Georgia Department of Transportation

Automated Traffic Signal Performance Measures

Reporting Details

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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

GDOT ....Georgia Department of Transportation

GOR ....Green Occupancy Ratio

GT .... Green Time

f_{LU}.. Lane Utilization Factor

MOE.. Measures of Effectiveness

MPH ....Miles Per Hour

PA .... Pedestrian Activation

PCD... Purdue Coordination Diagram

PHF .... Peak Hour Factor

PHV...Peak Hour Volume

ROR .... Red Occupancy Ratio

VPH... Vehicles per Hour

WCF .... Windows Communication Foundation

Introduction

This is the third 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 ATSPM website, including site navigation, reporting components, and report interpretation. This document is a detailed compilation of what is necessary to create reports and how to interpret reports within the ATSPM website.

1. Approach Delay

Approach Delay provides data regarding the delay experienced at an approach to an intersection. The calculated delay figure is simplified. It does not account for start-up delay, deceleration, or queue length exceeding the detection zone.

Note: The Approach Delay Chart has not been thoroughly quality-checked.

1.1. Requirements for Approach Delay Chart

The Approach Delay chart depicts the time between a detector activation during the red portion of the phase, and when that phase turns green. Not all intersections within the ATSPM are capable of providing the **Approach Delay** chart. In order to display this chart, applicable phases of an intersection must include properly configured parameters as listed below:

- Vehicle count detection, set back 350 to 400 feet from the stop bar (beyond the area where vehicle queues are common)
- Signal controller must track all events using the standard event codes, including the timing of red and green
- Controller logs must be retrievable by the ATSPM web server

1.2. Approach Delay Data

1.2.1. How Data is Gathered and Compiled

When the user generates this chart, the Measures of Effectiveness (MOE) Windows Communication Foundation (WCF) Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type ApproachDelayOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximums

- Bin size
- Flags for showing:
    - Plan statistics
    - Total delay per hour
    - Delay per vehicle

Using these parameters, a SignalPhaseCollection object is generated within the MetricOptions object.

Within this SignalPhaseCollection, the phases in use during the period and the associated detector events are analyzed. Data is gathered from the Controller_Event_Logs table. Delay is calculated for each individual arrival during red, then aggregated based on the analysis period.

1.2.2. How Data is Displayed

The MetricOptions object creates a chart object, generated by the web rendering engine provided in the .NET Framework. All the delay data is rendered to the chart as lines, based on the per-hour and per-vehicle preferences. The chart is then saved as an image file displayed on the website.

1.3. Interpreting the Approach Delay Chart

Plots are generated after selecting **Create Chart**, one for each movement meeting the requirements. In the example (Figure 1), the northbound approach (Phase 2) is displayed with the duration from 10:00 AM to 8:00 PM and 5-minute intervals. For the purpose of this interpretation, all options (check boxes) were selected before chart creation. The chart includes the following components:

- A legend (left of the chart):
    - —— **Approach Delay**, a red line that graphically represents the total duration of delay for all vehicles during the interval.
    - —— **Approach Delay Per Vehicle**, a blue line that graphically represents the average duration of delay per vehicle during the interval.
- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the phase number and movement (with direction).
- The fifth line has the Average Delay Per Vehicle and the Total Delay for Selected Period for the complete duration of the chart.
- Above each chart section in black text is the timing plan the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, the chart has five sections (plans) between 10:00 and 20:00.
    - Above each chart section in Blue Text is the numerical value in seconds for the Average Delay Per Vehicle for that section of the chart.

- o Above each chart section in Red Text is the numerical value in seconds for the Total Delay for that section of the chart.
- The X-axis (above the chart) is the date in m/d/yyyy format.
- The X-axis (below the chart) is the time of day in 24-hour hh:mm format.
- The Y-axis title (Left Side: Blue Text) and scale is the delay per vehicle given in seconds. In the example at 15:00 along the northbound approach, the average per vehicle delay was 24 seconds.
- The Y-axis title (Right Side: Red Text) and scale is the total delay given in hours. In the example at 15:00 along the northbound approach, the total delay was approximately 13 hours.
- Below the chart is the disclaimer that the chart is simplified and the data represents the duration between detector activation (during red) and initiation of the green phase.

Approach Delay

Redwood Road @ 7000 South - SIG#7115
Tuesday, November 2, 2021 10:00 AM - Tuesday, November 2, 2021 8:00 PM

Phase 2: NBT Ph2

Average Delay Per Vehicle (AD) = 24 seconds; Total Delay For Selected Period (TD) = 131.5 hours

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

Figure 1: Approach Delay (8-hour duration/5-minute intervals)

2. Approach Speed

The **Approach Speed** charts provide feedback regarding the posted speed limit, average speed, and 85th percentile speed. The speed calculation is generated from vehicles approaching during the green phase, not including the first X seconds of green, defined by the Movement Delay parameter in the detector configuration.

2.1. Requirements for Approach Speed Charts

This data requires the use of advance radar detection that can detect the speeds of vehicles at a setback distance between 350 and 400 feet from the stop bar. The detector used for this application is typically

a Wavetronix SmartSensor™ Advance detector. In order to display this chart, the intersection must include properly configured parameters as listed below:

- Setback count detection (350 to 400 feet or beyond the initial queue of vehicles).
- Signal controller must track all events using the standard event codes, including the start of green phase.
- Signal controller logs must be retrievable by the ATSPM web server.
- The Speed Listener component is installed, running, and configured to connect to the detector.

2.2.   Approach Speed Data

2.2.1.   How Data is Gathered and Compiled

When the user generates this plot, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common) which is of type ApproachSpeedOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximum and minimum
- Bin size
- Flags for showing:
    - Plan Statistics
    - Average Speed
    - Posted Speed
    - 85th Percentile Speeds
    - 15th Percentile Speeds

Using these parameters, one or more SpeedApproachDirection objects are generated within the MetricOptions object. Typically, one will be generated for each approach supporting speed detection. These will then be filtered by start date, end date, and signal ID.

Within these SpeedApproachDirection objects, vehicle detections are gathered from Controller_Event_Logs table and cross-referenced against the signal phase number and timeframe.

2.2.2.   How Data is Displayed

Each of the SpeedApproachDirection objects creates a chart object, generated by the web rendering engine provided in the .NET Framework. All the speed data is rendered to the chart as lines based on user preferences.

2.3.   Interpreting the Approach Speed Chart

The **Approach Speed** chart, shown in Figure 2, is a line graph generated for each movement meeting the requirements. It includes the following components:

- A legend (left of the chart):
  - ——— **Average MPH**, a red line that depicts the average speed.
  - ——— **85th Percentile Speed**, a blue line that depicts the 85th percentile speed. If there are insufficient vehicles during the period, the percentile will be zero.
  - ——— **15th Percentile Speed**, a black line that depicts the 15th percentile speed. If there are insufficient vehicles during the period, the percentile will be zero.
  - ——— **Posted Speed**, a green line that depicts the speed limit in miles per hour (MPH).
- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the phase number and movement (with direction).
- The fifth line is the detection type and speed accuracy. The speed accuracy is +/- 2 MPH for average speed and +/- 1.5 MPH for 85th percentile speed (*Source: Report No. UT-16.05 - May 2016 https://www.udot.utah.gov/main/uconowner.gf?n=28384521790001597*).
- The sixth line is the distance from the detector to the stop bar.
- The seventh line is the minimum speed filter and the time filter measured in seconds after the start of green.
- Directly above the chart (first line, black text) is the timing plan the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, the chart has five sections (and plans) between 10:00 and 20:00.
  - Above each chart section in Blue Text shows the 85th percentile speed in MPH for that section of the chart.
  - Above each chart section in Red Text shows the average speed in MPH for that section of the chart.
  - Above each chart section in Red Text shows the standard deviation in MPH from the average speed to the 85th percentile speed for that section of the chart.
  - Above each chart section in Black text (the last line) shows the 15th percentile speed in MPH for that section of the chart.
- The X-axis (above the chart) is the date in m/d/yyyy format.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the speed in MPH. In the example at 14:00, the 85th percentile speed was approximately 42 MPH, the average speed was approximately 37 MPH, and the 15th percentile speed was approximately 30 MPH.
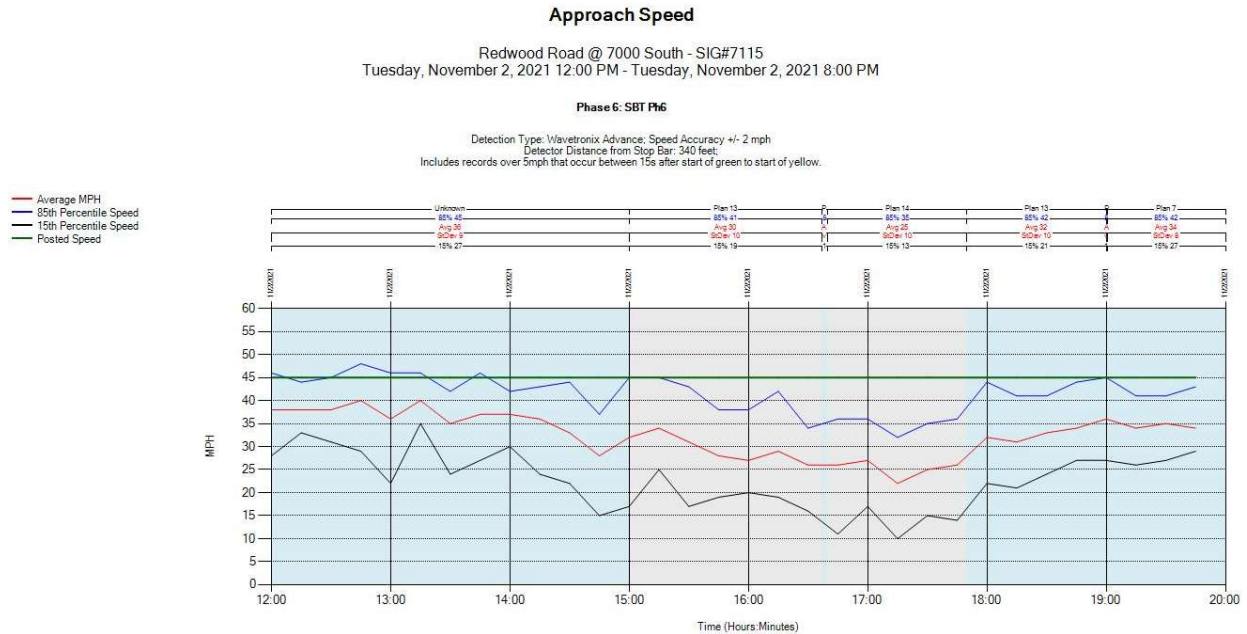
Figure 2: Approach Speed Chart

3. Approach Volume

The **Approach Volume** chart plots the traffic traveling toward the selected intersection. It utilizes both advance and stop bar detection (if available) to display comparisons between volume and flow factor for opposing directions. (A Wavetronix SmartSensor Advance detector typically provides advance detection). The results also include a table with metrics and values represented by the chart.

3.1. Requirements for Approach Volume Chart

Not all intersections in the ATSPM are capable of supporting the Approach Volume chart. In order to display this chart, the intersection must include properly configured parameters as listed below:

- Vehicle count detection: The detector(s) may be located either at the stop bar or set back (advanced). Advanced detection is typically provided using Wavetronix SmartSensor Advance.
- Signal controller must track all events using the standard event codes.
- Signal controller logs must be retrievable from the ATSPM web server.

3.2. Approach Volume Data

3.2.1. How Data is Gathered and Compiled

When the user generates this chart the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common) which is of type ApproachVolumeOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximums
- Bin size
- Flags for showing:
    - Directional Split
    - Total Volume
    - SB/WB Volume
    - NB/EB Volume
    - Turning Movement Count Detection
    - Advance Detection

Using these parameters, one or more ApproachVolumeChart objects are generated within the MetricOptions object. Typically, one will be generated for each pair of directions (north/south, east/west) and for each type of detection (stop bar, advance).

Within these ApproachVolumeChart objects, vehicle detections are gathered from the Controller_Event_Logs table and cross-referenced with the approach direction, detector ID, and timeframe.

3.2.2.   How Data is Displayed

Each of the ApproachVolumeChart objects creates a chart object, generated by the web rendering engine provided in the .NET Framework. All the volume data is rendered to the chart as lines based on user preferences. The ApproachVolumeChart object also contains a table object where the numeric statistics are recorded.

3.3.   Interpreting the Approach Volume Chart and Table

Once the **Approach Volume** metrics are generated, one chart for each supported movement will be created. Each chart will include a table for the respective representative data. An example chart is shown in Figure 3. For the purpose of this interpretation, all options (check boxes) were selected before chart creation). The chart includes the following components:

- A legend (left of the chart):
    - ——— **Northbound (or Eastbound)**, a solid blue line that graphically represents the volume of northbound or eastbound approaching traffic.
    - ——— **Southbound (or Westbound)**, a solid red line that graphically represents the volume of southbound or westbound approaching traffic.
    - – – – **Northbound (or Eastbound) D-Factor**, a dotted blue line that graphically represents the northbound to southbound (or eastbound to westbound) ratio.

o **– – – Southbound (or Westbound) D-Factor**, a dotted red line that graphically represents the southbound to northbound (or westbound to eastbound) ratio.
- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the approaches represented in the chart.
- The fifth line is the type of detection used and its distance upstream of the stop bar.
- The X-axis (above and below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side, primary Y-axis) and scale is the Volume in vehicles per hour (VPH). For example, in the chart at 15:00, the northbound volume is approximately 2,000 and the southbound is approximately 1,300.
- The Y-axis title (Right Side, secondary Y-axis) and scale is the Directional Split (D-Factor). In the example, at 15:00, the northbound split is approximately 0.6 and the southbound split is approximately 0.4.
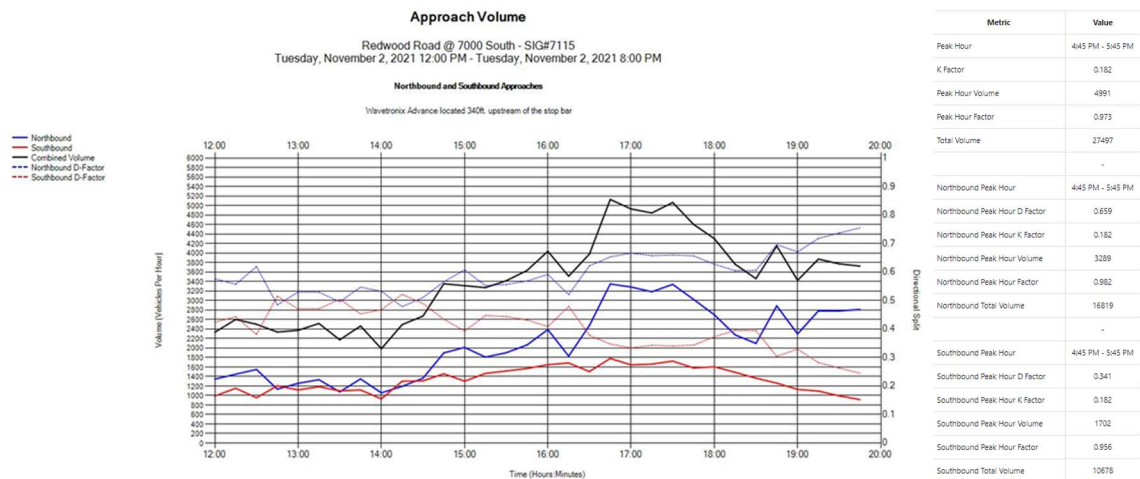
Figure 3: Approach Volume Chart using Advanced Detection

The table to the right of the chart includes additional information regarding data illustrated by the chart. Northbound and southbound information is replaced with westbound and eastbound information for tables with charts depicting west/east approaches. The table provides information regarding the volume for the prescribed period for the total volume as well as for each direction.

