 3PM-6PM)**
- **24-Hour Period (hourly reports 12:00AM - 11:59PM)**

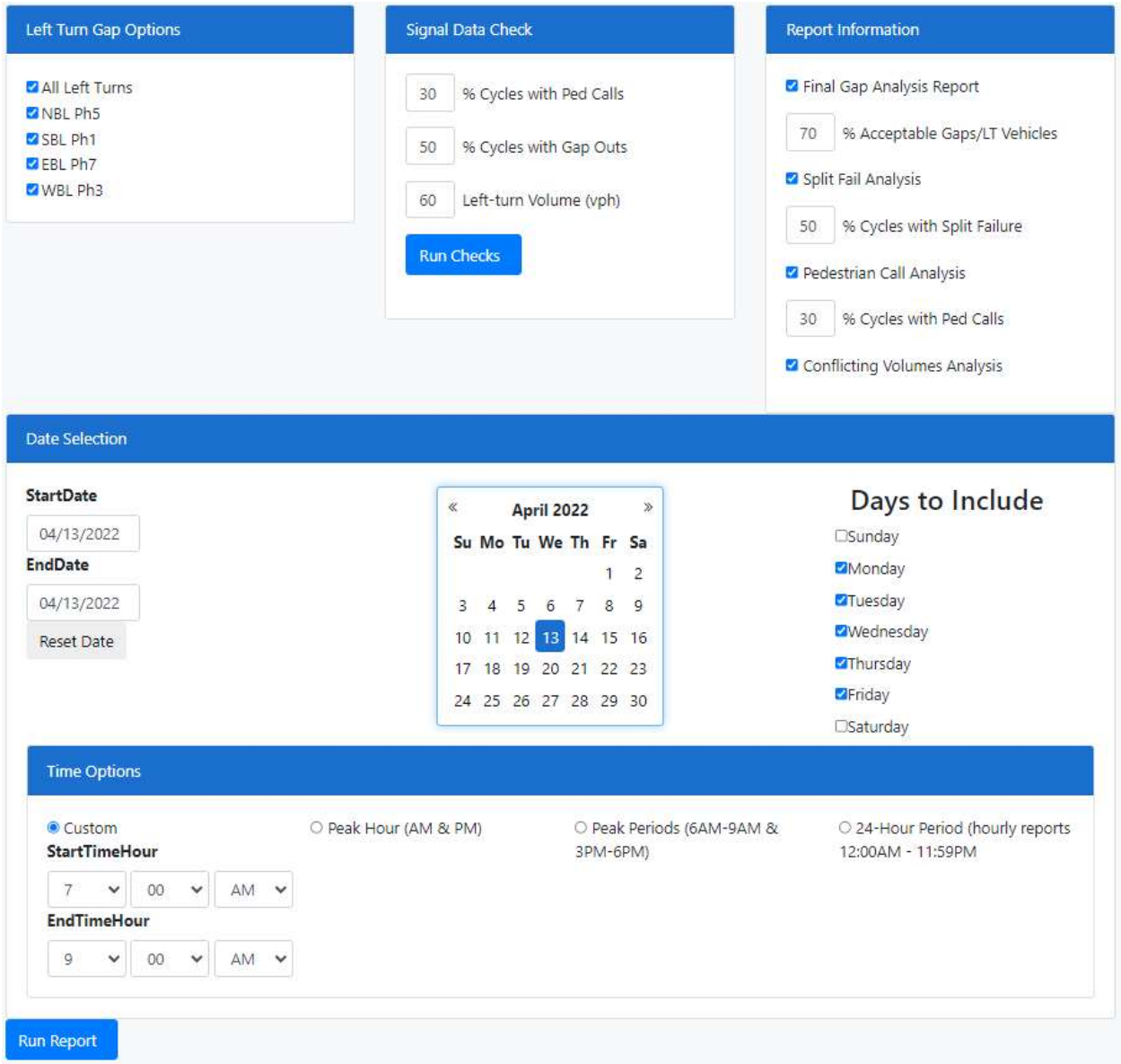


Figure 53: Left Turn Gap Analysis Report Options

There are two buttons on this report page that perform tasks, both of which should only be clicked after all options have been set to the desired settings. The first ("Run Checks") is a preliminary check on the data called the Signal Data Check (and the button is found in that section). In addition to checking that all required data is available, this process calculates the percent of cycles in the analysis period that are gap outs, the percent of cycles in the analysis period that had a pedestrian call, and the average left turn volume (vph) for the analysis period. The calculated values are compared with the thresholds in the Signal Data Check section, and messages showing the results of these comparisons are displayed at the bottom of the screen, an example of which is shown in Figure 54. Possible messages include:

- OK
- Check Phase Termination Data
- Check Ped Data
- Check Detectors
- Review Crash History

A reminder is also included below the signal data check results: "It is always good practice to review the Split Pattern performance in conjunction with using this report."

