PennDOT's Transportation Systems Management & Operations (TSMO) Program

TSMO Implementation Guidebook
December 6, 2017

- TSMO Implementation Guidebook
- Performance Measurement Framework
- Performance Measurement Tools

Part I. Planning

- Tie-in to the TSMO Strategic Framework and TSMO Program Plan
- Relationship/connection of TSMO to other PennDOT Planning Documents and Guidance
- Guidance for developing Regional Operations Plans (ROPs)
- Description and uses for each of the TSMO toolbox strategies
- Guidance on the use of IQ mapping for identifying congestion issues
- Incorporation of TSMO performance metrics, including MAP 21

Part **II.** Design

Part **III.** Deployment

Part **IV.** Maintenance

Part **V.** Operations

Future

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1. Introduction
2. TSMO Business Area Plans
3. Regional Operations Plans
4. Identifying Congestion
5. Classifying Congestion
6. Mitigating Congestion
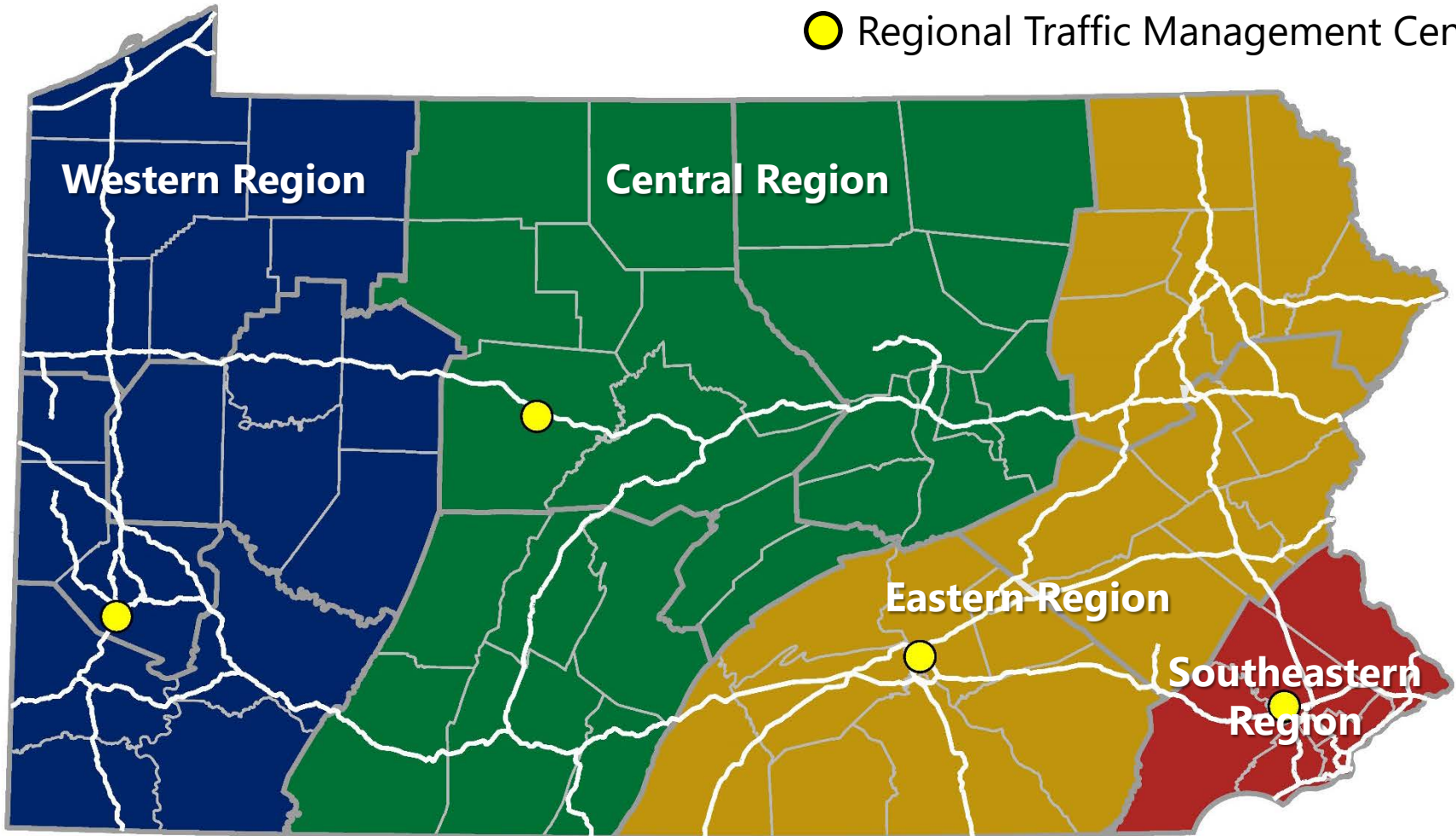7. Federal System Performance Measurement