These metrics are:

- Peak Hour – The hour with the highest total volume within the duration of the chart
- Peak Hour K Factor – The ratio between the peak hour and the total volume for the day
- Peak Hour Volume – The total vehicles in both directions approaching the intersection
  o When the bin size is 15 minutes, this is the cumulative value of the four bins
- Peak Hour Factor (PHF) – The ratio between the peak hour volume (PHV) and the highest bin of that period

- Total Volume – The total vehicles approaching both directions for the duration of the chart
- Northbound (or Eastbound) Peak Hour – The hour with the highest northbound (or eastbound) volume within the duration of the chart
- Northbound (or eastbound) Peak Hour D-Factor – The ratio between the northbound and southbound (or eastbound and westbound) volume during the northbound peak hour
- Northbound (or Eastbound) Peak Hour K-Factor – The K-Factor as calculated on the northbound (or eastbound) peak hour
- Northbound (or Eastbound) Peak Hour Volume – The number of northbound (or eastbound) vehicles during the Northbound Peak Hour
- Northbound (or Eastbound) PHF – The PHF as calculated on the northbound (or eastbound) peak hour
- Northbound (or Eastbound) Total Volume – The total northbound (or eastbound) vehicles for the duration of the chart
- Southbound (or Westbound) Peak Hour – The hour with the highest southbound (or westbound) volume within the duration of the chart
- Southbound (or Westbound) Peak Hour D-Factor – The ratio between the southbound and northbound (or westbound and eastbound) volume during the southbound peak hour
- Southbound (or Westbound) Peak Hour K-Factor – The K-Factor as calculated on the southbound (or westbound) peak hour
- Southbound (or Westbound) Peak Hour Volume – The number of southbound (or westbound) vehicles during the Northbound Peak Hour
- Southbound (or Westbound) PHF – The PHF as calculated on the southbound (or westbound) peak hour
- Southbound (or Westbound) Total Volume – The total southbound (or westbound) vehicles for the duration of the chart

4. Arrivals on Red

The **Arrivals on Red (AoR)** measure plots the quantity of vehicles that arrive on the red phase as well as the percentage of vehicles that arrive on the red phase compared to vehicles arriving on green or yellow.

4.1. Requirements for Arrivals on Red

This measure requires count detection that is set back from the stop bar between 350 and 400 feet (or beyond the initial queue of vehicles at the intersection). In order to display this chart, the intersection must include properly configured parameters as listed below:

- Setback count detection (350 to 400 feet). This advanced detection is typically provided using Wavetronix SmartSensor Advance.
- Signal controller must track all events using the standard event codes.
- Signal controller logs must be retrievable from the ATSPM web server.

4.2.   Report Data

4.2.1.   How Data is Gathered and Compiled

When the user generates this plot, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type AoROptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximum
- Bin size
- Flag for showing plans and plan statistics

Using these parameters, a SignalPhaseCollection object is generated within the MetricOptions object.

Within this SignalPhaseCollection, the phases in use during the period, and the associated detector events, are analyzed. Data is gathered from the Controller_Event_Logs table, in this case, detector actuations during the red portion of the cycle.

The detector timestamps are projected ahead to vehicle arrivals at the stop bar using the Speed and Distance from Stop Bar in the detector configuration. The configuration parameter Decision Point can be used to offset the vehicle arrival back X number of seconds. This is typically left at zero seconds.

4.2.2.   How Data is Displayed

The MetricOptions object creates one or more chart objects generated by the web-rendering engine provided in the .NET Framework. All the delay data is rendered to the chart as lines based on user preferences. The chart is then saved as an image file displayed on the website.

4.3.   Interpreting the Arrivals on Red Chart

Once the AoR metrics are created, as shown in Figure 4, there will be one chart for each supported movement. The example below is the westbound approach set to display the AoR from 12:00 PM to 8:00 PM with a 15-minute volume bin. The chart components are:

- A legend (left of the chart):
    - **– – – Arrivals on Red**, a dotted red line that graphically represents the number of vehicles arriving during the red phase.
    - **——— Percent Arrivals on Red**, a solid red line that graphically represents the percentage of AoR versus all arrivals at any time in the specified date and time range.

- o **━ ━ ━ Total Vehicles**, a dotted black line that graphically represents the number of vehicles approaching the intersection at any time in the specified date and time range.
- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- fourth third line is the phase number and movement (with direction)
- The fifth line is the numerical value of the total detector hits (all phases), the numerical value of AoR, and the percent AoR for the complete duration of the chart.
- Directly above the chart, in black text is the timing plan that the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, the chart has five sections (and plans) between 12:00 PM and 8:00 PM.
  - o Above each chart section in Blue Text is the numerical value for the Percent AoR for that section of the chart.
  - o Above each chart section in Red Text is the numerical value for the percentage of time the signal indication is red (Red Time) for that section of the chart.
- The X-axis (above the chart) is the date in m/d/yyyy format.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side, primary Y-axis) and scale is the Volume in VPH. In the example at 14:00, the AoR volume is approximately 1,250 and the total number of vehicles is approximately 1,800.
- The Y-axis title (Right Side, secondary Y-axis) and scale is the Percent AoR. In the example at 14:00, the AoR is approximately 70%.
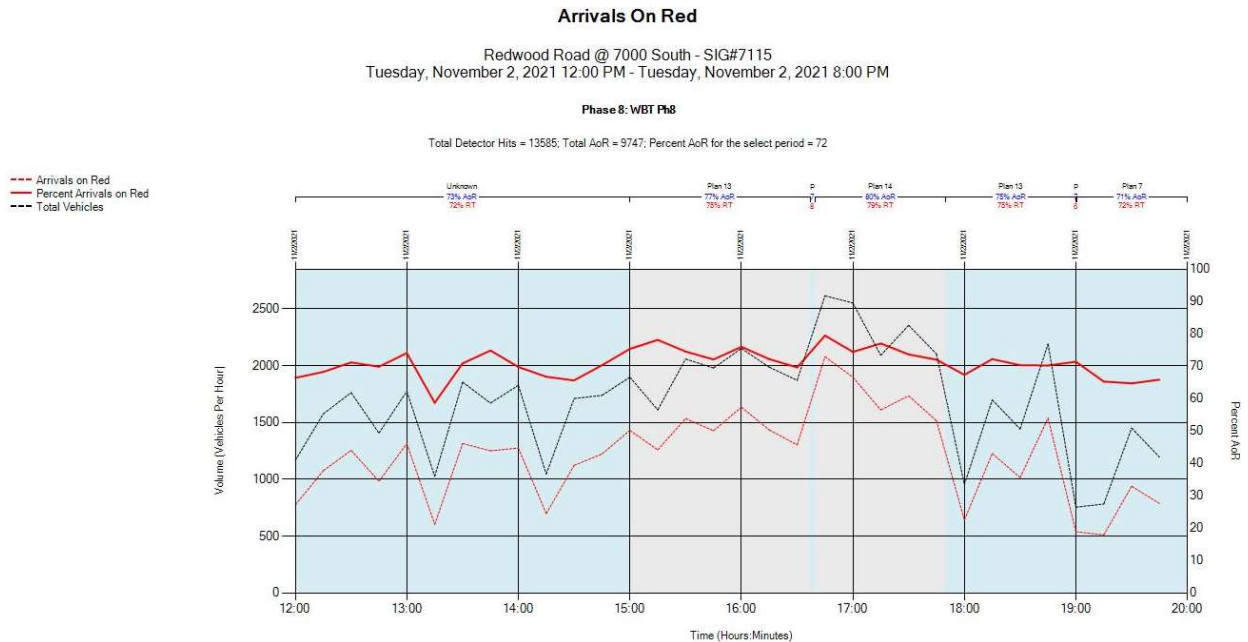
Figure 4: Arrivals on Red Chart

5. Pedestrian Delay

The **Pedestrian Delay** chart displays the duration a pedestrian waits to receive the walk indication after actuation of the pedestrian call.

5.1. Requirements for Pedestrian Delay

This measure requires that the intersection is set up as shown below. No special configuration is necessary to run this measure.

- One or more movements must have pedestrian actuation.
- Signal controller must track all events using the standard event codes, including pedestrian actuation and the subsequent start of walk.
- Signal controller logs must be retrievable by the ATSPM web server.

5.2. Report Data

5.2.1. How Data is Gathered and Compiled

When the user generates this chart, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common).

These MetricOptions are bound by:

- Analysis period start date and time

- Analysis period end date and time
- Signal ID
- Y-axis maximum
- Time buffer between unique ped detections
- Flags for showing the:
    - Pedestrian begin walk
    - Cycle length
    - Percent delay
    - Ped recall indication
- Ped recall threshold (percent)

Using these parameters, a PedDelaySignal object is generated within the MetricOptions object.

Within this PedDelaySignal, data is gathered from the Controller_Event_Logs table, in particular, pedestrian events (pedestrian call, pedestrian detection, begin walk, begin don't walk). The phases in the signal cycle containing pedestrian events are determined. Finally, for each phase "cycle" objects are created that contain timestamped pairs of pedestrian calls and begin walk indications.

5.2.2. How Data is Displayed

The MetricOptions object creates one or more chart objects generated by the web rendering engine provided in the .NET Framework. All the delay data (for each cycle, the difference between call and walk) is rendered to the chart as bars. The other data is rendered as points or lines. The chart is then saved as an image file displayed on the website.

5.3. Interpreting the Pedestrian Delay Chart

Once **Create Chart** is selected, a chart for each approach with a crosswalk is created. An example chart is given in Figure 5. The chart includes the following components:

- A legend (left of the chart):
    - ——— **Cycle Length**, a red line that graphically represents the cycle length in seconds for each cycle.
    - ▆ **Pedestrian Delay per Ped Requests**, blue bars that graphically represent the duration in minutes after actuation until the first pedestrian to actuate the pedestrian button receives a walk indication.
    - ● **Start of Begin Walk**, gold dots that graphically represent the start of the begin walk pedestrian interval.
    - ----- **% Delay by Cycle Length**, a dashed light blue line that graphically represent the duration in minutes after actuation until the first pedestrian to actuate the pedestrian button receives a walk indication.
- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.

- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the phase number associated with the pedestrian movement.
- The fifth line is a summary for the analysis period, including:
    - Number of pedestrian presses (PP)
    - Number of cycles with pedestrian requests (CPR)
    - Number of Time Buffered Presses (TBP)
    - Minimum delay, displayed in seconds
    - Maximum delay, is displayed in seconds
    - Average delay (AD), displayed in seconds
- Directly above the chart, the first line shows the timing plan(s) that the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, there are four signal plans active for the analysis period.
    - The second line above each chart section is the number of cycles with pedestrian requests for that section of the chart.
    - The third line above each chart section is the number of time buffered presses for that plan.
    - The fourth line above each chart section is the average delay for that plan given in seconds.
    - The fifth line above each chart section is the average cycle length for that section of the chart.
    - If the plan likely had a ped recall on (begin walk may run automatically on the coordinated phase; ped recall is placed by time-of-day, etc.), then the words "Ped Recall On–" indicating such is listed above the line showing the timing plan.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the Pedestrian Delay per Ped Requests in seconds. In the example, the pedestrian delay around 10:00 PM was approximately 40 seconds.
- The Y-axis title (Right Side) and scale is the Percent Delay by Cycle Length.
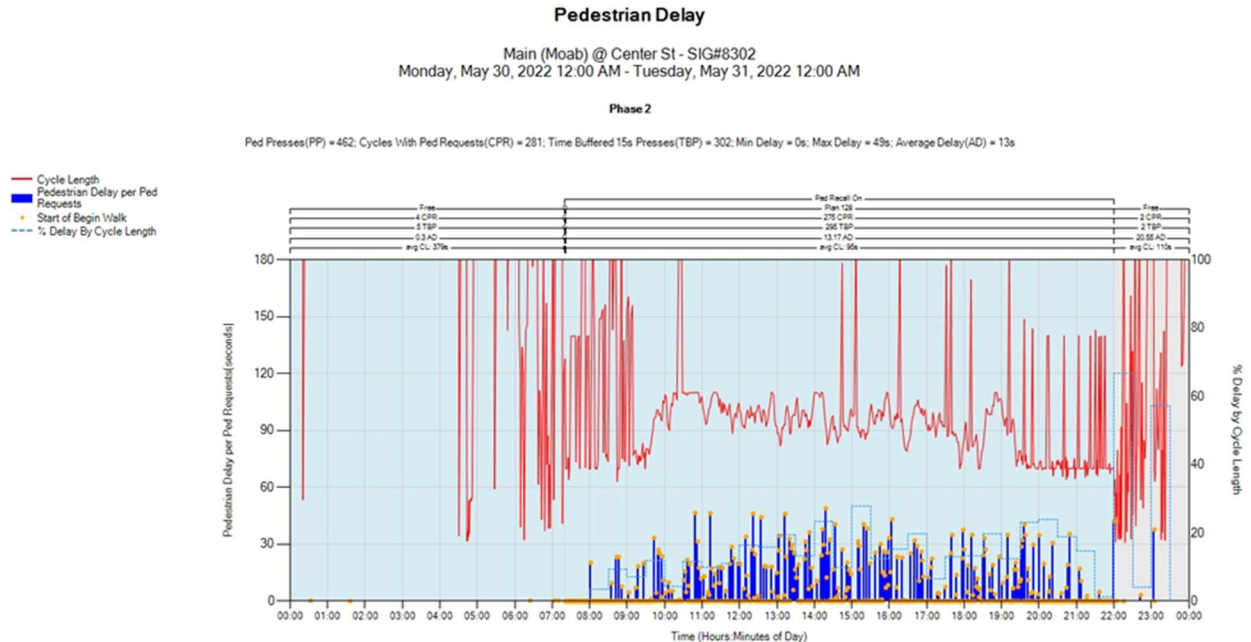
Figure 5: Pedestrian Delay Chart

6. Preemption Details

After generating the **Preemption Detail** report, the ATSPM provides feedback via three separate charts. The data represented depicts preemption from the request through end of preemption service. Preemption can occur for both rail and emergency requests. Both rail and emergency preemption metrics include multiple charts. These reports have the same legends regardless of preemption type, but some data are not available on the emergency charts.

6.1. Requirements for Report

To support the Preemption Detail measure, the intersection must meet these requirements. No special configuration is necessary to run this measure.

- The intersection controller must be configured for preemption.
- The intersection must include preemption detection hardware.
- The controller log must include instances of preemption where a preemption request was received and serviced by the controller.
- Signal controller must track all events using the standard event codes, including Preemption events.
- Signal controller logs must be retrievable by the ATSPM web server.

6.2.   Report Data

6.2.1.   How Data is Gathered and Compiled

When the user generates these plots, the MOE WCF Service creates a MetricGenerator object. This object is linked to three MetricOptions objects on the client side (MOE.Common), which are of types PreemptServiceMetricOptions, PreemptServiceRequestOptions, and PreemptDetailOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID

For each chart, data is gathered from the Controller_Event_Logs table for all preemption event codes (99-131).

For the Preempt Request and Preempt Service charts, data is compiled as timestamp and event parameter pairs.

For the Preempt Details charts, the phases in the signal cycle containing preemption events are determined. Finally, for each phase "cycle" objects are created, which contain time to service, dwell time, (entry) delay, input on (call activated), input off (end call), call max out, track clear, and gate down data paired with their respective timestamps.

6.2.2.   How Data is Displayed

The MetricOptions objects create one or more Chart objects, generated by the web rendering engine provided in the .NET Framework. All the preemption data is rendered to the chart as bars and points. The chart is then saved as an image file displayed on the website.

6.3.   Interpreting the Preemption Charts

After selecting **Create Chart**, the **Preemption Details** charts are displayed if the time-period includes preemption event codes. A set of charts will be generated for each movement supporting the measure. The top two charts display only the number of preempt requests and preempt services. Next, there will be a detailed chart for each preemption number (phase) that includes the appropriate event code.

Chart properties are described in detail below.

Preempt Request Chart (example charts for emergency and rail preempt requests are shown in Figure 6 and Figure 9, respectively):

- A legend (left of the chart):
  - ◆ **Preempt Request**, a black dot that graphically represents each time a request for preemption was received by the controller.

- The first line of text at the top of the chart contains the title of the chart.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The Y-axis title (Left Side) and scale is the Preempt Number. In the examples, all preempt requests were made on Preemption 1.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.

Preempt Service Chart (example charts for emergency and rail preempt services are shown in Figure 7 and Figure 10, respectively):

- Left side is the legend
    - ◆ **Preempt Service**, a black dot that graphically represents each time there is a service for preemption.
- The first line of text at the top of the chart contains the title of the chart.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during criteria selection.
- The Y-axis title (Left Side) and scale is the Preempt Number. In the examples, all preempt services were received on Preempt 1.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.