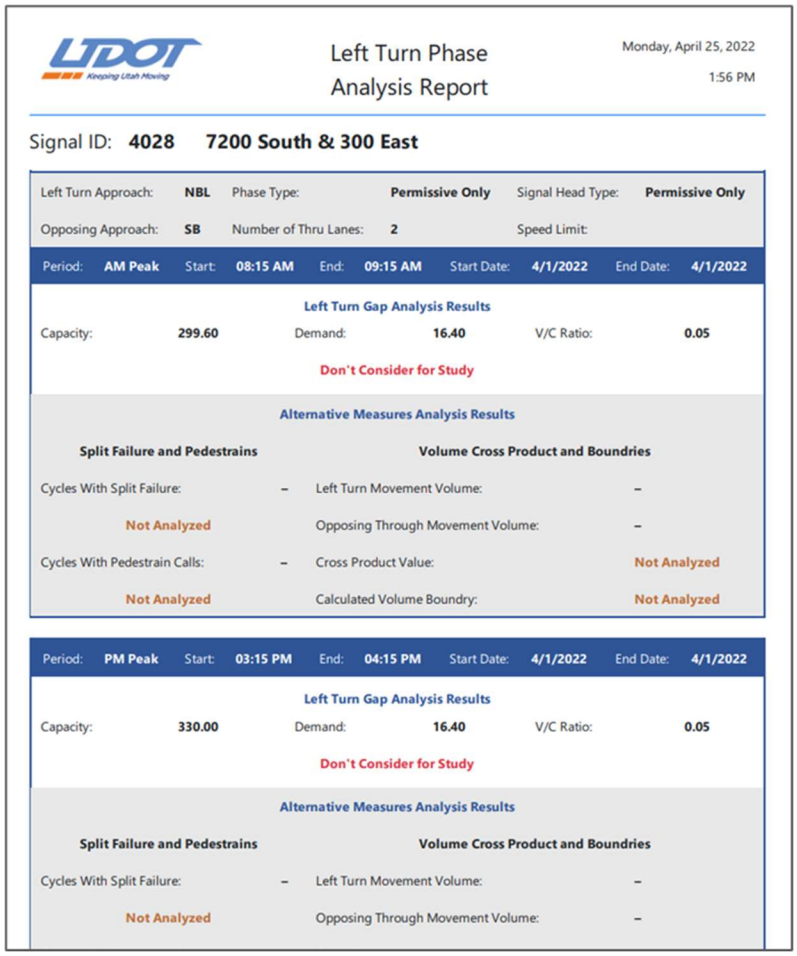
Signal data check complete please note the following results:

Checks	Acceptable Range (Threshold)	NBL Ph(4)	WBL Ph(2)
Left Turn Gap Data	N/A	OK	OK
Split Fail Data	N/A	OK	OK
Cycle Data	N/A	OK	OK
Detector Event Count	N/A	OK	OK
Phase Termination Data	N/A	Check Phase Termination Data	Check Phase Termination Data
Ped Data	N/A	Check Ped Data	OK
Left Turn Volume	60 vph	OK	OK
Gap Out %	< 50%	OK	OK
% Cycles with Peds	< 30%	Review Crash History	Review Crash History

It is always good practice to review the Split Pattern performance in conjunction with using this report.

Figure 54: Left Turn Gap Analysis Signal Data Check Results

The second button ("Run Report") on the Left Turn Gap Analysis Report page is located below the Time Options section, and it runs the analyses selected in the Report Information section. The results are displayed in a PDF that opens in a new browser tab. The PDF report, and example of which is shown in Figure 55, lists the results of the selected analyses for each left turn chosen. The recommendation to "Consider for Study" (in green text) or "Do not Consider for Study" (in red text) is shown for each analysis, and displayed below each recommendation are the numerical values used in the analysis.



Left Turn Phase Analysis Report

Monday, April 25, 2022
1:56 PM

Signal ID: **4028** **7200 South & 300 East**

Left Turn Approach:	**NBL**	Phase Type:	**Permissive Only**	Signal Head Type:	**Permissive Only**
Opposing Approach:	**SB**	Number of Thru Lanes:	**2**	Speed Limit:	

Period:	**AM Peak**	Start:	**08:15 AM**	End:	**09:15 AM**	Start Date:	**4/1/2022**	End Date:	**4/1/2022**

Left Turn Gap Analysis Results

Capacity:	**299.60**	Demand:	**16.40**	V/C Ratio:	**0.05**

Don't Consider for Study

Alternative Measures Analysis Results

Split Failure and Pedestrains		**Volume Cross Product and Boundries**	
Cycles With Split Failure:	–	Left Turn Movement Volume:	–
Not Analyzed		Opposing Through Movement Volume:	–
Cycles With Pedestrain Calls:	–	Cross Product Value:	**Not Analyzed**
Not Analyzed		Calculated Volume Boundry:	**Not Analyzed**

Period:	**PM Peak**	Start:	**03:15 PM**	End:	**04:15 PM**	Start Date:	**4/1/2022**	End Date:	**4/1/2022**

Left Turn Gap Analysis Results

Capacity:	**330.00**	Demand:	**16.40**	V/C Ratio:	**0.05**

Don't Consider for Study

Alternative Measures Analysis Results

Split Failure and Pedestrains		**Volume Cross Product and Boundries**	
Cycles With Split Failure:	–	Left Turn Movement Volume:	–
Not Analyzed		Opposing Through Movement Volume:	–

Figure 55: Portion of Left Turn Gap Analysis PDF Report

3. Log Action Taken

Selecting **Log Action Taken** displays a data entry form for the Create Action Log as shown in Figure 56.