Transportation Systems Management and Operations (TSMO)

Implementation Guidebook

PART I: PLANNING

Pub XXX (09-17)

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ROPs: Four Regions

Regional Traffic Management Center

Western Region

Central Region

Eastern Region

Southeastern Region

Lead: SPC   Lead: Central RTMC   Lead: TBD

Lead: DVRPC

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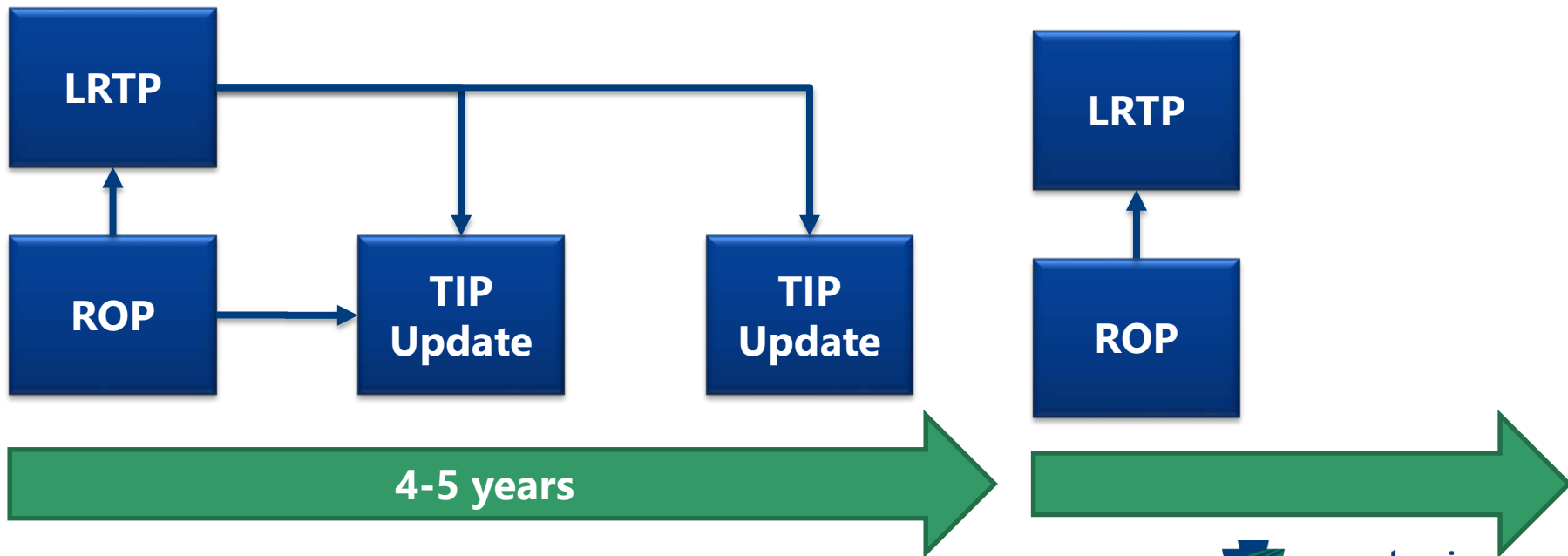
- Timeline
  - Ideal: ROP planning horizon and update cycle same as LRTP
    - 20-30 year horizon
    - 4-5 year update cycle
  - Reality: Not all ROP regions geographically aligned with MPO/RPO boundaries, so achieve to maximum extent possible