Preempt Details Chart (example charts for emergency and rail preempt details are shown in Figure 8 and Figure 11, respectively):

- Left side is the legend:
    - ▲ **Gate Down**, a brown triangle that graphically represents that start of when the gate arm is down
    - • **Input Off**, a black dot that graphically represents when a preemption call ends
    - • **Input On**, a green dot that graphically represents when a preemption call is activated
    - x **Call Max Out**, a red X that graphically represents when a preemption call times out (receives no service)
    - **Dwell Time**, a green bar that graphically represents the elapsed time during preempt service
    - **Track Clear**, a blue bar that graphically represents when the rail is clear
    - **Time to Service**, a yellow bar that graphically represents the elapsed time from call to service
    - **Delay**, a red bar that graphically represents when a failure occurs
- The first line of text at the top of the chart is the title of the chart.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis as specified during criteria selection.
- The fourth line is the preempt number for which the chart is made.

- The X-axis (above and below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the elapsed time in seconds. In the emergency example, the Time to Service for the preemption at 12:10 PM was approximately 4 seconds.

6.3.1. Emergency Preemption Charts

Note that for the complete details chart, there are no Entry Delay occurrences.

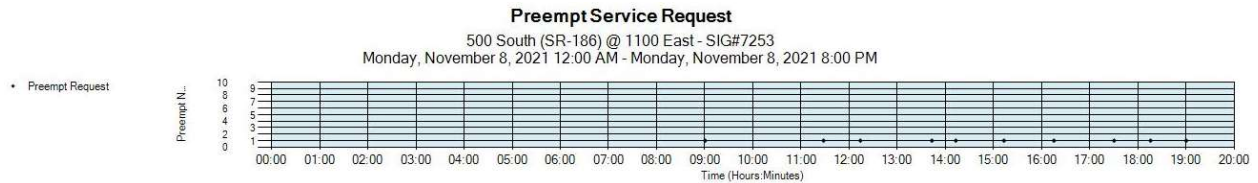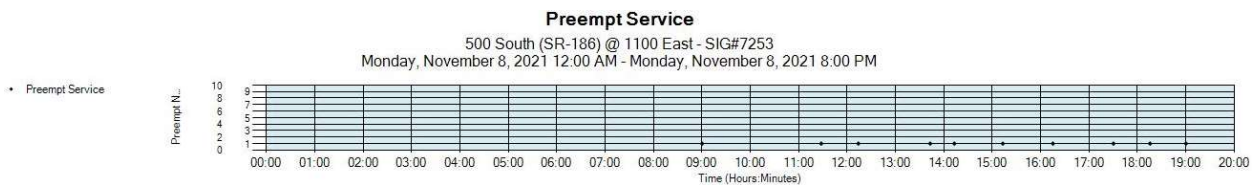**Figure 6: Preemption Request (Emergency)**

Figure 7: Preemption Service (Emergency)
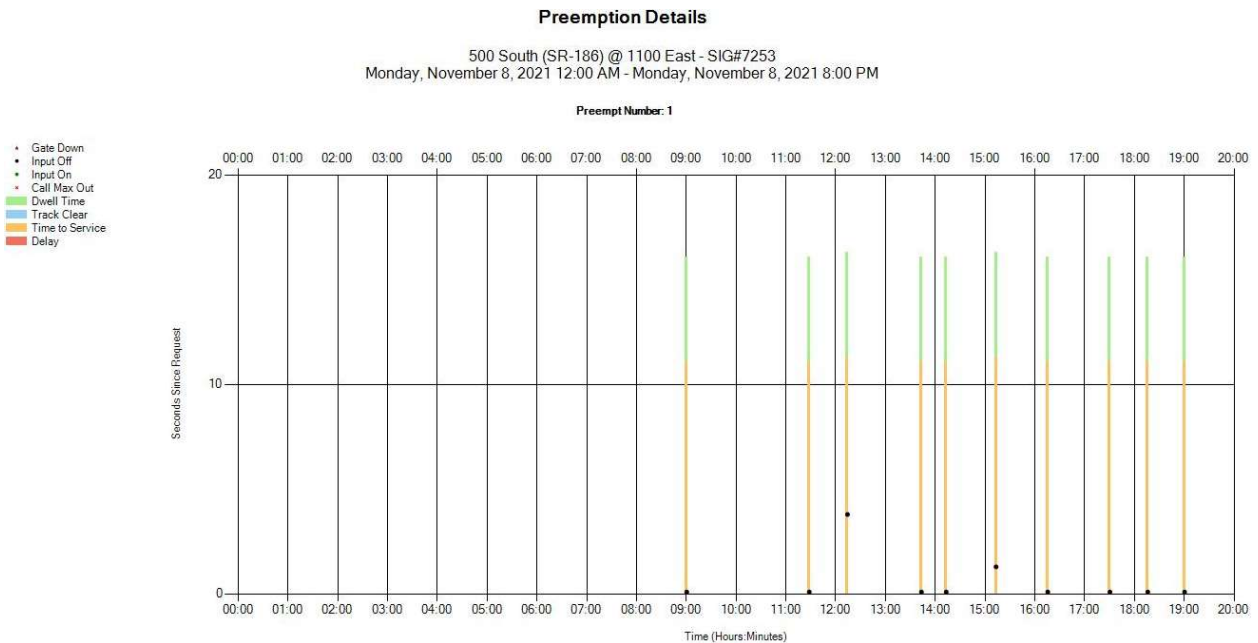
Figure 8: Preemption Details (Emergency)

6.3.2. Rail Preemption Charts

Unlike the Emergency chart above, the Rail Preemption Details chart includes Entry Delay.
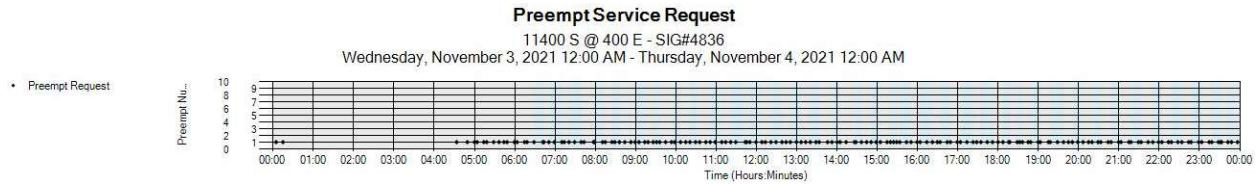
Figure 9: Preemption Request (Rail)
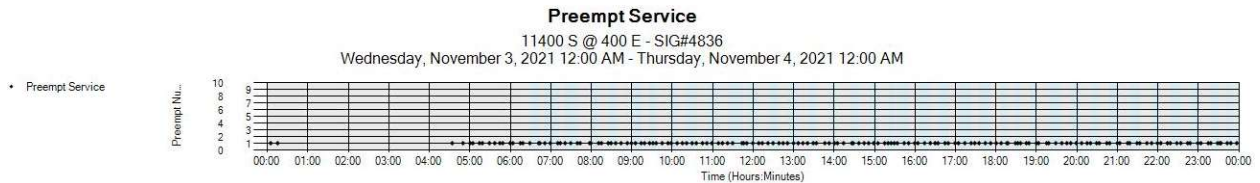
Figure 10: Preemption Service (Rail)
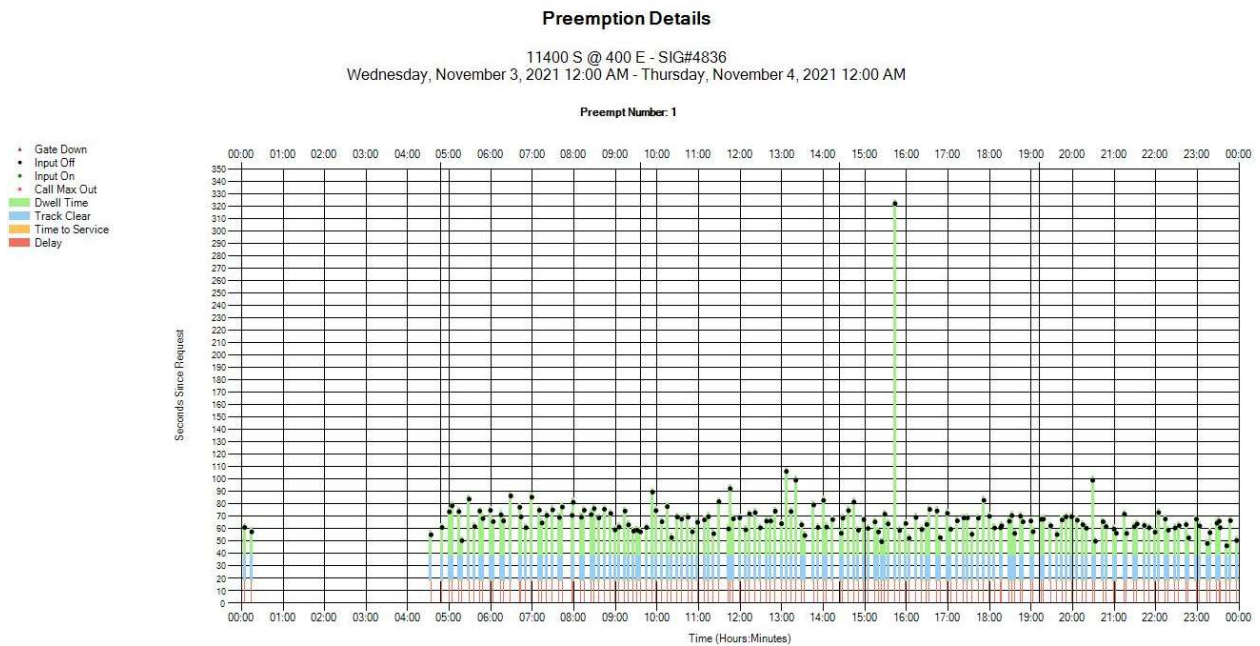
Figure 11: Preemption Details (Rail)

7.   Purdue Coordination Diagram

The **Purdue Coordination Diagram** (PCD) is a diagram that depicts all phases (green, yellow, and red) and traffic arrivals during each movement of the cycle. Each cycle is depicted separately as a series of vehicles (dots). It starts at the bottom of the diagram during AoR, and tracks up and to the right until the next change to red. By these means, the diagram depicts vehicle arrivals in a spatial manner and allows for platoon analysis.

7.1.   Report Data

7.2.   Requirements for the Purdue Coordination Diagram

The PCD requires count detection at a setback between 350 and 400 feet from the stop bar (beyond the typical queuing of vehicles at the intersection). In order to display this diagram, the intersection must include properly configured parameters as listed below:

- Vehicle detection capable of counting vehicles approaching the intersection (setback of 350-400 feet).
- Signal controller must track all events using the standard event codes, including the timing of red, yellow, and green phases.
- Signal controller logs must be retrievable by the ATSPM web server.

7.2.1.   How Data is Gathered and Compiled

When the user generates this diagram, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type PCDOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximums
- Volume bin size
- Line size
- Dot size
- Flags for showing:
    - Plans and plan statistics
    - Volumes

Event Data is gathered from the Controller_Event_Logs table. Data is then compiled into Change to Green, Change to Yellow, Change to Red, Detector Activation, and possibly Volume per Hour chart series.

The detector timestamps are projected ahead to vehicle arrivals at the stop bar using the Speed and Distance from Stop Bar in the detector configuration. The configuration parameter Decision Point can be used to offset the vehicle arrival back X number of seconds. This is typically left at zero seconds.

7.2.2.   How Data is Displayed

The MetricOptions objects create one or more Chart objects, generated by the web rendering engine provided in the .NET Framework. All the PCD data is rendered to the chart as bars and points. The chart is then saved as an image file displayed on the website.

7.3.   Interpreting the Purdue Coordination Diagram

Like many of the other charts, the **PCD** will generate a diagram for each supported movement of the intersection. An example is given in Figure 12. The diagram includes the following components:

- A legend (left of the chart):
    - ———— **Volume Per Hour**, a black line that graphically represents the volume per hour.
    - · **Detector Activation**, black dots that graphically represent each time a vehicle arrives.
    - ———— **Change to Green**, a green line that graphically represents when the signal indication changes to green.
    - ———— **Change to Yellow**, a yellow line that graphically represents when the signal indication changes to yellow.
    - ———— **Change to Red**, a red line that graphically represents when the signal indication changes to red.
    - **AoG – Arrival On Green**, blue text that displays the percentage for AoG above each chart section.
    - **GT – Green Time**, blue text that displays the percentage for GT above each chart section.
    - **PR – Platoon Ratio**, brown text that displays the calculated PR above each chart section.
- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the distance from the detector to the stop bar.
- The fifth line is the phase number and movement (with direction).
- The sixth line is the overall percentage of detector activations that occurred during green for the complete duration of the chart.
- Directly above the chart in black text is the timing plan the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, Plan 1 is active through about 9:15 AM, then Plan 7 is active.
    - Above each chart section in Blue Text (first blue line) is the percentage of the AoG for that section of the chart.
    - Above each chart section in Blue Text (second blue line) is the percentage of the cycle length that was green for that section of the chart.

- o Above each chart section in Brown Text is the Platoon Ratio for this plan. The platoon ratio is calculated by dividing AoG by GT.
- The X-axis (above and below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side, primary Y-axis) and scale is the cycle time in seconds. In the example, at 8:30 the cycle total time is approximately 150 seconds, with the red split lasting approximately 80 seconds before the following green begins. This is followed by yellow clearance at approximately 145 seconds into the cycle (60 seconds after change to green).
- The Y-axis title (Right Side, secondary Y-axis) and scale is the Volume per Hour.
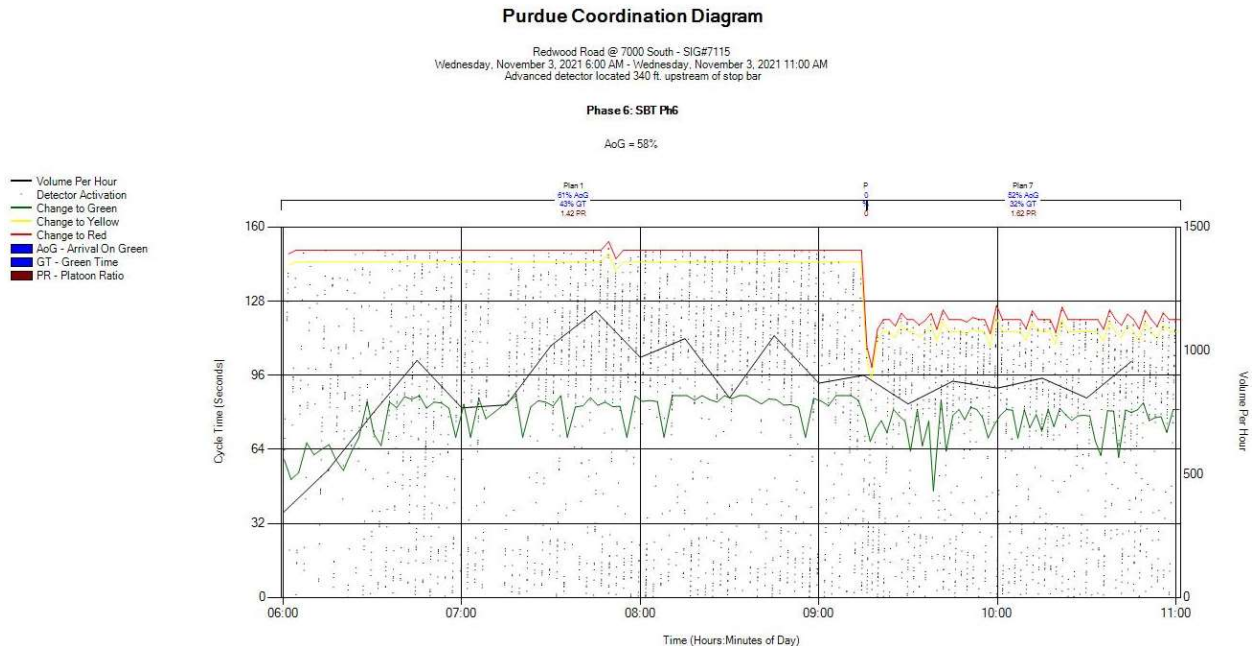
Figure 12: Purdue Coordination Diagram

8. Purdue Phase Termination

The **Purdue Phase Termination** chart is a graphical representation of why each phase terminated during a user-selected period.

8.1. Requirements for Purdue Phase Termination Chart

The intersection must be equipped as followed to support the Purdue Phase Termination chart. No special configuration is necessary to run this measure.

- Signal controller must track all events using standard event codes, including phase termination reasons.
- Additional vehicle detection other than that done by the controller is not necessary for this measure.
- Signal controller logs must be retrievable from the ATSPM web server.