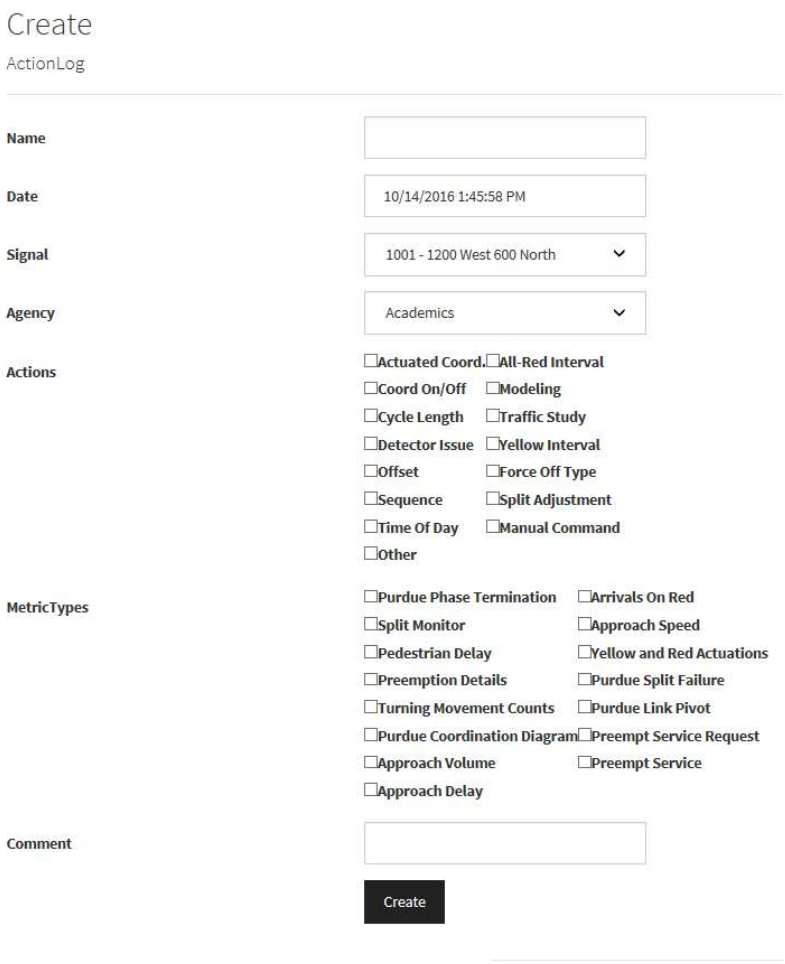


Figure 56: Create Action Log Form

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 measure. Select the applicable measure or measures 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 (https://docs.lib.purdue.edu/jtrpdata/3/) 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, and it 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, and 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** (this document)**, 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 measure as well as how the data is gathered, displayed, and interpreted.

6.4. ATSPM User Case Examples Manual

The ATSPM User Case Examples is a PineTop Engineering publication for UDOT. It is a detailed description of how the ATSPM data and website can be used to help with two major components of signal operations: signal system monitoring and signal coordination.

6.5. ATSPM Detection Suggestions

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

- Page 1 (Figure 57): 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 measures that will work under each of the detection configuration options. For example, in order to use the Purdue Split Failure measure, you need presence detection at the stop bar with channels broken out lane-by-lane or grouped together.

- Page 2 (Figure 58): This shows a sample layout of a UDOT intersection and the detection requirements for various measures. It is not uncommon for some large intersections to use 40+ channels of detection.

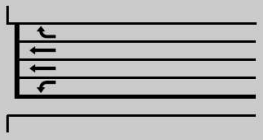
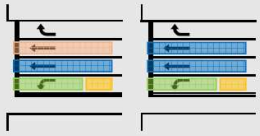
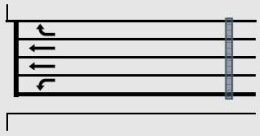
Detection	Metric
None (metrics will display and show info in ATSPM without detection, however, the metrics will be more useful with detection) 	Purdue Phase Termination (without detection, only maxouts/forceoffs) Split Monitor (without detection, splits will be fixed time) Preemption Details (requires preemption device) Pedestrian Delay (requires pedestrian detection) Timing and Actuation (without detection, only timing will be displayed)
Lane-by-lane or Lane Group Presence 	Purdue Split Failure
Lane-by-lane Stop Bar Count	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)
Advanced Count (Lane-by-lane or group) 	Purdue Coordination Diagram Purdue Link Pivot Offset Optimization Approach Volume Approach Delay Arrivals on Red Approach Speed (requires detection with speed service)

Figure 57: ATSPM detection requirements for each measure

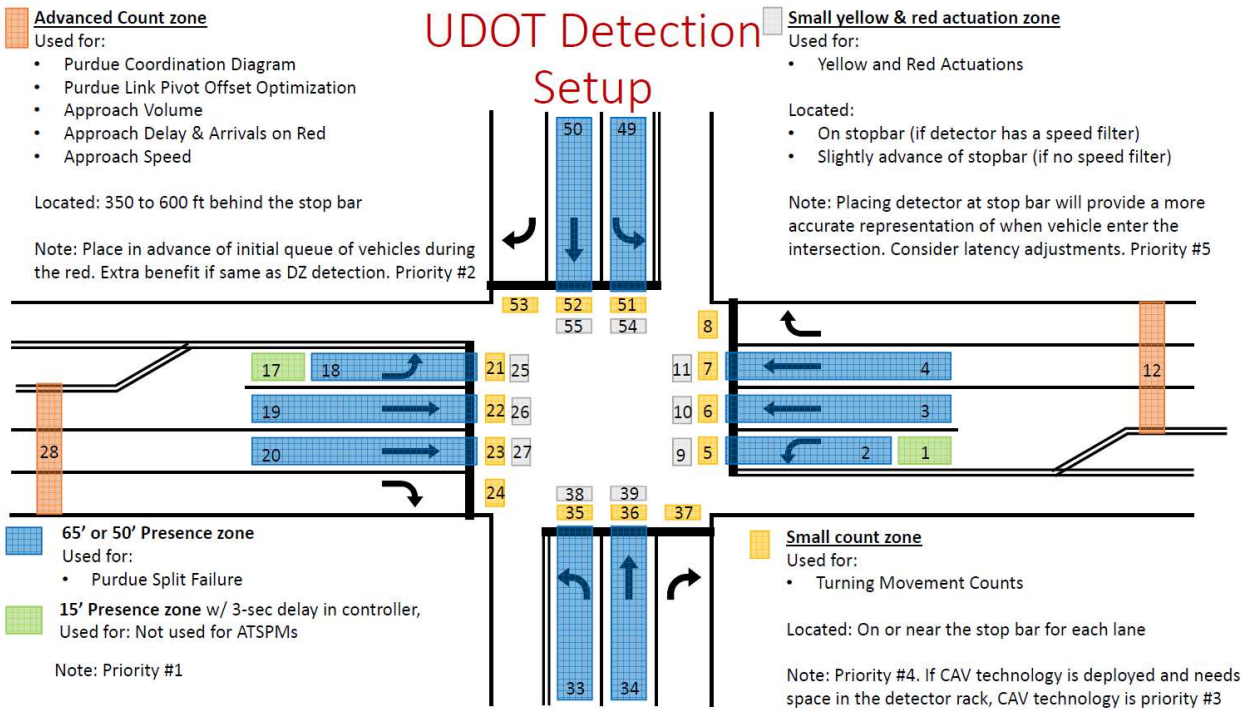


Figure 58: UDOT detection setup example

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

The Admin tab is only viewable after signing in with an Admin-registered account. The "Log in" button in the top right corner of the website should be used to sign in. Depending on the permission levels of the account, the Admin tab will appear after logging in.