ROPs: Regional Goals & Objectives

- **GOST** structure
  - **Goals**, which are broad outcomes and answer "what" is trying to be accomplished
  - **Objectives** are measurable, specific, and are a subset of goals
  - **Strategies** answer "how" the defined objectives will be achieved
  - **Tactics** are actions that are used to achieve the defined objectives and associated strategies

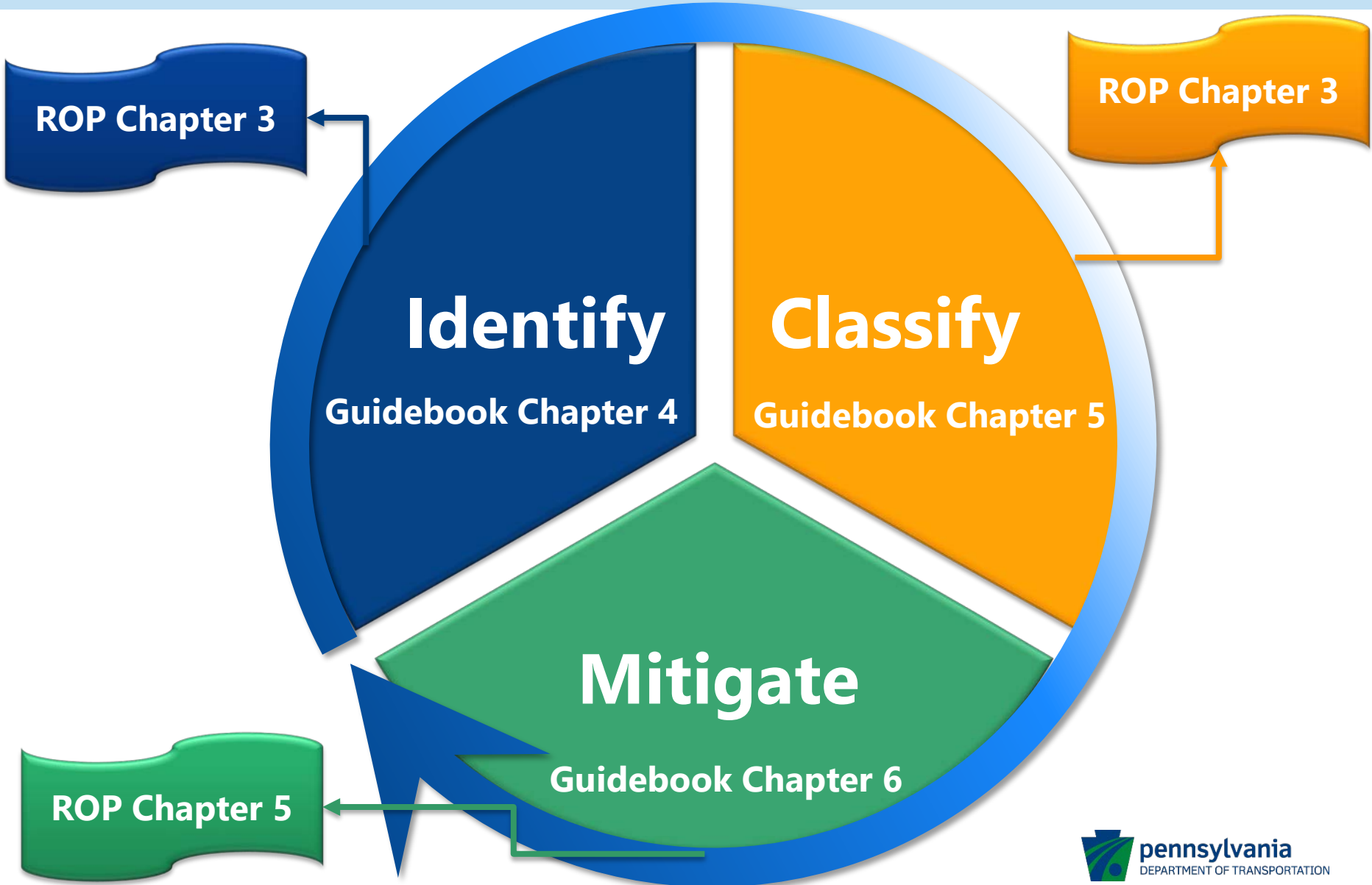|	Not Objective-Driven and Performance Based	Objective-Driven and Performance Based
Transportation System Need	Deployment of additional CCTV cameras	Incident Management (could include CCTV coverage) along a corridor based on the number or crashes/incidents on non-recurring congestion
Performance Measure	Number of CCTV cameras deployed	Reduction in the number of crashes and/or delays due to incidents along the corridor