8.2. Report Data

8.2.1. How Data is Gathered and Compiled

When the user generates this chart, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type PhaseTerminationOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximum
- Minimum number of consecutive terminations to be displayed
- Flags for showing:
    - Plans
    - Pedestrian activity

Using these parameters, an AnalysisPhaseCollection object is generated within the MetricOptions object.

Within this AnalysisPhaseCollection, the phases in use during the period and the associated phase termination events are analyzed. The termination events meeting the consecutives threshold are gathered from the database for the Controller_Event_Logs table. The events tracked are Gap Out, Max Out, Force Off, and Pedestrian.

8.2.2. How Data is Displayed

The MetricOptions object creates a chart object, generated by the web rendering engine provided in the .NET Framework. All the termination events are rendered to the chart as data points, and the chart is then saved as an image file displayed on the website.

8.3. Interpreting the Purdue Phase Termination Chart

The **Purdue Phase Termination** chart includes a representation for each phase, the controller plan, and the time of day. One chart is generated and includes each supported phase. The legend (shown in Figure 13) is displayed above the chart and includes:

- **Gap Out**, a green dot that graphically represents when a phase is terminated due to a gap out.
- **Max Out**, a red dot that graphically represents when a phase is terminated due to a max out.
- **Force Off**, a blue dot that graphically represents when a phase is terminated due to a force off.

- **Unknown**, a yellow dot that graphically represents when a phase is terminated for an unknown reason.
- **Ped Activity**, a gold dot that graphically represents when a pedestrian walk signal is turned on.
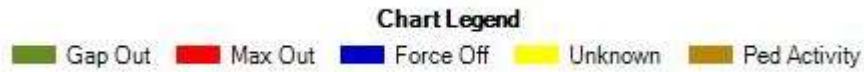
Figure 13: Purdue Phase Termination Legend

The chart for the **Purdue Phase Termination** data is displayed below the legend. An example is shown in Figure 14. The chart includes the following components:

- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and signal number.
- The third line is the selected date and time range of the analysis period as specified during the criteria selection.
- The fourth line provides an indication of how some of the data are displayed. In the example, force-offs, max-outs, and gap-outs with a consecutive occurrence of 1 or more are displayed.
- The fifth line is a constant line of text that states "Pedestrian events are never filtered."
- Directly above the chart is the timing plan the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, Plan 1 is active until approximately 9:15 AM and then Plan 7 is active.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the phase number. In the example, phase 6 has mostly force off terminations with a few gap out terminations.

Purdue Phase Termination

Redwood Road @ 7000 South - SIG#7115
Wednesday, November 3, 2021 6:00 AM - Wednesday, November 3, 2021 11:00 AM

Currently showing Force-Offs, Max-Outs and Gap-Outs with a consecutive occurrence of 1 or more.
Pedestrian events are never filtered
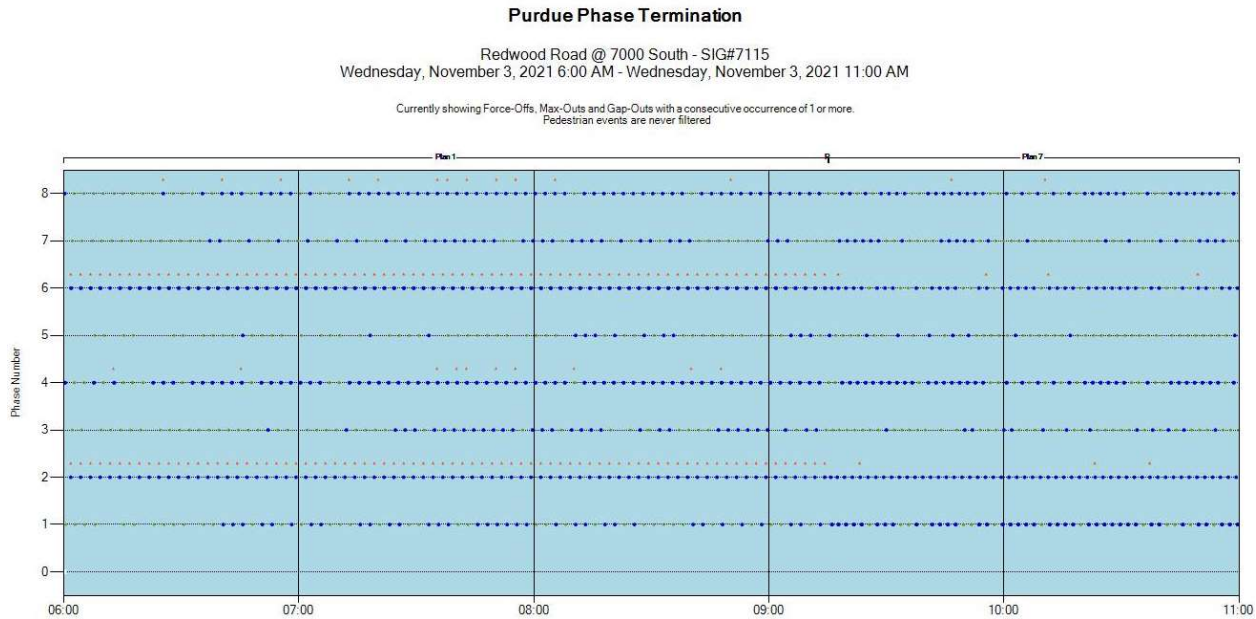
Figure 14: Purdue Phase Termination Chart

9. Purdue Split Failure

The **Purdue Split Failure** chart includes a great deal of information, the culmination of which is the reporting of the count, percentages, and classifications of split failure. It utilizes stop bar presence detection to calculate the green occupancy ratio (GOR) and red occupancy ratio (ROR). When both are above 80 percent, the phase is considered a split failure for that cycle.

9.1. Requirements for the Purdue Split Failure Chart

To support the Purdue Split Failure chart, the intersection must support the following:

- Traffic detection at the stop bar, either by lane group or individual lane. It's important that detection channels are not shared across signal phases.
- Signal controller must track all events using standard event codes, including phase terminations.
- Signal controller logs must be retrievable by the ATSPM web server.

9.2. Report Data

9.2.1. How Data is Gathered and Compiled

When the user generates this chart, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type SplitFailOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- First Seconds of Red
- Flags for showing:
  - Fail Lines
  - Average Lines
  - Percent Failure Lines

Event Data is gathered from the Controller_Event_Logs table. Data is then compiled into split fail, GOR gap out, GOR force off, ROR gap out, ROR force off, average ROR, average GOR, and percent fails series.

9.2.2.   How Data is Displayed

The MetricOptions objects create one or more chart objects, generated by the web rendering engine provided in the .NET Framework. All split failure data is rendered to the chart as lines and points. The chart is then saved as an image file displayed on the website.

9.3.   Interpreting the Purdue Split Failure Chart

Once **Create Chart** is selected, a chart for each movement supporting the measure will be created. An example chart is shown in Figure 15. For the purpose of this interpretation, all options (check boxes) were selected before chart creation). The chart includes the following components:

- A legend left of the chart:
  - **Split Fail**, a yellow vertical line graphically representing when a failure occurs.
  - **GOR Gap Out**, a green triangle graphically representing the GOR each time a gap out occurs.
  - **GOR Force Off**, a green dot graphically representing the GOR each time a force off occurs.
  - **ROR Gap Out**, a red triangle graphically representing the ROR each time a gap out occurs.
  - **ROR Force Off**, a red dot graphically representing the ROR each time a force off occurs.
  - **Average ROR**, a solid red line depicting the average ROR for each 15-minute bin in the analysis.
  - **Average GOR**, a solid green line depicting the average GOR for each 15-minute bin in the analysis.
  - **Percent Fails**, a dotted blue line depicting the average percentage of failures for each 15-minute bin in the analysis.
- The first line of text at the top of the chart is the title of the measure.
- The second line is the name of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis as specified during the criteria selection.
- The fourth line is the phase number and movement (with direction).

- The fifth line is the total number of split fails over the complete duration of the chart.
- Directly above the chart, the first line shows the timing plan(s) the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, Plan 1 is active until approximately 9:15 AM and Plan 7 is active after that.
    - The second line above each chart section is the number of split fails during the plan.
    - The third line above each chart section is the percentage of split fails during the plan.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the Occupancy Ratio in percent. In the example from 8:45 AM to 9:00 AM, the average GOR was approximately 90 percent, the average ROR was approximately 16 percent, and the percent split failures was 0 percent.
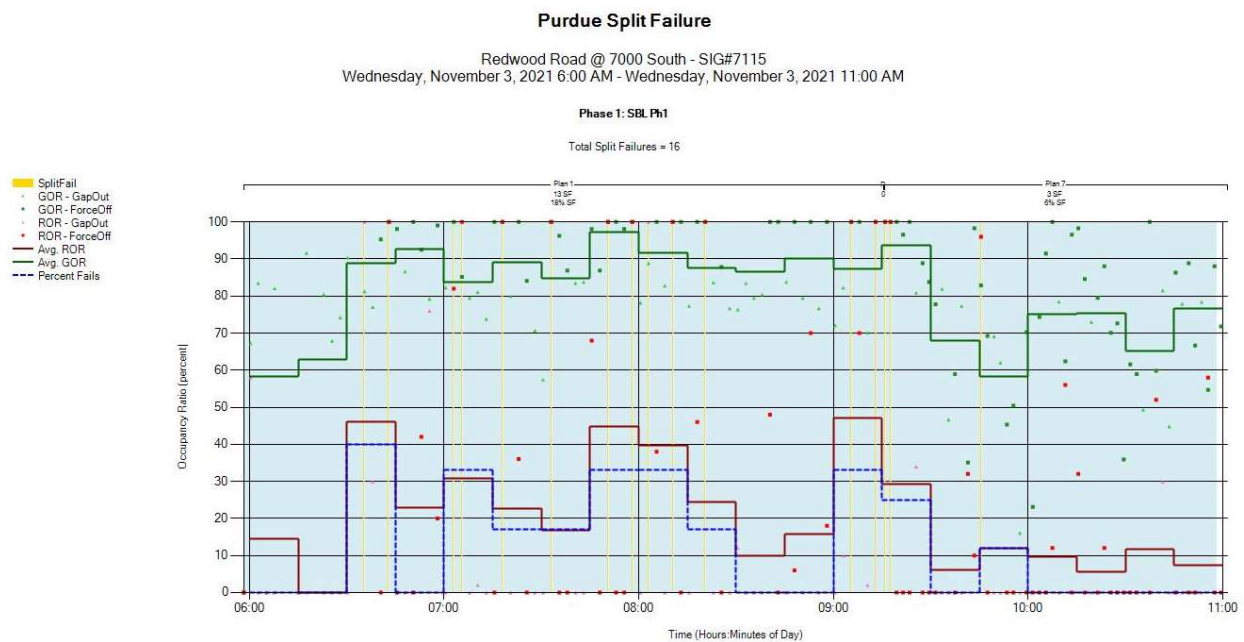
Figure 15: Purdue Split Failure Chart

10.   Split Monitor

Similar to the **Purdue Phase Termination**, the **Split Monitor** depicts the factor that terminates the phase. The **Split Monitor** report separates the data into charts for each phase and adds the phase duration in seconds. Each chart depicts the reason the phase terminated over a user-selected time frame.

10.1.   Requirements for the Split Monitor Chart

To support the Split Monitor chart, the intersection must support the following. No special configuration is necessary to run this measure.

- Signal controller must track all events using standard event codes, including phase terminations.
- Signal controller logs must be retrievable by the ATSPM web server.

10.2. Report Data

10.2.1. How Data is Gathered and Compiled

When the user generates this chart, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type SplitMonitorOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximum
- Selected Percentile Split
- Flags for showing:
  - Plan Stripes
  - Pedestrian Activity
  - Average Split
  - Percent Max Out and Force Off
  - Percent Gap Outs
  - Percent Skip

Event Data is gathered from the Controller_Event_Logs table. Data is then compiled into programmed split, gap out, max out, force off, unknown, and pedestrian activities series.

10.2.2. How Data is Displayed

The MetricOptions objects create one or more chart objects, generated by the web rendering engine provided in the .NET Framework. All the split monitoring data is rendered to the chart as lines and points. The chart is then saved as an image file displayed on the website.

10.3. Interpreting the Split Monitor Chart

Once the **Split Monitor** charts are generated, the user will see a legend followed by the chart(s). The legend (an example of which is shown in Figure 16) is displayed at the top and includes:

- **Programmed Split**, an orange line that graphically represents the programmed split length.
- **Gap Out**, a green dot that graphically represents when a phase is terminated due to a gap out.

- ████ **Max Out,** a red dot the graphically represents when a phase is terminated due to a max out.
- ████ **Force Off,** a blue dot that graphically represents when a phase is terminated due to a force off.
- ████ **Unknown**, a black dot that graphically represents when a phase is terminated and the termination cause is unknown.
- ████ **Ped Activity**, a gold circle that graphically represents the end of the pedestrian flashing don't walk interval.

Chart Legend
████ Programmed Split ████ Gap Out ████ Max Out ████ Force Off ████ Unknown Termination Cause ████ Ped Activity

Figure 16: Split Monitor Legend

For each supported movement, a chart for the **Split Monitor** data is displayed below the legend. An example chart is shown in Figure 17. The chart includes the following components:

- The first line of text at the top of the chart is the title of the measure.
- The second line is the name of the intersecting roads and signal number.
- The third line is the selected date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the timing phase number.
- Directly above the chart, the first line displays the timing plan(s) the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example, multiple signal plans are active over the 24-hour analysis period.
  - o The second line above each chart section in **Purple Text** is the 85th percentile split for that section of the chart.
  - o The third line above each chart section in black text is the average split for that section of the chart.
  - o The fourth line above each chart section in Blue Text is the percentage of force offs for that section of the chart.
  - o The fifth line above each chart section in Green Text is the percentage of gap outs for that section of the chart.
  - o The sixth line above each chart section in black text is the percentage of skips (phase skipped due to lack of demand) for that section of the chart.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the phase duration in seconds. In the example at approximately 8:30 AM, phase 2 was terminated at approximately 78 seconds with a force off. A pedestrian activation is also displayed approximately at the 70 second mark.
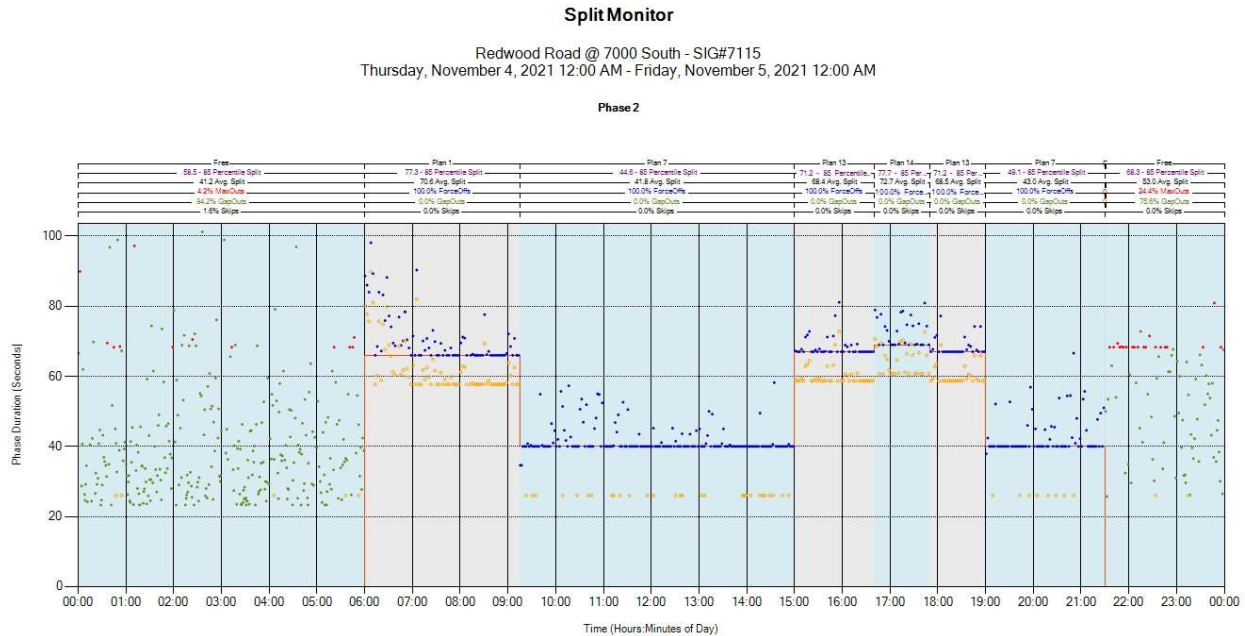
Figure 17: Split Monitor (includes Programmed Split)

11. Turning Movement Counts

The **Turning Movement Counts** measure displays counts for all supported turn and through movements. Once the user selects the appropriate intersection and time period and clicks **Create Chart**, a separate graph for each dedicated movement for each approach is generated. If there is no dedicated right or left turn lane, there will not be a chart for that movement; however, if there is a shared through-turn lane, that lane will be indicated as "Thru Right" or "Thru Left."