8.1. Signal Configuration

To access the Signal Configuration page, the user account logged into the system must have Admin, Configuration, or Technician Privileges. Click **Admin** and then **Signal Configuration**, which will lead you to the ATSPM Configuration Tool website. The ATSPM Configuration Tool, shown in Figure 59, 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 60, asking for the signal ID number.

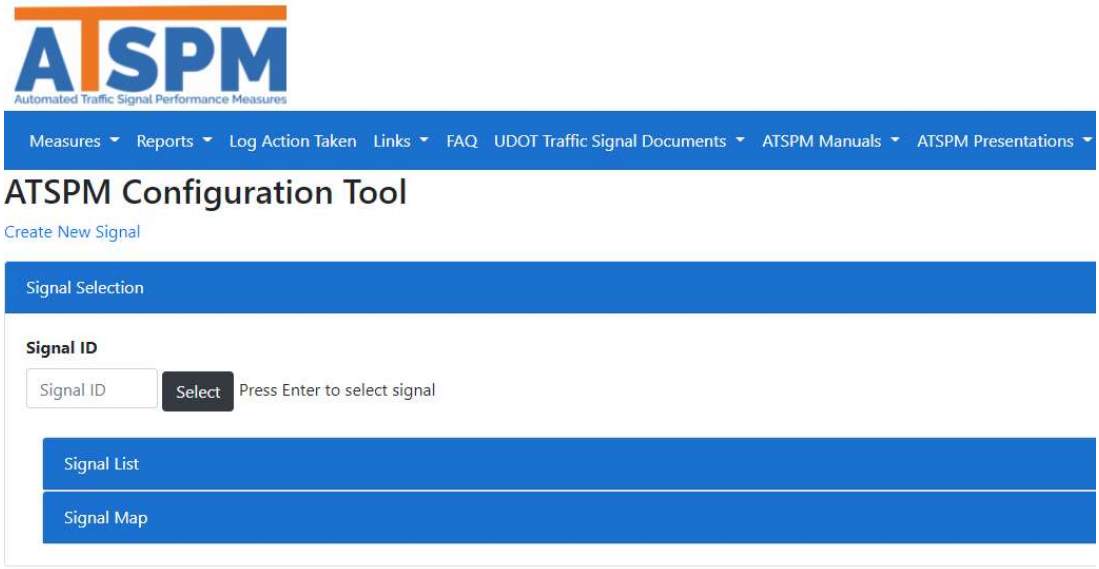


Figure 59: Admin Selection Options and ATSPM Configuration site

Figure 60: 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 measures 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; can be switched to a different version by using the dropdown
- **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
- **Areas:** User-selected areas to which the signal applies
- **Jurisdiction:** The agency that owns the signal; can be changed by using the dropdown
- **Controller Type:** The controller type
- **Display on Map:** A checkbox to choose whether the signal is displayed on the map
- **All Peds are 1:1:** A checkbox to choose whether all pedestrian phases are equivalent to their associated protected phases
- **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 61) that once clicked displays all detector information including the Detector ID, Detector Channel, Phase, and other detector settings

Configuration Table

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
534101	1	WB	0	8	False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Left	1	Vehicle						Lane group - thru & left
534102	2	WB	8		False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Thru	1	Vehicle						
534103	3	EB	0	4	False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Left	1	Vehicle						Lane group - thru & left
534104	4	EB	4		False	True	Stop Bar Presence	Wavetronix Matrix	1.2	Thru	1	Vehicle						
534106	6	NB	2		False	True	Advanced Count Advanced Speed	Wavetronix Advance	0	Thru	1	Vehicle	50	350		15	5	
534108	8	SB	6		False	True	Advanced Count Advanced Speed	Wavetronix Advance	0	Thru	1	Vehicle	50	350		15	5	

Figure 61: 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 62) 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 the permissive phase
  - **Pedestrian Phase:** If applicable, the number of the pedestrian phase
  - **Ped. Detector(s):** If applicable, the number(s) of the pedestrian detectors
  - **Approach Speed (MPH):** The speed limit of the approach
  - **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
  - **Ped. Phase Overlap:** A checkbox to select if the phase is a pedestrian 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
    - Advanced Presence
  - **Detection Hardware:** A dropdown to select the detection hardware, including:
    - Unknown
    - Wavetronix Matrix
    - Wavetronix Advance
    - Inductive Loops
    - Sensys

    - Video
    - FLIR: Thermal Camera
- **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) and 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.
- **Distance To Stop Bar (Advanced Count):** The distance to the stop bar for Purdue Coordination. This option is only available if Advanced Count is selected as a detection type.
- **Min Speed Filter (Advanced Speed):** Any speeds below this value (usually 5 MPH) will not be included in the calculation of average or percentile speeds. This option is only available if Advanced Speed is selected as a detection type.
- **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. This option is only available if Advanced Count is selected as a detection type.
- **Movement Delay (Advanced Speed):** The approximate time in seconds (usually 15 seconds) needed to clear the queue to the sensor. This option is only available if Advanced Speed is selected as a detection type.
- **Date Added:** a calendar field for date & time selection.
- **Detector Comment:** Internal comments not pushed to public site
    - **Add Detector Comment:** To enter a new comment, press the blue plus sign; this opens a new **Comment Text** field and a **Create** button.