- Executive Summary (optional)
- Chapter 1: Overview of the Region
- Chapter 2: Existing Regional Demographics and Transportation Elements
- Chapter 3: Existing and Future Operations
- Chapter 4: Transportation Needs and Operational Issues
- Chapter 5: Strategies and Projects
- Chapter 6: ROP Coordination and Maintenance
- Appendix
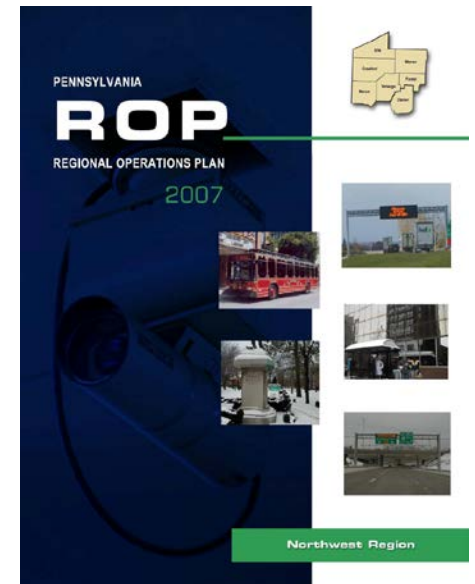
Roadway Tiering System

Road Type	Tier	Criteria
Limited Access (NHS)	1A	AADT > 75,000
	1B	AADT between 50,000 and 75,000
	1C	AADT < 50,000
Non-Limited Access (NHS)	2A	AADT > 25,000
	2B	AADT between 10,000 and 25,000
	2C	AADT < 10,000
Non-NHS	3A	AADT > 10,000
	3B	AADT between 2,000 and 10,000
	3C	AADT < 2,000

ROP Chapter 3

ROP Chapter 3

Identify

Guidebook Chapter 4

Classify

Guidebook Chapter 5

Mitigate

Guidebook Chapter 6

ROP Chapter 5

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- Baseline measures for comparing changes in congestion as various TSMO strategies are applied to reduce congestion.

- **When** is congestion occurring?

- **Where** is congestion happening?

- How **intense** is congestion?