11.1. Requirements for Turning Movement Counts

This data requires stop bar detection with count for each travel lane. In order to display this chart, the intersection must include properly configured parameters as listed below:

- Stop bar/count detection for each lane in movement(s) to be analyzed.
- Signal controller must track all events using standard event codes.
- Signal controller logs must be retrievable by the ATSPM web server.

11.2. Report Data

11.2.1. How Data is Gathered and Compiled

When the user generates this plot, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type TMCOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximums
- Volume bin size
- Flags for showing:
    - Movement type (per-lane) volume
    - Total volume
    - The data table

Using these parameters, separate charts for each movement direction of vehicle, exit ramp, bicycle, pedestrian, HOV, light rail, and bus lanes are created within the MetricOptions object. The Controller Event Log is queried on a per-detector basis for each chart.

11.2.2. How Data is Displayed

The MetricOptions object creates a chart object, generated by the web rendering engine provided in the .NET Framework. All of the per-lane and total volumes are rendered to the chart as data points. The chart is then saved as an image file displayed on the website.

11.3. Interpreting Turning Movement Counts

The **Turning Movement Counts** chart is a line graph over the analysis period. An example chart is given in Figure 18. Charts include the following components:

- The first line of text at the top of the chart is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the movement and direction. In the example shown in Figure 18, the chart is for the Northbound Thru vehicle movement.
- The fifth line details statistics of the selected time for the total volume of the specified movement/lane group. This includes: total volume, peak hour, peak hour volume in VPH, PHF and lane utilization factor (f_{LU}).
- Above each chart section is the timing plan(s) the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In the example shown in Figure 18, an unknown plan is active from 12 PM to 4:00 PM, Plan 13 is active from 4 PM to 6 PM, and Plan 1 is active from 6 PM to 8 PM.
- The X-axis (above the chart) is the date in m/d/yyyy format.
- The X-axis (below the chart) is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the volume in VPH.
- A legend (below the chart) with *only the applicable components* from the following list (in the example, the Total Volume, Lane 1, Thru Left, and Through Right lines are shown):

- o —— **Total Volume**, a black line that graphically represents the total for all lanes (only used if there is more than one lane and if the "Show Total Volume" option is checked).
- o —— **Lane 1**, a brown line that graphically represents the VPH for the left-most exclusive lane in the lane group.
- o —— **Lane 2**, a gold line that graphically represents the VPH for the second exclusive lane from the left in the lane group.
- o ········ **Lane 3**, a dotted blue line that graphically represents the VPH for the third exclusive lane from the left in the lane group.
- o ········ **Lane 4**, a dotted brown line that graphically represents the VPH for the fourth exclusive lane from the left in the lane group.
- o ········ **Thru Left**, a dotted gold line that graphically represents the VPH for a shared through-left lane.
- o —— **Thru Right**, a blue line that graphically the VPH for a shared through-right lane.
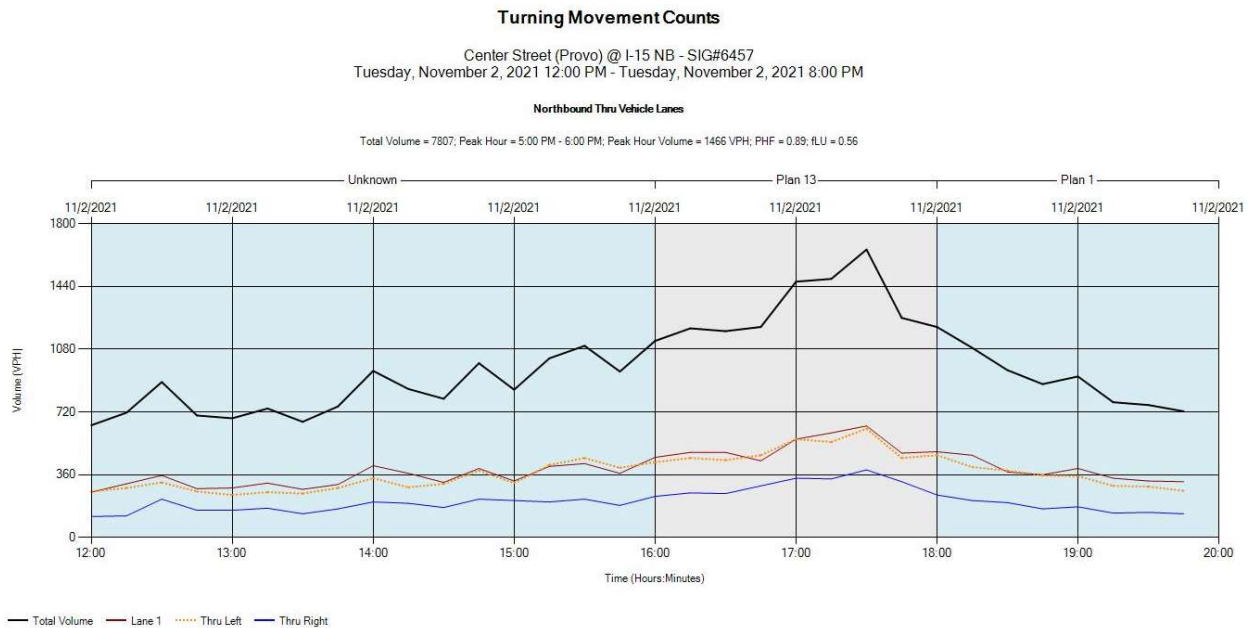
Figure 18: Turning Movement Counts

12. Yellow and Red Actuations

Yellow and Red Actuations is a graphical representation of when vehicles enter the intersection during the yellow and red indications for each phase. This is based on analyzing vehicle speed and its distance from the intersection to predict whether the vehicle can stop. With additional configuration parameters, vehicles could also be counted as they cross the stop bar and enter the intersection (if the detection system is configured for this purpose).

The overarching purpose of this measure is to identify when engineering countermeasures might be needed to deal with red-light running.

Note: This measure occasionally flags vehicles that are probably passing through on green or yellow as violations.

12.1. Requirements for Yellow and Red Actuations

In order to produce the Yellow and Red Actuations chart, there must be a determination if a vehicle either: 1) passes beyond the stop bar into the intersection, or 2) can or cannot stop before the stop bar. These measures determine whether the vehicle likely entered the intersection during the yellow and red indications of each phase. The Utah ATSPM site mostly utilizes radar detection (Wavetronix SmartSensor Matrix) with a count sensor at or slightly in front of the stop bar. A minimum speed threshold, usually 5 mph, is set in the sensor software and vehicles traveling less than this speed are omitted (https://udottraffic.utah.gov/ATSPM/Images/WavetronixMatrixLatencyInformation.pdf). In addition, UDOT often uses a detector latency of 1.2 seconds when using Wavetronix Matrix that is further discussed in the pdf listed above. Radar detection or a loop that collects data within the intersection itself would be optimal. In order to display this chart, the intersection must include properly configured parameters as listed below:

- Detection (multiple methods) to determine entrance beyond the stop bar into the intersection.
- Signal controller must track all events using standard event codes.
- Signal controller logs must be retrievable by the ATSPM web server.

12.2. Report Data

12.2.1. How Data is Gathered and Compiled

When the user generates this plot, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type YellowAndRedOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Y-axis maximum
- Severe Red Light Violations (number of seconds after the start of red that count as severe violations)
- Flags for showing:
  - Red Light Violations
  - Severe Red Light Violations
  - Percent Red Light Violations

- o   Percent Severe Red Light Violations
- o   Average Time Red Light Violations
- o   Yellow Light Occurrences
- o   Percent Yellow Light Occurrences
- o   Average Time Yellow Occurrences

Using these parameters, separate charts for each signal phase are created within the MetricOptions object. Approach data is queried for all approaches relevant to the signals selected.

12.2.2.   How Data is Displayed

The MetricOptions object creates a chart object, generated by the web rendering engine provided in the .NET Framework. The chart is then saved as an image file to later be displayed on the website.

12.3.   Interpreting Yellow and Red Actuations

After the report generates, there will be a separate chart for each movement available. An example chart is shown in Figure 19. The abbreviations for the "Yellow and Red Actuations" measure are defined in the Component Details document. Each graph includes these components:

- •   The first line of text at the top of the chart is the title of the measure.
- •   The second line is the names of the intersecting roads and the signal number.
- •   The third line is the date and time range of the analysis period as specified during the criteria selection.
- •   The fourth line is the phase number and movement (with direction).
- •   The fifth line lists the count and percent of the total violations (vehicles entering during red clearance or red), severe violations (calculated based on the **Severe Red Light Violations** input), and yellow light occurrences (vehicles entering during yellow) for the complete duration of the chart.
- •   Directly above each chart section, the first line displays the timing plan the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In Figure 19, Plan 7 is active for the first three hours of the analysis period, Plan 13 is active for the next 3.5 hours, and Plan 7 is active again for the last half hour.
  - o   The second line above each chart section is the TYLO (Average Time Yellow Occurrences), which is the average time in seconds that vehicles enter the intersection after the start of yellow for that section of the chart.
  - o   The third line above each chart section is the %YLO (Percent Yellow Light Occurrences), which is the percentage of vehicles entering the intersection relative to the total flow for that section of the chart.
  - o   The fourth line above each chart section, the fourth line is the #YLO (Yellow Light Occurrences), which is the number of vehicles entering the intersection during yellow for that section of the chart.

- o The fifth line above each chart section is the Ave TRLV (Average Time Red Light Violations), which is the average time in seconds when red light violations occur after the start of red for that section of the chart.
- o The sixth line above each chart section is the %SRLV (Percent Severe Red Light Violations), which is the percentage of severe red light violations relative to the total flow for that section of the chart.
- o The seventh line above each chart section is the %RLV (Percent Red Light Violations), which is the percentage of red light violations relative to the total flow for that section of the chart.
- o The eighth line above each chart section is the SRLV (Severe Red Light Violations), which is the total number of severe red light violations that occurred for that section of the chart.
- o The ninth line above each chart section is the RLV (Red Light Violations), which is the total number of red light violations (entering on red clearance or red) for that section of the chart.

- The X-axis (above and below the chart) is the hour in 24-hour format.
- The Y-axis title (left of the chart) and scale is Yellow Red Time in seconds. In the example, the last detector activation before the 17:00 hour is graphed at approximately 4 seconds.
- A legend (right of the chart):
  - o **Red**, a solid light red area that graphically represents the duration of the red indication.
  - o **Red Clearance**, a solid red area that graphically represents the duration of the red clearance.
  - o **Yellow Change**, a solid yellow area that graphically represents the duration of the yellow clearance.
  - o **Detector Activation**, black dots graphically representing times where a vehicle would enter the intersection; each are based on a detector activation that indicates a vehicle cannot stop in time to keep from entering the intersection during the yellow, all red, or red indication.
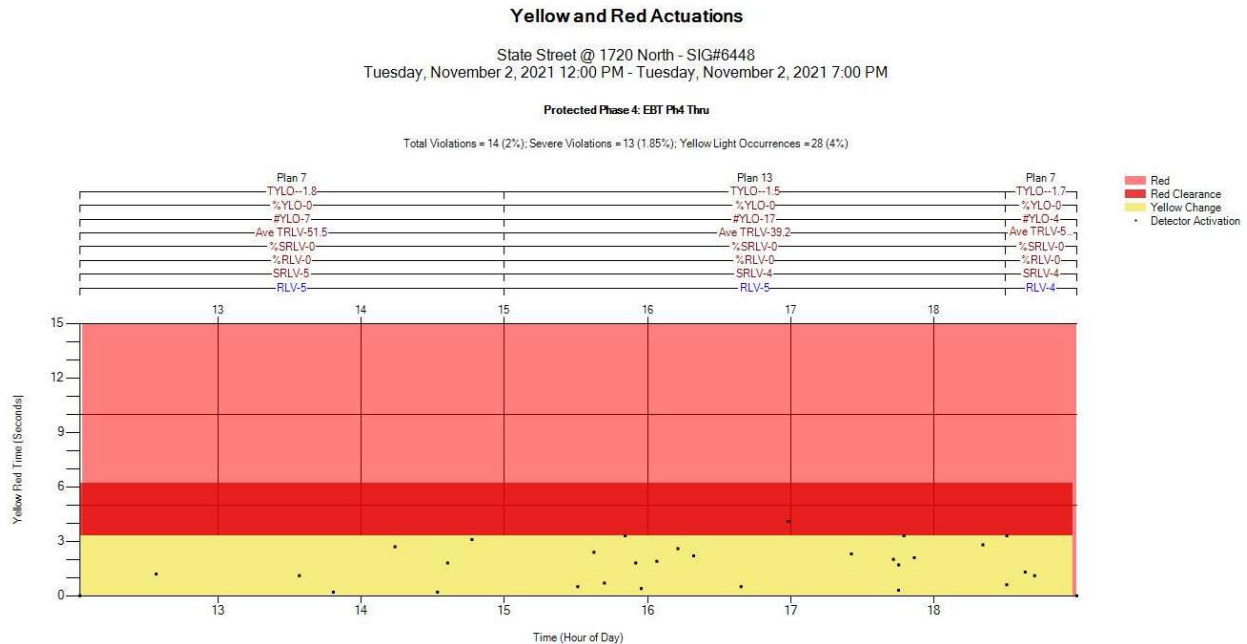
Figure 19: Yellow and Red Actuations Graph

13. Timing and Actuation

The **Timing and Actuation** measure depicts a detailed view of the vehicle and pedestrian cycles for each phase overlaid with detection actuations. In addition, this measure allows custom enumeration codes to be plotted for further analysis. This measure is most useful for mesoscopic level (for time durations of 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 period 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).

13.1. Requirements for Timing and Actuation

This measure requires that the intersection is set up as shown below.

- Configuring the phases in ATSPM Signal configuration is necessary to see data for this measure (unless "Raw Data Display" is enabled). If "Raw Data Display" is enabled, the algorithm will ignore the signal configuration and will look for up to 16 phases and 16 overlaps for active phase and pedestrian events.
- Without "Raw Data Display" enabled, to see timing and detection actuation charts, the phase needs to be assigned and detectors mapped to the phase.

- Signal controller must track all events using the standard event codes, including pedestrian actuation and the subsequent start of walk.
- Signal controller logs must be retrievable by the ATSPM web server.

13.2. Report Data

13.2.1. How Data is Gathered and Compiled

When the user generates this chart, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common).

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Various Timing and Actuation Options:
    o Option to show the legend
    o Option to show a header for each phase
    o Option to combine lanes for each phase
    o Dot and marker size
    o Phase filter
- Boxes to list Phase and Global Custom Codes:
    o Phase event codes (enumeration codes entered will display under each phase that is displayed; for the data to be relevant, it is up to the user to consult with the Indiana Traffic Signal Hi Resolution Data Logger Enumerations (https://docs.lib.purdue.edu/jtrpdata/3/) and to select the event codes that have an event parameter defined as "Phase #")
    o Global event codes (enumeration event codes entered will display on a separate blue chart at the bottom of the phase charts, if data is available)
    o Global event parameters (enumeration event parameters entered will display on a separate blue chart with the global event codes at the bottom of the phase charts, if data is available)
- Chart options:
    o Option to show all lanes for each phase
    o Option to show detector on/off lines (if this is enabled, a line will be drawn connecting the detector on data point to their respective detector off data point)
    o Option to show event start stop pairs
    o Option for raw data display
    o Option to show permissive phases
- Vehicle Signal Display Options
    o Option to extend search by minutes
    o Option to show vehicle signal display
    o Option to show pedestrian intervals

- Option to extend start/stop search by minutes
- Option to show pedestrian actuations
- Option to include stop bar presence detection
- Option to include lane-by-lane count detection
- Option to include advanced presence detection
- Option to include advanced count detection
- Option to offset the advanced count by seconds

Using these parameters, a TimingAndActuation object is generated within the MetricOptions object.