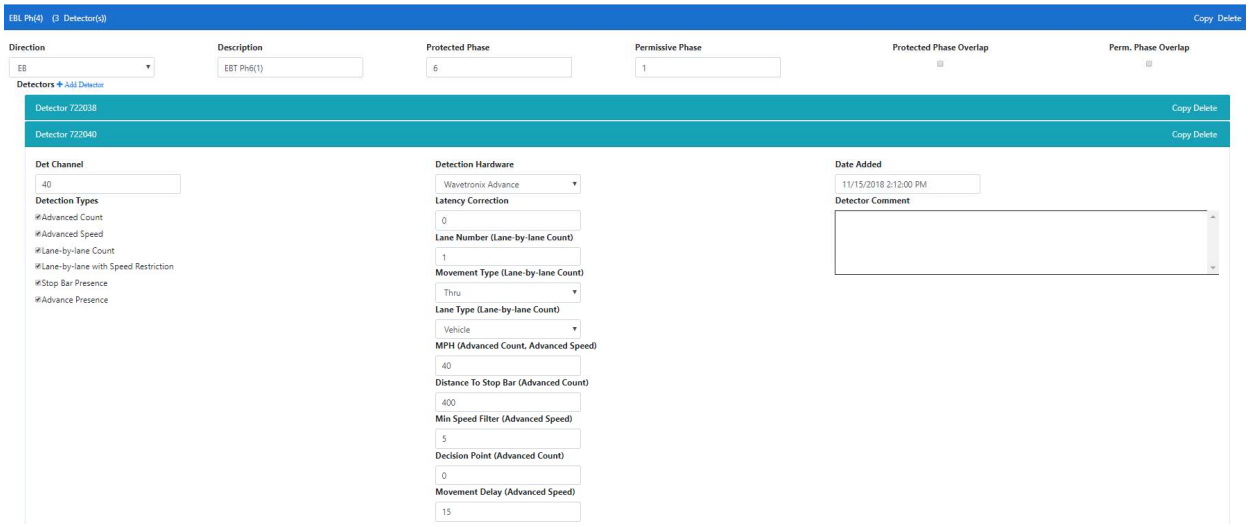


Figure 62: Approach Configuration

8.2. Menu Configuration (Admin Only)

To access the Menu Configuration page shown in Figure 63, 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 63: Menu Configuration Details page

The menu configuration page 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.

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

To access the Link Pivot & Aggregate Data Route Configuration page shown in Figure 64, the user account logged into the system must have Admin, Configuration, or Technician Privileges. Click **Admin** and then **Route Configuration**.

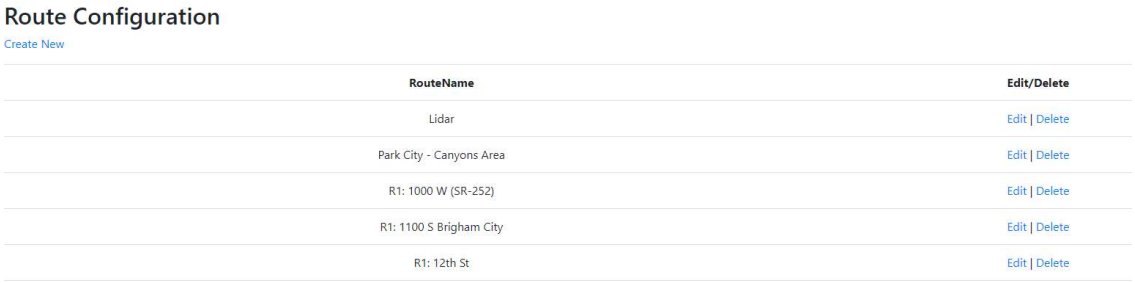


Figure 64: Route Configuration page

The route configuration page, shown in Figure 65, displays all existing **RouteName** and links to edit or delete. There is also a link to **Create New** in the upper left corner. These links do the following actions:

- **Create New:** Starts a new route
- **Edit:** Opens the route for configuration
    - Signals can be added to the route by selecting them from a map or list in the **Signal Selection** section
    - The order of selected signals within the route can be modified by using the **Move Up** and **Move Down** buttons located below the table in the top-left corner
    - A signal can be removed from the route by clicking the **Remove** button. Clicking the Remove button shows a message on the page which asks "Are you sure you want to delete signal [Signal ID]?" Choosing the Delete button deletes the intersection from the route and removes the selected route from the table.
- **Delete:** Selecting **Delete** opens a delete page which asks "Are sure you want to delete this?" Clicking OK deletes the route from the list of routes and returns the user to the Index.

Figure 65: Route Details page

8.4. Area Configuration

To access the Area Configuration page, the user account logged into the system must have Admin or Configuration Privileges. Click **Admin** and then **Area Configuration**. On this page there is a list of configured Area Names and links to edit or delete each area. There is also a link to **Create New** in the upper left corner. These links do the following actions:

- **Create New:** Creates a new route and opens a create page to give the new area a name
- **Edit:** Opens an edit page to modify the name of the area
- **Delete:** Selecting **Delete** opens a delete page which asks "Are sure you want to delete this?" Clicking Delete deletes the area from the list of areas and returns the user to the Index. The deleted area is removed from all signals.

8.5. 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 measures.
- Image URL: Directs the Website of where to access the chart images for all measures.
- 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.
- Seconds After Chart End Date to Complete Cycle:

8.6. Measure Defaults Settings

To access the Default Chart Settings page, the user account logged into the system must have Admin Privileges. Click **Admin** and then **Area Configuration**. This page is used to modify the default chart options for the measures. As shown in Figure 66, there is an expandable section for each metric that contains all chart options available to users when running a measure. Changing the values in the Default Chart Settings page and then clicking the **Save Changes** button will modify the chart options for all users.