- How **reliable** is travel time?
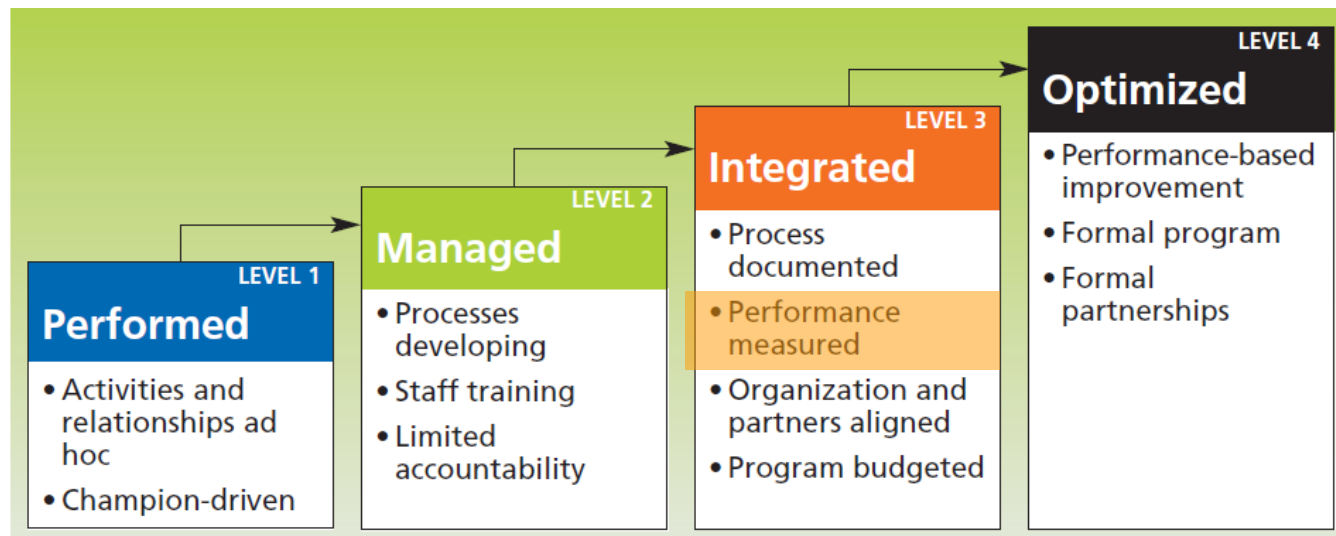
Congestion Identification: Performance Measures