Within this TimingAndActuation, data is gathered from the Controller_Event_Logs table, in particular:

- Active Phase Events: phase begin green [1], phase min complete [3], phase begin yellow clearance [8], phase end yellow clearance [9], phase end red clearance [11]
- Overlap Events: overlap begin green [61], overlap begin trailing green [62], overlap begin yellow [63], overlap begin red clearance [64], overlap off [65], pedestrian overlap begin walk [67], pedestrian overlap begin clearance [68], pedestrian overlap begin solid don't walk [69].
- Detector Events: detector off [81], detector on [82], ped detector on [90], ped detector off [89].

13.2.2. How Data is Displayed

The MetricOptions object creates one or more chart objects generated by the web rendering engine provided in the .NET Framework. All the delay data (for each cycle, the difference between call and walk) is rendered to the chart as bars. The chart is then saved as an image file displayed on the website.

13.3. Interpreting the Timing and Actuation Chart

Once the **Timing and Actuation** charts are generated, the user will see a chart for each configured phase followed by a legend. The legend (an example of which is shown in Figure 20) includes the color and shape of each chart object alongside detailed descriptions of the event and code that each chart object represents.
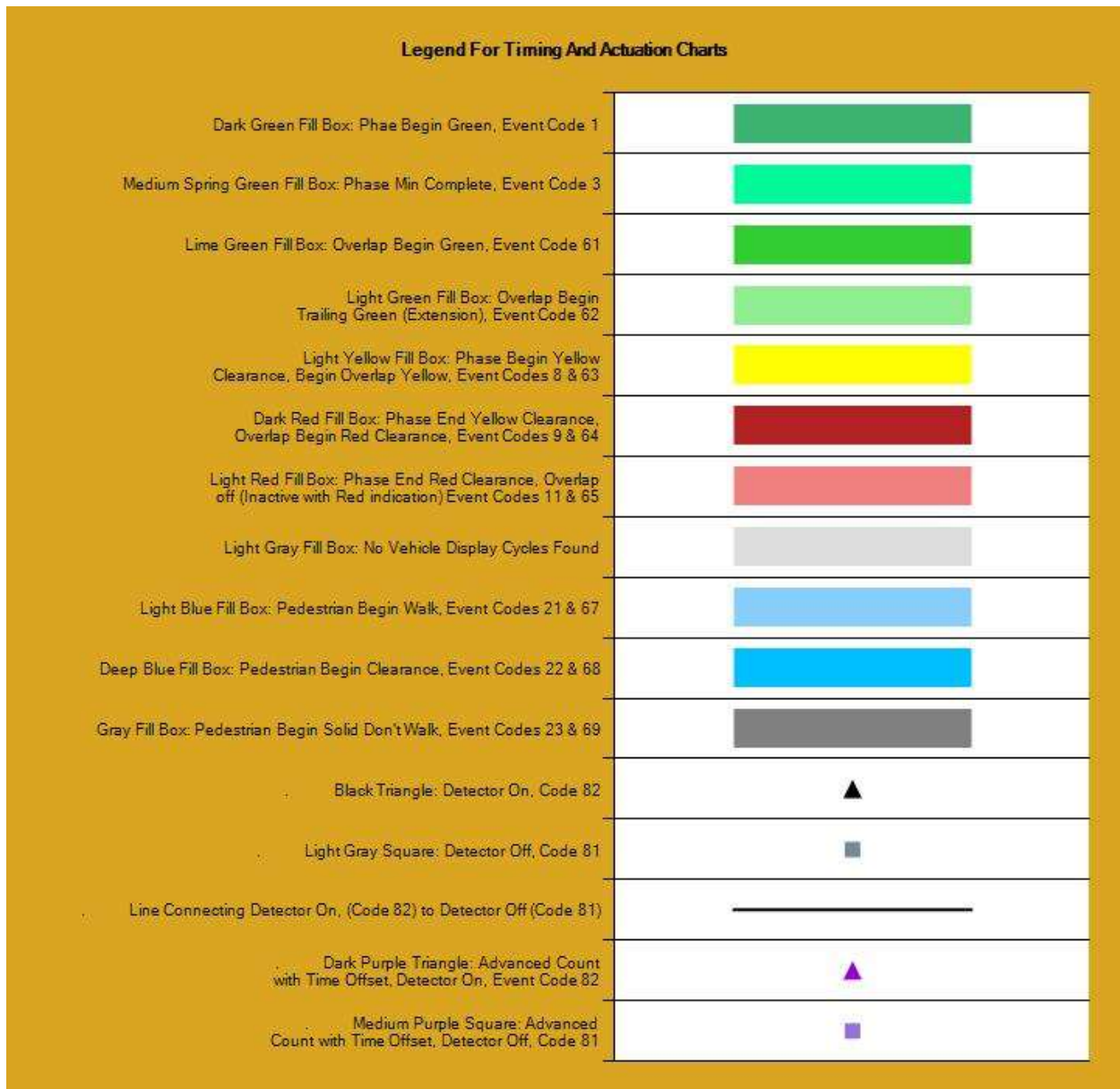
Legend For Timing And Actuation Charts

Dark Green Fill Box: Phae Begin Green, Event Code 1	
Medium Spring Green Fill Box: Phase Min Complete, Event Code 3	
Lime Green Fill Box: Overlap Begin Green, Event Code 61	
Light Green Fill Box: Overlap Begin Trailing Green (Extension), Event Code 62	
Light Yellow Fill Box: Phase Begin Yellow Clearance, Begin Overlap Yellow, Event Codes 8 & 63	
Dark Red Fill Box: Phase End Yellow Clearance, Overlap Begin Red Clearance, Event Codes 9 & 64	
Light Red Fill Box: Phase End Red Clearance, Overlap off (Inactive with Red indication) Event Codes 11 & 65	
Light Gray Fill Box: No Vehicle Display Cycles Found	
Light Blue Fill Box: Pedestrian Begin Walk, Event Codes 21 & 67	
Deep Blue Fill Box: Pedestrian Begin Clearance, Event Codes 22 & 68	
Gray Fill Box: Pedestrian Begin Solid Don't Walk, Event Codes 23 & 69	
Black Triangle: Detector On, Code 82	▲
Light Gray Square: Detector Off, Code 81	■
Line Connecting Detector On, (Code 82) to Detector Off (Code 81)	—
Dark Purple Triangle: Advanced Count with Time Offset, Detector On, Event Code 82	▲
Medium Purple Square: Advanced Count with Time Offset, Detector Off, Code 81	■

Figure 20: Timing and Actuation Legend

For each configures phase, a chart for the Timing and Actuation data is displayed.

- The first line of text at the top of the charts is the title of the measure.
- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the phase number and movement (with direction). If "Header For Each Phase" is checked, then these first four lines of text are above the chart for each phase; if unchecked, then they are above just the first chart.

- The X-axis (below the chart) is the time from start time to end time that was selected for analysis.
- The Y-axis (if the options are enabled) will show the following:
  - Vehicle signal display
  - Pedestrian Intervals
  - Pedestrian Detector Actuations
  - Lane Detection (each lane and detector type is listed in a unique row)
  - Phase Event Codes (if entered).

Figure 21 shows phase 2 for signal 6448. The time range is from 12:00 PM to 12:05 PM. The diagram shows the green, yellow and red clearance time of the vehicle signal display, as well as the pedestrian interval timing (walk, flashing don't walk, solid don't walk) and detector actuations.
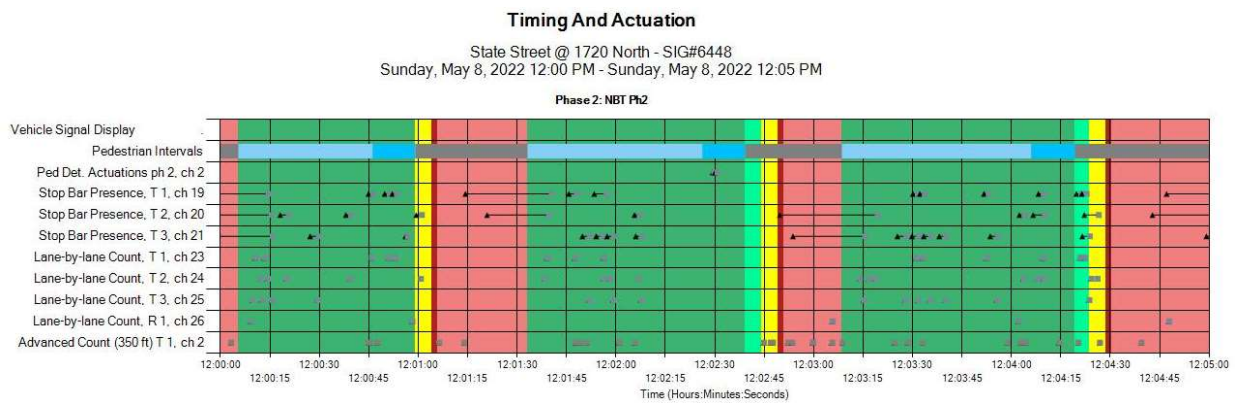

Figure 21: Timing and Actuation Chart

Figure 22 below shows the same data as found in Figure 21 with the addition of Phase Event code 6 (phase force off) which was entered in the Phase Event Code text box during the criteria selection.
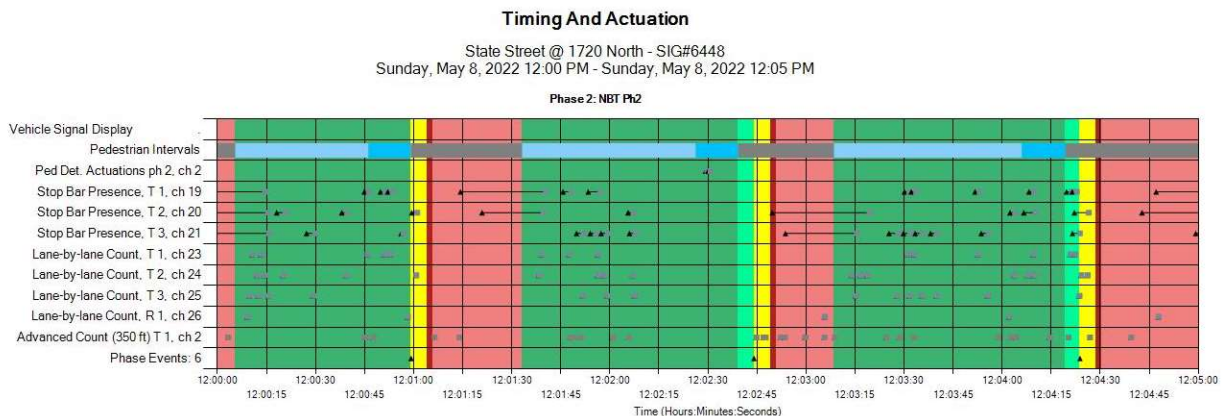

Figure 22: Timing and Actuation Chart - Phase Event Codes

Figure 23 shows the global event codes and parameters that display on a separate chart if codes and parameters are specified in the designated text boxes during the criteria selection. For the example, "81" was typed into the Global Event Codes text box and "2,4" was typed into the Global Event Params text box.
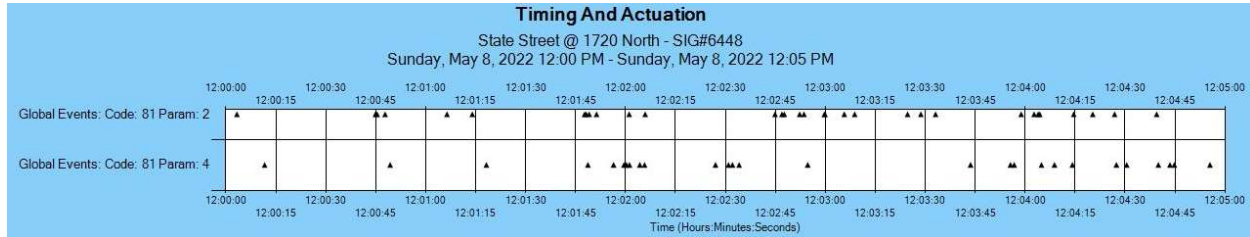

Figure 23: Custom Global Event Codes & Parameters

14. Left Turn Gap Analysis

The **Left Turn Gap Analysis** is used to evaluate available gaps in opposing traffic for a left-turning vehicle 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 it is available; the report will say in the title which detection type was used for the calculations.

The gap analysis has four gap groups with a secondary Y-axis trend line gap threshold. The user defined gap groups are:

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

The gap values were determined based from 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).

14.1. Requirements for Left Turn Gap Analysis

The **Left Turn Gap Analysis** measure requires that the intersection is set up as shown below. No special configuration is necessary to run this measure.

- The left turn approach and the opposing through approach must have lane-by-lane count or stop bar presence detection.
- Signal controller must track all events using the standard event codes.
- Signal controller logs must be retrievable by the ATSPM web server.

14.2. Report Data

14.2.1. How Data is Gathered and Compiled

When the user generates this chart, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common).

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Left Turn Gap Analysis Options
    - Gap 1 Range (Default: 1 to 3.3 seconds)
    - Gap 2 Range (Default: 3.3 to 3.7 seconds)
    - Gap 3 Range (Default: 3.7 to 7.4 seconds)
    - Gap 4 Range (>7.4 seconds)
    - Trend Line Gap Threshold (>7.4 seconds default)
    - Bin Size (15 minutes default)

14.2.2. How Data is Displayed

The MetricOptions object creates a chart object, generated by the web rendering engine provided in the .NET Framework. The chart is then saved as an image file to later be displayed on the website.

14.3. Interpreting the Left Turn Gap Analysis Chart

Once the **Left Turn Gap Analysis** charts are generated, the user will see a legend followed by the chart(s) for each through phase. The legend (an example of which is shown in Figure 24) is displayed at the top and includes:

- **1 - 3.3 seconds (or user-defined Gap 1 range)**, a red bar that graphically represents the number of gaps in the Gap 1 range (1.0 to 3.3 seconds by default).
- **3.3 - 3.7 seconds (or user-defined Gap 2 range)**, a light green bar that graphically represents the number of gaps in the Gap 2 range (3.3 to 3.7 seconds by default).
- **3.7 - 7.4 seconds (or user-defined Gap 3 range)**, a dark green bar that graphically represents the number of gaps in the Gap 3 range (3.7 to 4.7 seconds by default).
- **7.4+ seconds (or user-defined Gap 4 range)**, a turquoise bar that graphically represents the number of gaps in the Gap 4 range (> 7.4 seconds by default).

- ——— **% of Green Time where Gaps ≥ 7.4 seconds (or user-defined threshold)**, a blue line that graphically represents the percentage of green time greater than the trendline gap threshold as shown on the secondary Y-axis.