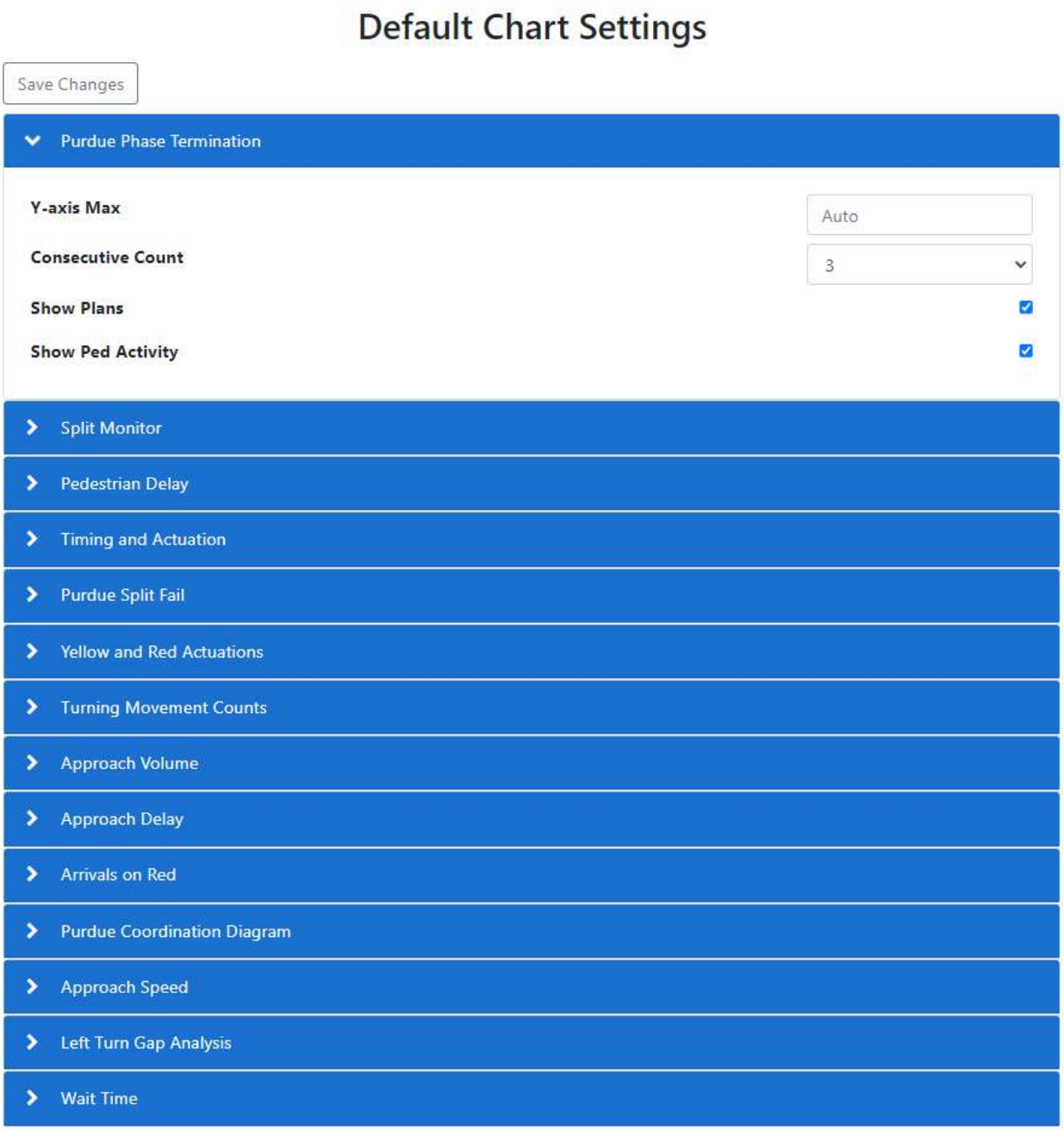


Figure 66: Measure Defaults Settings page

8.7. Raw Data Export

To access the Raw Data Export, the user account logged into the system must have Admin or Data Privileges. 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**. Select a signal and then follow the instructions on the raw data export page to download the desired data (Figure 67).

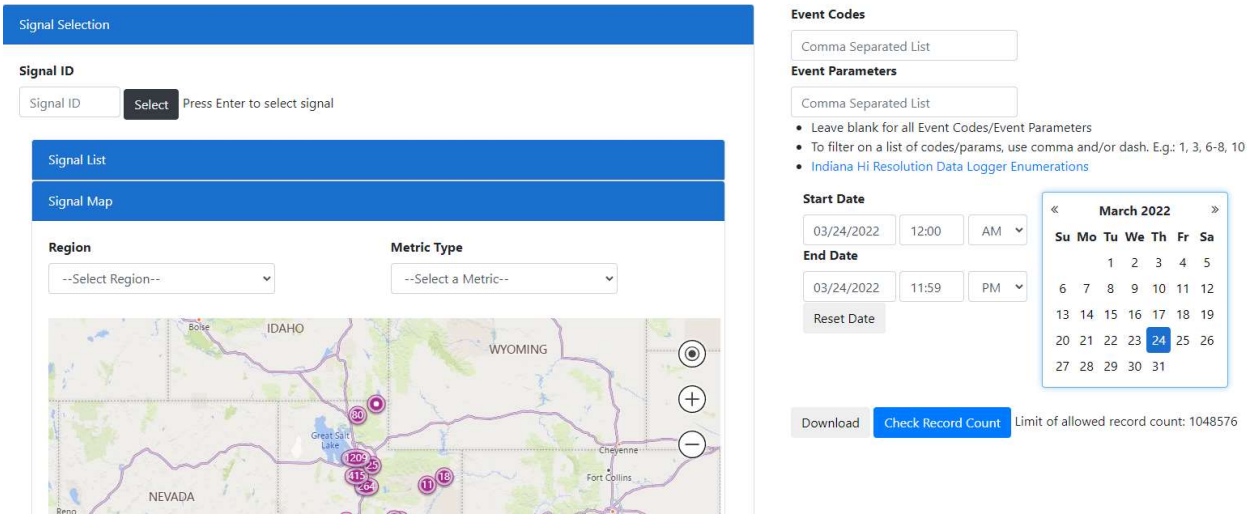


Figure 67: Raw Data Export page

8.8. Watch Dog (Admin Only)

The ATSPM Watch Dog 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 (Max Out, 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: the email address to which Watch Dog emails will be sent.
- 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.

8.9. 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 68). Partition databases are needed for this to work and there are some adjustments to the scripts that will need to be made specific for each agency. 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 settings.

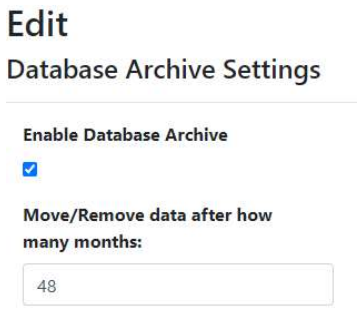


Figure 68: Database Archive Settings

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.

8.10. 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. Note that the FAQs are written in HTML style on this page. HTML markings will be interpreted (not shown) for the general use FAQ page.

The FAQ Editor page, shown in Figure 69, 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.