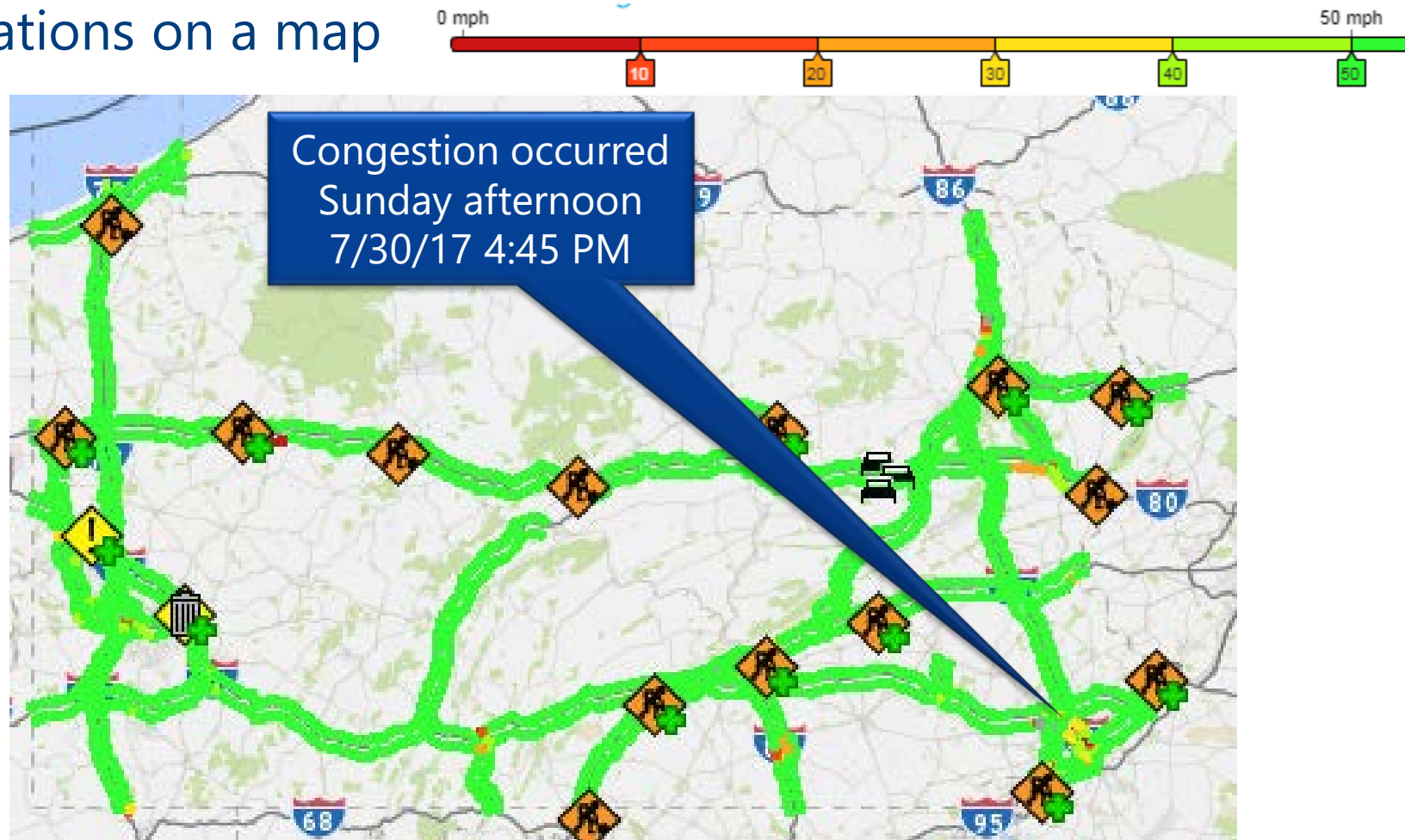| Measure	Questions Answered			
	How **Intense** is Congestion?	How **Reliable** is Travel Time?	**When** is Congestion Occurring?	**Where** is Congestion Occurring?
Time Delay	X		X	X
Time Delay per VMT	X		X	X
Delay Cost	X		X	X
Delay Cost per VMT	X		X	X
Travel Time Index (TTI)	X		X	X
Planning Time Index (PTI)		X	X	X
Buffer Time Index (BTI)		X	X	X
Bottleneck Identification and Ranking	X		X	X

Identify

- Tools
  - RITIS: Probe Data Analytics Suite (formerly Vehicle Probe Project)
  - PennDOT purchased probe speed data available through PDA
  - TSMO IQ Mapping
- Methods
  - Congestion has both spatial and time dimensions
  - Need to hold one dimension constant to visualize variation in the other dimensions
  - Time constant → Map visual of where congestion is at that time
  - Location constant → Timeline of when congestion occurs at that location

- Pick a snapshot in time and visualize congestion locations on a map

0 mph
50 mph
10 20 30 40 50

Congestion occurred Sunday afternoon 7/30/17 4:45 PM

Source: PDA Suite, Trend Map

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- Pick a road or region, see timeline of when it's congested