Chart Legend

■ 1 - 3.3 seconds   ■ 3.3 - 3.7 seconds   ■ 3.7 - 7.4 seconds   ■ 7.4+ seconds   ——— % of Green Time where Gaps ≥ 7.4 seconds

Figure 24: Left Turn Gap Analysis Legend

For each supported movement, a chart for the **Left Turn Gap Analysis** data is displayed below the legend. An example chart is shown in Figure 25. The chart includes the following components:

- The first line of text at the top of the chart is the title of the measure.
- The second line is the name of the intersecting roads and signal number.
- The third line is the selected date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the description of the analysis phase (phrased as "Left Turn Crossing Phase X").
- The fifth line is the detection type used to create the chart.
- The X-axis is the hour in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the Number of Gaps during the bin size period.
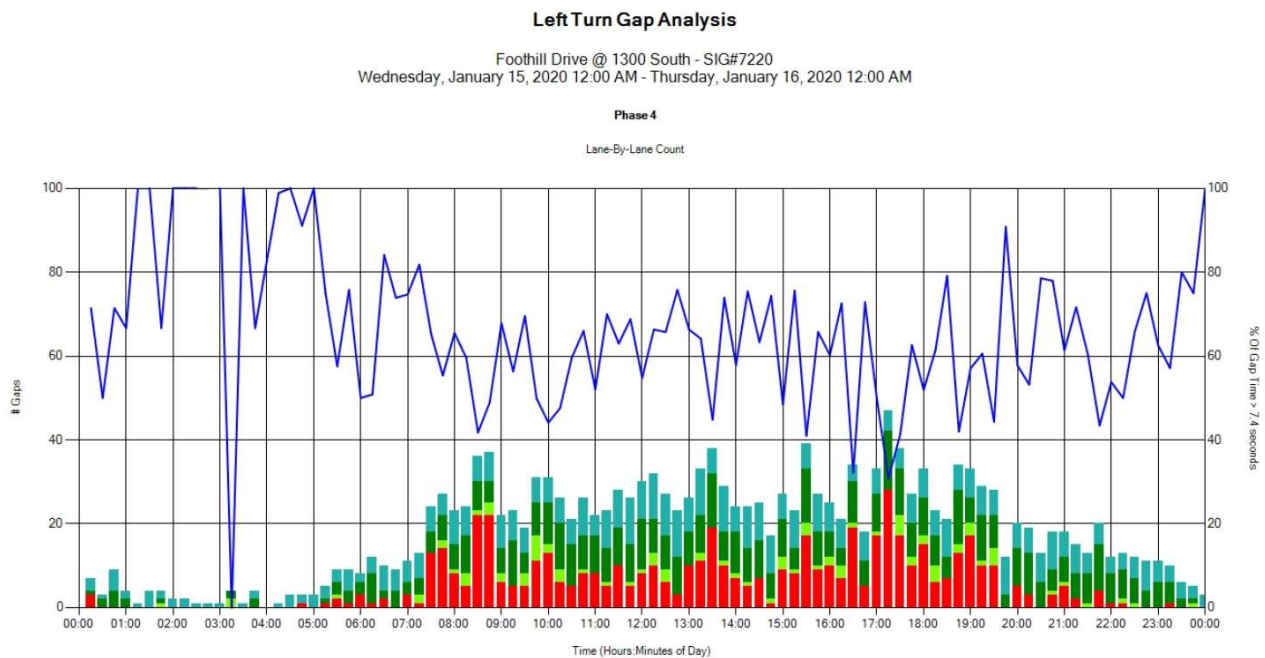- The Y-axis title (Right Side) and scale is the Percent of Green Time where Gaps ≥ 7.4 seconds (in percent).

Figure 25: Left Turn Gap Analysis

15. Wait Time

The **Wait Time** measure is a graphical representation of how long vehicles using each phase wait between green indications. The wait time is calculated as the time duration (in seconds) between the first detector call on a phase during red and the following time that the indication for that phase turns green. For reference, data on the termination type of the previous phase and the volume per hour for the phase are also charted.

15.1. Requirements for Wait Time

To support the Wait Time chart, the intersection must support the following.

- Signal controller must track all events using standard event codes, including phase terminations.
- Signal controller logs must be retrievable by the ATSPM web server.
- Stop bar/count detection for each lane in movement(s) and/or advance detection for movement(s) to be analyzed.

15.2. Report Data

15.2.1. How Data is Gathered and Compiled

When the user generates this chart, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type WaitTimeOptions.

These MetricOptions are bound by:

- Analysis period start date and time
- Analysis period end date and time
- Signal ID
- Flag for showing plans and plan statistics

Using these parameters, separate charts for each signal phase are created within the MetricOptions object.

15.2.2. How Data is Displayed

The MetricOptions object creates a chart object, generated by the web rendering engine provided in the .NET Framework. The chart is then saved as an image file to later be displayed on the website.

15.3. Interpreting the Wait Time Chart

The **Wait Time** chart, shown in Figure 26, is generated for each signal phase meeting the requirements. It includes the following components:

- The first line of text at the top of the chart is the title of the measure.

- The second line is the names of the intersecting roads and the signal number.
- The third line is the date and time range of the analysis period as specified during the criteria selection.
- The fourth line is the phase number and movement (with direction).
- The fifth line is the type of detection used to create the volume per hour line.
- Directly above each chart section, the first line displays the timing plan the intersection signal controller was using for each bracketed section of the chart. Charts may have multiple sections/plans depending on the time scale. In Figure 26, Plan 13 is active for the majority of the analysis period.
    - The second line above each chart section is the average wait time in seconds.
    - The third line above each chart section is the maximum individual wait time occurring for that section of the chart.
- The X-axis (below the chart) is the time in 24-hour hh:mm format.
- The Y-axis title (Left Side) and scale is the Wait Time in seconds.
- The Y-axis title (Right Side) and scale is the Volume Per Hour.
- A legend (left of the chart):
    - —— **Volume Per Hour**, a blue line that graphically represents the vehicular volume per hour for each time interval within the analysis period.
    - • **Gap Out**, a green dot graphically representing each wait time that ended shortly after the previous phase terminated from a gap out.
    - • **Max Out**, a red dot graphically representing each wait time that ended shortly after the previous phase terminated from a max out.
    - • **Force Off**, a blue dot graphically representing each wait time that ended shortly after the previous phase terminated from a force off.
    - • **Unknown**, a black dot graphically representing each wait time that ended shortly after the previous phase terminated for an unknown reason.
    - —— **Average Wait**, a pink line that graphically represents the average wait time for each time interval within the analysis period.
    - —— **Programmed Split**, an orange line that graphically represents the programmed signal timing split for the phase.
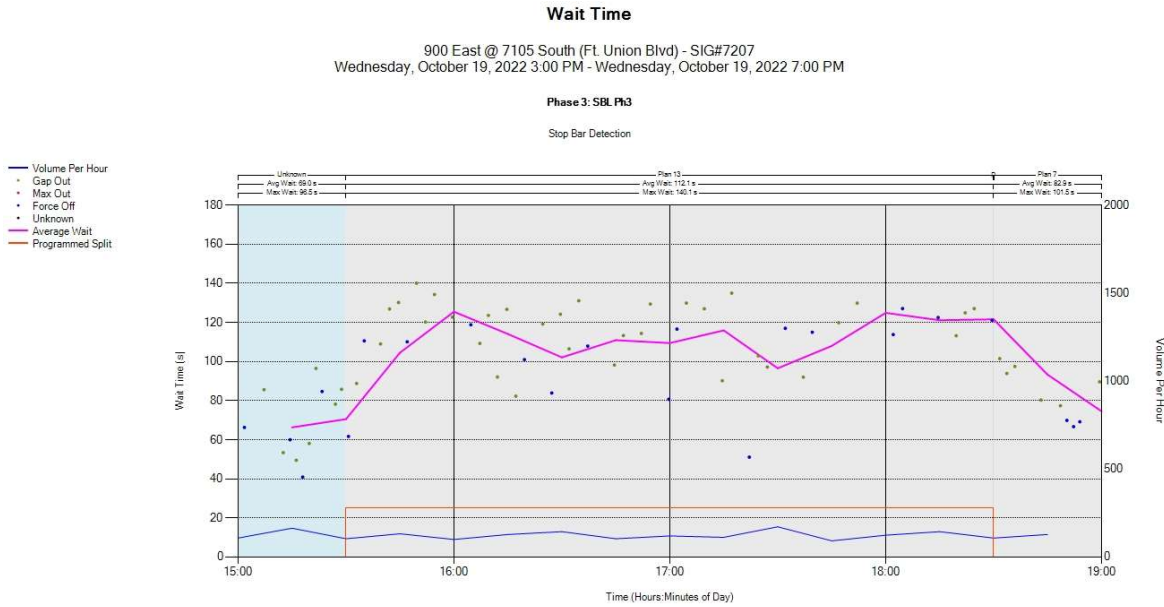
Figure 26: Wait Time Chart

16.   Chart Usage

The **Chart Usage** charts tabulate the cumulative entries agencies submitted via the **Log Action Taken** form on the ATSPM website.

Access **Chart Usage** from the **Reports** tab, select the desired start and end dates, and click **Create Chart**. After the page loads, the charts are ready for viewing. There are two usage pie charts, two measure tabulation bar charts, and 15 measure action bar charts. If there is no data during the selected time period for a specific chart, a blank chart will display as a placeholder.

16.1.   Report Data

16.1.1.   How Data is Gathered and Compiled

When the user generates these charts, the Usage.js script makes a web request with the GetMetricsUsage, GetAgencyUsage, GetReportRuns, GetActionsCharts, and GetActionsByMetric functions to the ActionLogController. These requests have two arguments, start date and end date.

The GetMetricsUsage function gathers all data between the start and end date from the action log and groups it by metric type. The GetAgencyUsage function gathers all data between the start and end date from the action log and groups it by agency. The GetReportRuns function gathers all logged chart generated events from the application event log. The GetActionCharts function gathers all data between start and end date and creates a chart for each action listing the metrics used for that action. The GetActionsByMetric function gathers all data between the start and end date from the action log and creates a chart for each measure type grouped by action type.

16.1.2. How Data is Displayed

The functions described above then create chart objects generated by the web rendering engine provided in the .NET Framework. The charts are then saved as an image file to later be displayed on the website.

16.2.   Pie Charts

The **Chart Usage** pie charts are typical pie charts, as shown in Figure 27, showing a relative percentage of each component. When the mouse pointer is hovered over a section of the chart, that section highlights and displays the number associated with the measure for the corresponding item.
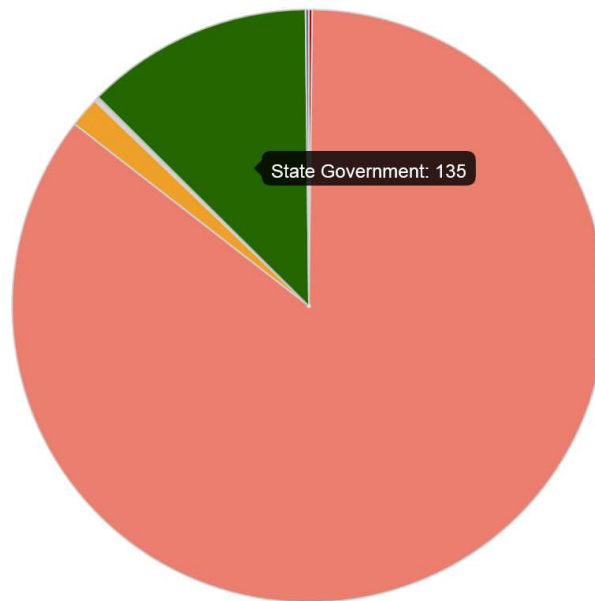

Figure 27: Example Pie Chart

16.2.1. Chart Usage

The **Chart Usage** pie chart tabulates the total usage of each chart during the defined period. The chart legend, as shown in Figure 28, lists all available chart types, though some may not be included or discernable while viewing the chart.

Figure 28: Chart Usage Legend

16.2.2. Agency Usage

The **Agency Usage** pie chart tabulates each agency's usage during the defined period. The chart legend, as shown in Figure 29, lists all available chart types, though some may not be included or discernable while viewing the chart.
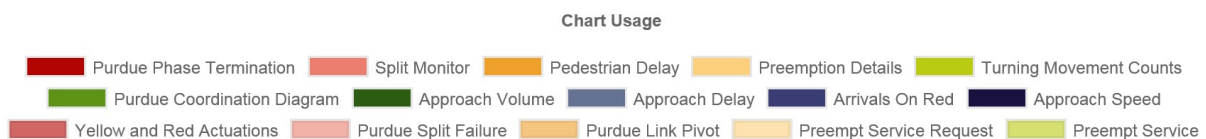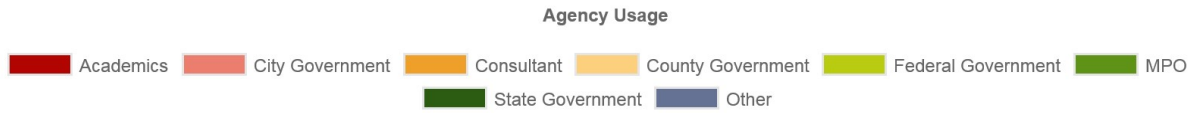

Figure 29: Agency Usage Legend

16.3. Measure Tabulation Bar Charts

The Measure Tabulation bar charts are typical bar charts, as shown in Figure 30, showing bars with height-relative components. When the mouse pointer is hovered over a section, that section highlights and displays the number associated with the measure for the corresponding item. Both of the Measure Tabulation charts, **Reports Run** and **Actions By Metric**, have the same categories, which are: Purdue Phase Termination, Split Monitor, Pedestrian Delay, Preemption Details, Turning Movement Counts, Purdue Coordination Diagram, Approach Volume, Approach Delay, AoR, Approach Speed, Yellow and Red Actuations, Purdue Split Failure, Purdue Link Pivot, Preempt Service Request, and Preempt Service.
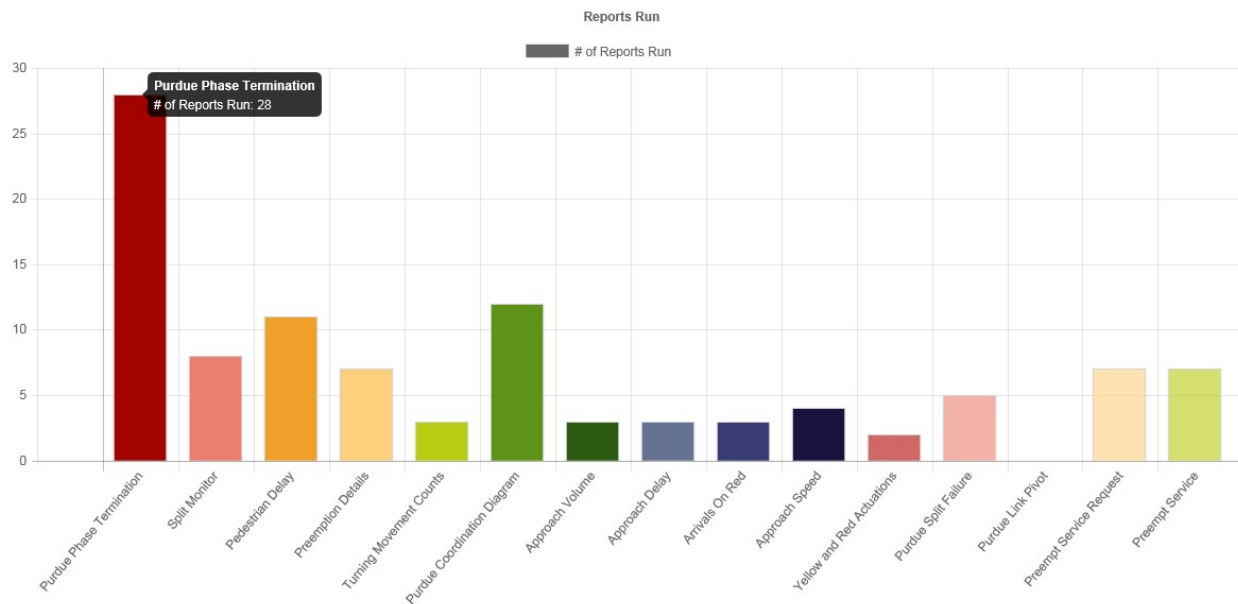

Figure 30: Example Bar Chart

16.4. Measure Action

The **Measures Action** bar charts (Figure 31) tabulate the actions for 15 measures. These measures are those listed in the tabulation bar charts and the number of actions (e.g. Detector Issue, Offset, or other) that were required for each measure.
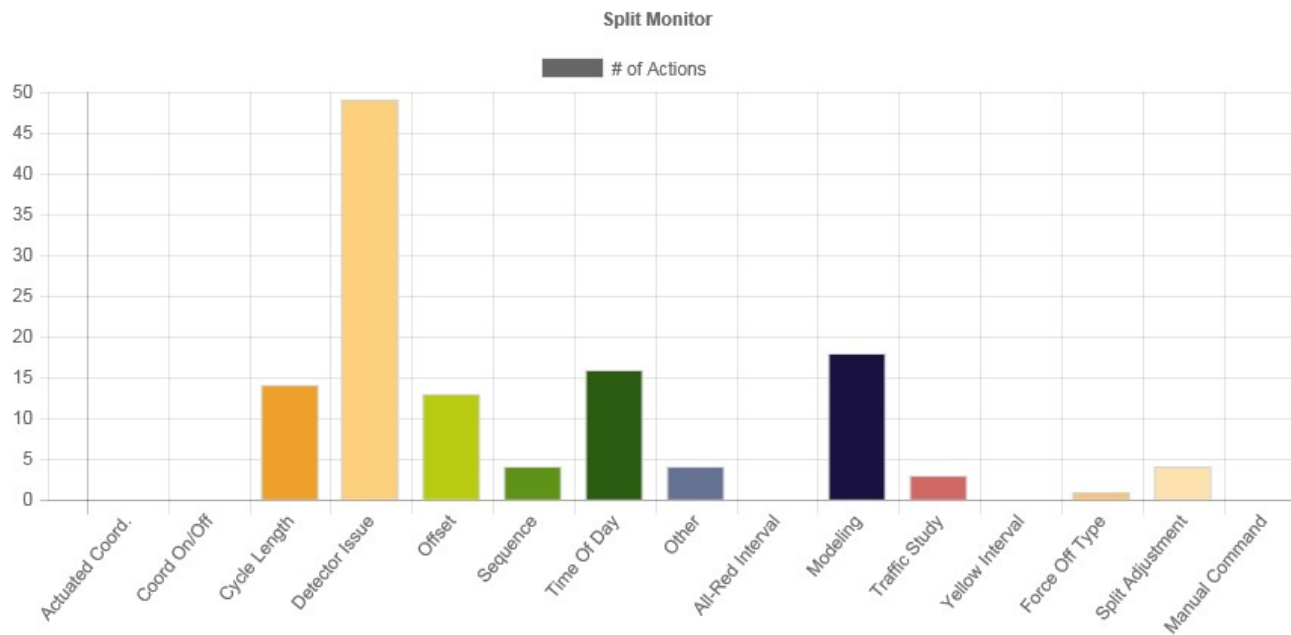

Figure 31: Example Measure Action Chart

17. Purdue Link Pivot

The **Purdue Link Pivot** report is a compilation of data in two separate reports and includes links to additional graphs. The data is presented in relation to the AoG for the corridor regarding upstream/downstream traffic flow and can be used to interpolate possible outcomes by editing offset.