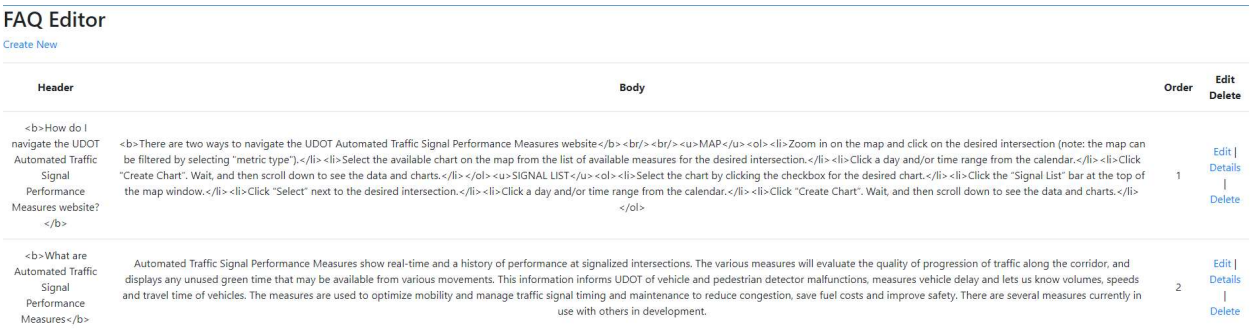


Figure 69: FAQs Editor page

8.11. Jurisdiction Configuration

To access the Jurisdiction Configuration page, the user account logged into the system must have Admin or Configuration Privileges. Click **Admin** and then **Jurisdiction Configuration**. On this page there is a list of configured Jurisdiction Names with additional information such as MPO, County/Parish Name, and Other Partners. They are listed in alphabetical order based on the Jurisdiction Name. Each configured Jurisdiction has links to edit or delete it. There is also a link to **Create New** in the upper left corner. These links do the following actions:

- **Create New:** Creates a new route and opens a create page to give the new jurisdiction a name and fill out additional information (MPO, County/Parish Name, and Other Partners) as shown in Figure 70.
- **Edit:** Opens an edit page to modify the name of the jurisdiction and its additional information.
- **Delete:** Selecting **Delete** opens a delete page which displays the jurisdiction name and asks “Are you sure you want to delete this?” If there are any signals to which the jurisdiction is assigned, then a message is displayed: “Warning: This Jurisdiction is connected to [X number of] signals. Please assign the following signals to a different jurisdiction before deleting,” followed by a list of related signals. Once the jurisdiction is no longer connected to any signals, this page will instead display a delete button. Clicking Delete deletes the jurisdiction from the list of jurisdictions and returns the user to the Index.

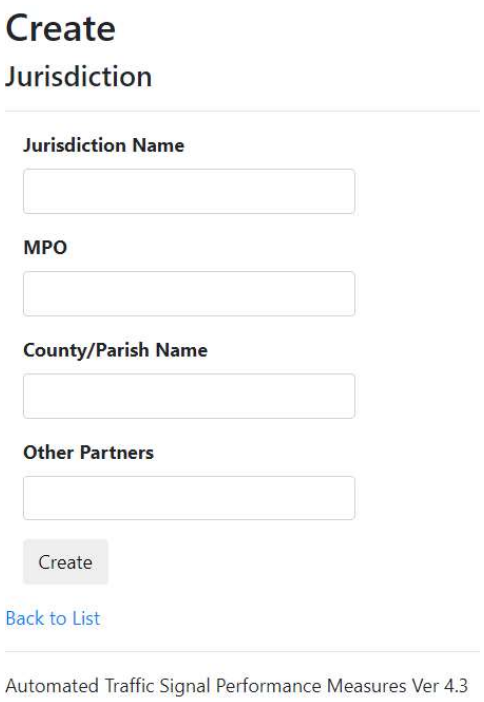


Figure 70: Create Jurisdiction page

8.12. 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 that users have or delete users. The users can also be assigned to receive alerts, such as the Watch Dog email.

8.13. Roles (Admin Only)

To access the Roles page shown in Figure 71, 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**.
- Restricted Configuration –
- 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**.

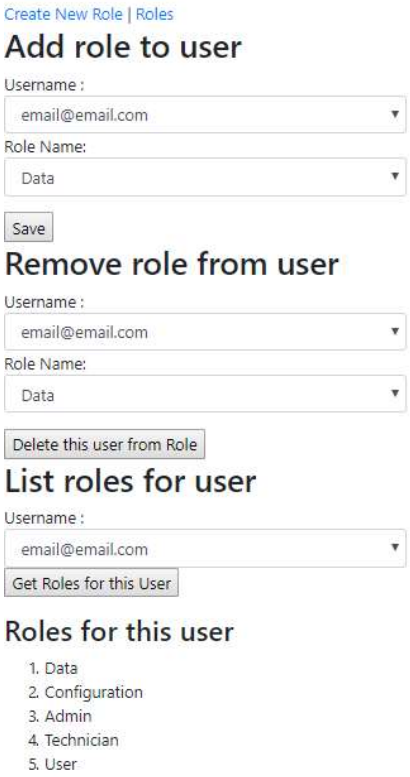


Figure 71: Adding Roles to ATSPM Users

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 72, 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.