17.1. Adjustments

The first report displayed after running the report is the **Adjustments** table. This report includes offset data for each signal in the route.

17.1.1. Requirements for Report

The **Adjustments** table requires that one or more link pivot routes be set up (via **Charts > Purdue Link Pivot Route Setup**). The routes must consist of consecutive traffic signals with advanced count vehicle detection along the route. PCDs must be configured for all approaches on the route.

17.1.2. Report Data

17.1.2.1. How Data is Gathered and Compiled

When the user generates a Purdue Link Pivot report, a LinkPivotController object is created. This object connects to the LinkPivotService which generates all report content including the adjustments section. The user selected options are contained in a LinkPivotViewModel.

This LinkPivotViewModel object is bound by:

- Start date and time
- End date and time
- Route
- Cycle Length
- Days to Include
- Starting Point
- Bias
- Bias Direction

Next, the GetLinkPivot function is called which gathers data from the Approach Route Details table with a matching route ID. This data is compiled into a list of link pivot pairs. Each pair is then enhanced with the statistics data found in the final adjustments table.

17.1.3. How Data is Displayed

The LinkPivotController object creates a link pivot diagram, generated by the web rendering engine provided in the .NET Framework. All adjustment data is rendered to a table defined in the LinkPivotViewModel.

17.1.4. Interpreting Adjustments

The **Adjustments** table (Figure 32) represents recommended offsets for coordinated operation along a pre-defined route of consecutive signals.

This table includes eight columns as follows:

- **Link** – the sequential number for the link within the route.
- **Signal ID** – the number assigned to the signal during setup.
- **Location** – the main and side streets where the signal is located (also shows the Signal ID).
- **Link Delta** – the recommended delta (change) to the offset for that portion of the link.
- **Edit Link Delta** – a change field to simulate adjustments to the offset; default is zero.
- **Offset(+ to Offset)** – a calculated value adding **Link Delta** and **Edit Link Delta**.
- **Existing Offset** – a change field to enter the programmed offset for the link; default is zero.
- **New Offset** – a calculated value adding **Offset(+ to Offset)** and **Existing Offset**.

Link	Signal	Location	Link Delta	Edit Link Delta	Offset(+ to Offset)	Existing Offset	New Offset
1	6319	6319 - University Parkway 400 West	0	0	0	0	0
2	6320	6320 - University Parkway 200 West	0	0	0	0	0
3	6321	6321 - University Parkway Main Street	0	0	0	0	0
4	6322	6322 - University Parkway 200 East	0	0	0	0	0

Figure 32: Adjustments Table

17.2. Approach Link Comparison

The **Approach Link Comparison** table displays segment (signal-to-signal) data from the corridor and provides AoG data, upstream and downstream, for existing and predicted flow.

17.2.1. Requirements for Report

This report has the same requirements as the **Adjustments** table discussed in Section 17.1.1.

17.2.2. Report Data

17.2.2.1. How Data is Gathered and Compiled

This report gathers and compiles data the same way as is done for the **Adjustments** table discussed in Section 17.1.2.1.

17.2.3. How Data is Displayed

This report displays data the same way as is done for the **Adjustments** table discussed in Section 17.1.3.

17.2.4. Interpreting Approach Link Comparison

The **Approach Link Comparison** table is comprised of seven major columns as shown in Figure 33. These columns are:

- **Link**, which is a sequential number to define each segment.
- **Approaches** is split into two columns. The first column is **Upstream**, which lists the Signal ID and direction in the first row and the main and cross streets in the second row for the upstream signal. Next is **Downstream**, which lists the Signal ID and direction in the first row and the main and cross streets in the second row for the downstream signal.
- **Upstream AoG** is split among three columns:
  - **Existing** – the number of arrivals on green computed with existing data;
  - **Predicted** – the number of vehicles predicted to arrive on green at the chosen delta; and
  - **Change** – the pie chart shows the existing percent arrivals on green (light green) and the predicted gain in arrivals on green (dark green) or predicted loss (red).
- **Downstream AoG** is split among the same three columns (Existing, Predicted, and Change).

- **Total Link AoG** is split among the same three columns (Existing, Predicted, and Change).
- **Delta**, which corresponds to the delta in the **Adjustments** table.
- **AoG Chart** displays a thumbnail image for the Results Graph (see Figure 33) of traffic through the intersection. If clicked, the thumbnail will open full-sized in a new browser tab. Further discussion on the results graph is given in Section 17.3. Below the thumbnail is a **PCD Options** link, which displays the Purdue Coordination Diagrams when clicked. A discussion on the PCD Options is given in Section 17.4.

Figure 33: Approach Link Comparison Table

As shown in Figure 34, the last row in the **Approach Link Comparison** table is the Corridor Summary that tallies the Upstream, Downstream, and Total Link AoG for the corridor.

Figure 34: Corridor Link Summary

17.3. Max Arrivals On Green Chart

Clicking on the thumbnail image in the **AoG Chart** column of the **Approach Link Comparison** table displays the Max Arrivals On Green By Second chart. This chart is an interpolative representation on what the AoG would be if the offset were adjusted.

17.3.1. Requirements for Report

This report has the same requirements as the **Adjustments** table discussed in Section 17.1.1.

17.3.2. Report Data

17.3.2.1. How Data is Gathered and Compiled

When the user generates this diagram, the MOE WCF Service creates a MetricGenerator object. This object is linked to a MetricOptions object on the client side (MOE.Common), which is of type PCDOptions.

These MetricOptions are bound by:

- Analysis period start date
- Analysis period end date
- Signal ID
- Y-axis maximums
- Volume bin size
- Dot size
- Whether or not to show plan statistics
- Whether or not to show volumes

Event Data is gathered from the Controller_Event_Logs table. Data is then compiled into Change to Green, Change to Yellow, Change to Red, Detector Activation, and possibly Volume per Hour chart series.

17.3.2.2. How Data is Displayed

The MetricOptions objects create one or more Chart objects, generated by the web rendering engine provided in the .NET Framework. All the PCD data is rendered to the chart as bars and points. The chart is then saved as an image file displayed on the website.

17.3.3. Interpreting Max Arrivals On Green By Second

The **Max Arrivals On Green By Second** chart displays the cumulative AoG volume of the selected time period for each direction (upstream and downstream) as well as the total AoG (both directions). Additionally, it calculates the projected AoG per direction based on adding seconds to the offset. An example is given in Figure 35. The X-axis is limited to the cycle length as defined when selecting the route, starting point, date, and time. The components of the chart are:

- Chart Title, "Max Arrivals On Green By Second."
- Left side is the legend:
    - ———— Total AOG, depicts the total of upstream and downstream AoG for the selected time duration.
    - ———— Downstream AOG, depicts the total downstream AoG for the selected time duration.
    - ———— Upstream AOG, depicts the total upstream AoG for the selected time duration.
- The Y-axis title is "Arrivals On Green". The Y-axis scale is automatically expanded to display the total vehicles from each direction that arrive on green. These are the initial Downstream and

Upstream values on the Y-axis, and are combined for the Total AOG. These numbers are affected by analytics based on what the AOG would be if the offset were adjusted (X-axis).

- The X-axis title is "Adjustment(seconds)", and the range is from zero to cycle length.

The adjustment in seconds (X-axis value) where the projected total AOG is the highest would be the recommended delta value for both the Adjustments and Approach Links tables.
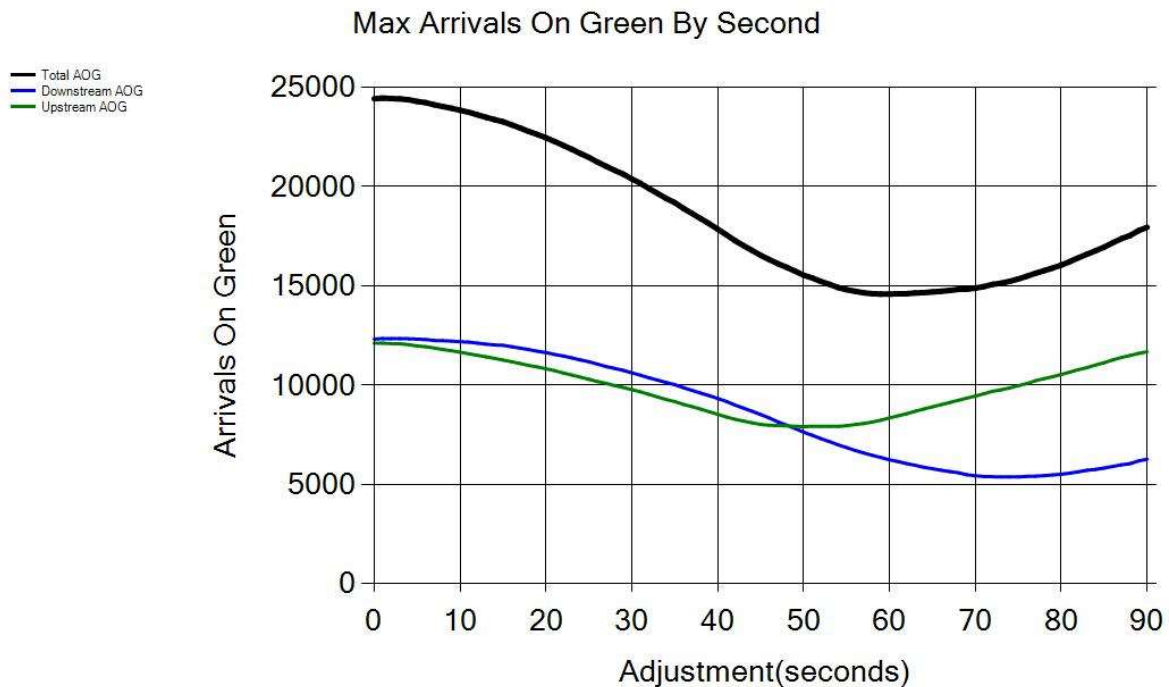

Figure 35: Max Arrivals On Green By Second

17.4. PCD Options

After clicking **PCD Options** in the **AoG Chart** column of the **Approach Link Comparison** table, the PCD Options menu will appears below the Report Options menu. The settings include a date selection (selection must be a single day within the analysis period used to create the **Approach Link Comparison** table), Y-axis maximum, and the delta value. After choosing the desired PCD Options settings and clicking **View PCDs**, the charts are displayed. As shown in Figure 36, there are two PCD charts side by side for each travel direction of the link selected in the **Approach Link Comparison** table. The side-by-side charts are the Existing and Predicted AoG. The left side (existing) is the same as though the analysis had run using the **Purdue Coordination Diagram** Signals measure. Additionally, the right side (predicted) displays the PCD with the delta applied. The delta can be manipulated and reapplied to view varying results. Quantified above the charts are the total number of AoG and the total percent AoG in the Existing and Predicted scenarios (total meaning both travel directions are considered).

Except for the delta, the requirements, components, and interpretation are the same as those for the **Purdue Coordination Diagram** Signals measure (discussed in Section 7). The legend is not included on the Purdue Link Pivot Analysis page, but the graphs displayed are the same as those created in the **Purdue Coordination Diagram** measure.
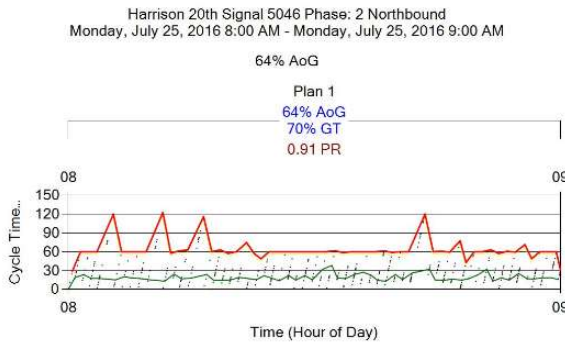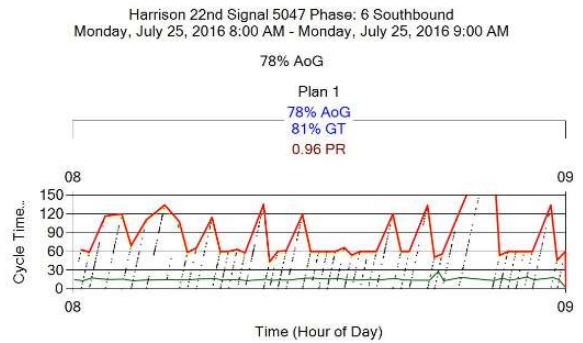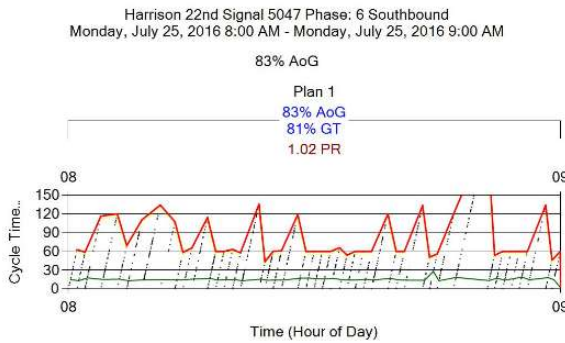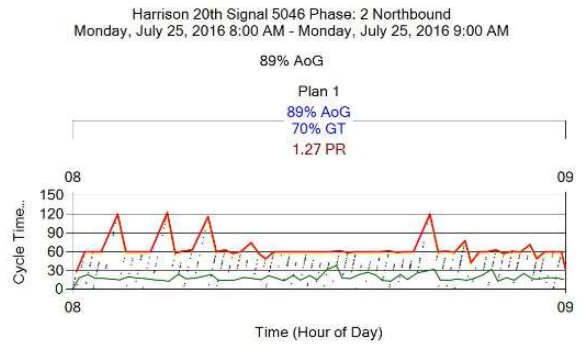

Figure 36: PCD (Existing & Predicted) for Purdue Link Pivot

Appendix A.   Glossary

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

A.1.   Actuation (pedestrian)

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

A.2.   Approach Delay

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

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

A.3.   D (Directional) Factor

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

A.4.   Dwell Time

On signal controllers supporting preemption, dwell time is the time elapsed while 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.5.   Entry Delay

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

A.6.   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.7.   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.8. Green Occupancy Ratio

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

A.9. Green Time

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

A.10. K Factor

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

A.11. Lane Utilization 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 per hour. V_{g1} is the unadjusted demand flow rate on the single lane in the lane group with the highest volume. A f_{LU} of 1.0 indicates that all lanes in the group have the exact same flow rate.

A.12. 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.13. Max Out (preemption)

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

A.14. 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.15. Peak Hour Volume

PHV is the vehicle count recorded during the peak hour.

A.16.   Peak Hour Factor

PHF measures the relationship between the PHV, 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 PHV, 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.17.   Preemption

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

A.18.   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.19.   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.20.   Split

Split is the fraction of the overall cycle time the signal controller assigns to a particular phase.

A.21. 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.22. 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.