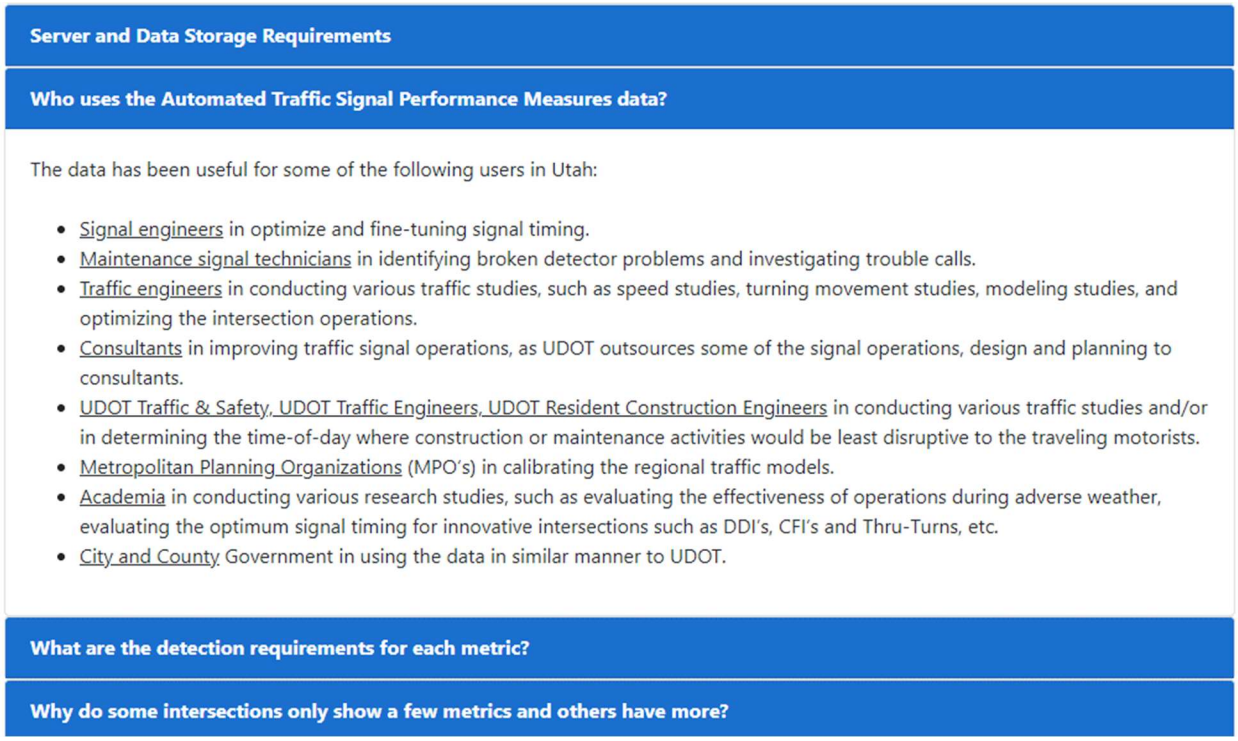


Figure 72: FAQ site with a question expanded

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 73). 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.

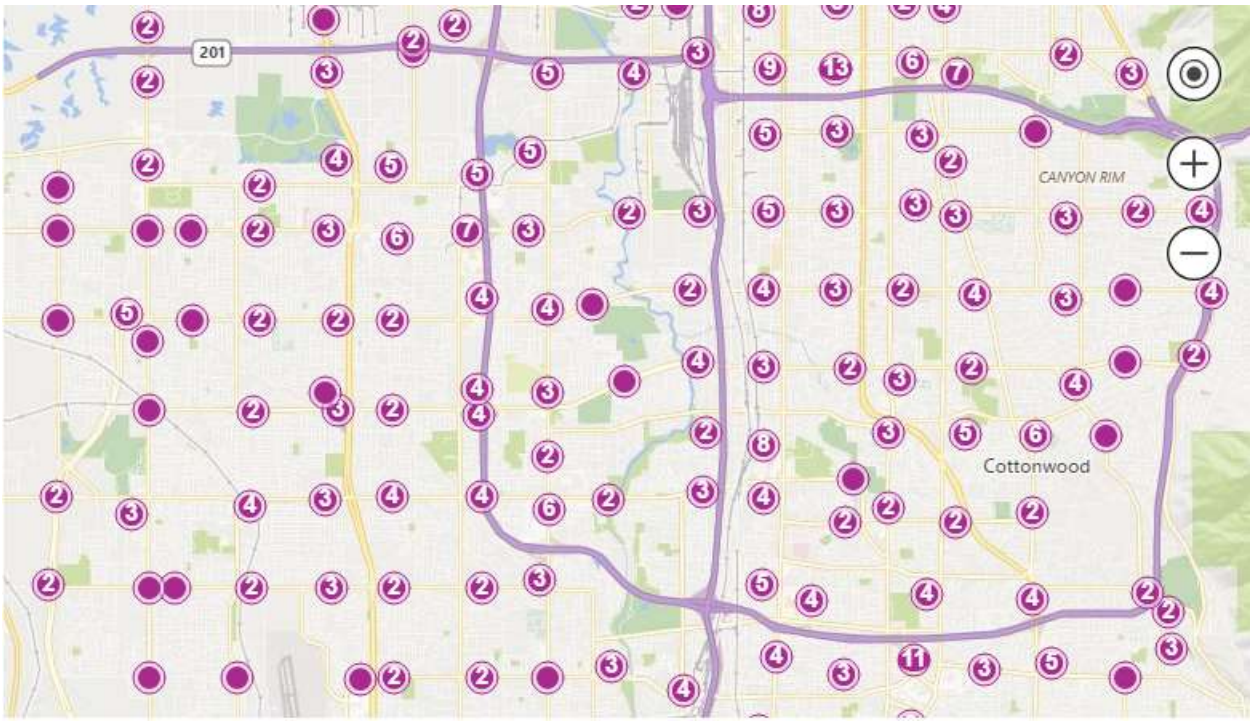


Figure 73: Map pins generated by JavaScript

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:

- **Path*N***: The physical or network path where the JavaScript code 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 they 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 it allows them to be generated in a timely manner. It saves 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 Watch Dog

The ATSPM Watch Dog 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.

Watch Dog 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 Watch Dog runs. For example, if Watch Dog 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 it 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 Watch Dog. 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 Watch Dog criteria to apply.
- **StartHour** and **EndHour:** The hours of the day between which the Watch Dog 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 Watch Dog emails. If the mail server is hosted on the same machine running Watch Dog, 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 Watch Dog 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 Watch Dog criteria. Applied in conjunction with **PercentThreshold**.
- **LowHitTheshold:** The volume threshold, tallied between **StartHour** and **EndHour**, below which the low hit count Watch Dog 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-ViewModel 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 duration starting when a call is first placed on a phase 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. N is the number of lanes in the lane group. 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_{15max} 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.