Each bar represents one day of February 2017

Recurring congestion Monday-Friday during AM Peak

Monday holiday

Color of bars represent length of queue

PM peak congestion less predictable
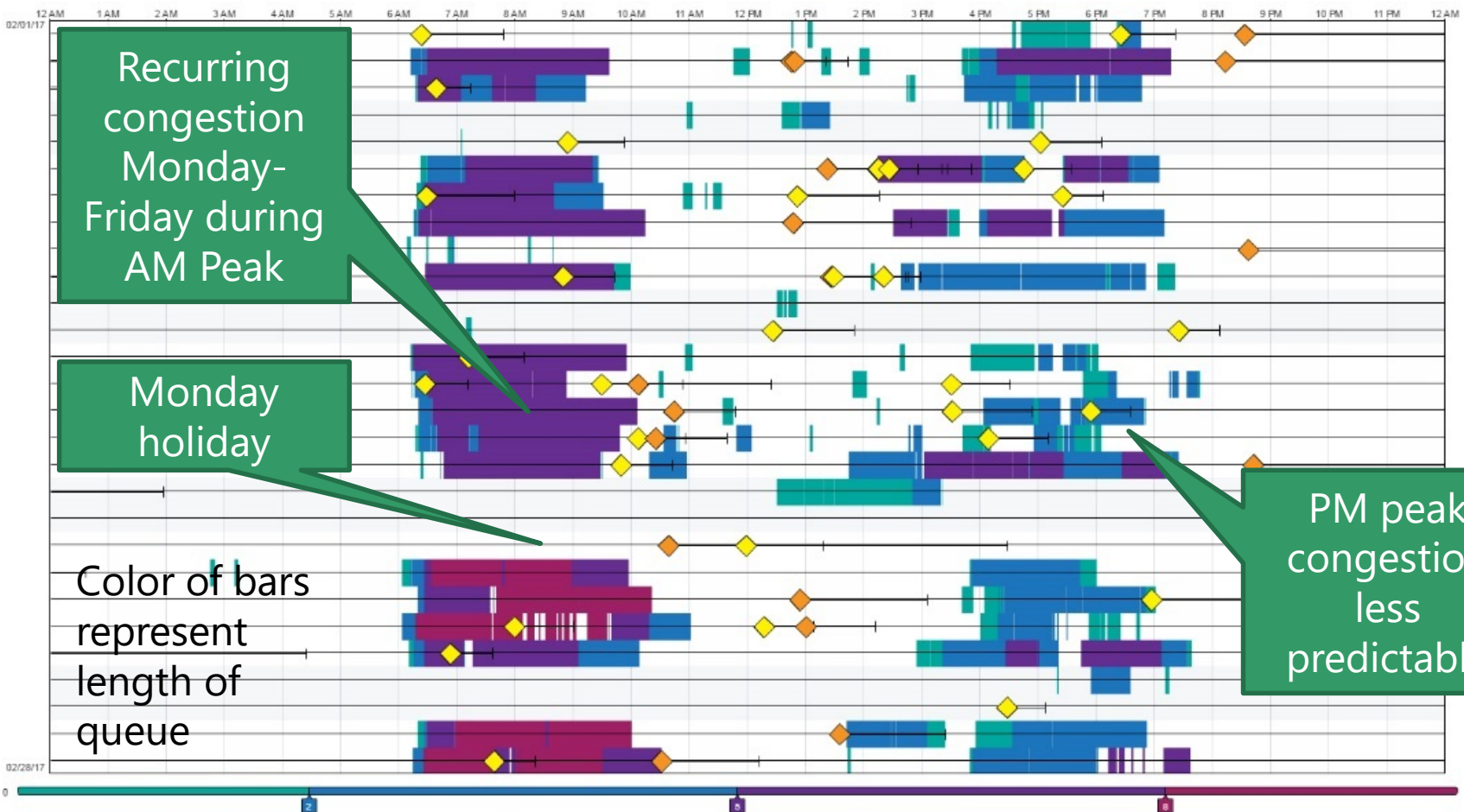
Time of day on horizontal axis (midnight to midnight)
Source: PDA Suite, Bottleneck Ranking Tool

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Classify

- Something causes each instance of congestion
- Attempt to classify every congestion event
  - Recurring Congestion
    - Bottlenecks
    - Poor Signal Timing
  - Non-Recurring Congestion
    - Traffic Incidents
    - Work Zones
    - Inclement Weather
    - Special Events

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Congestion Event:
I-76 WB Schuylkill Expressway
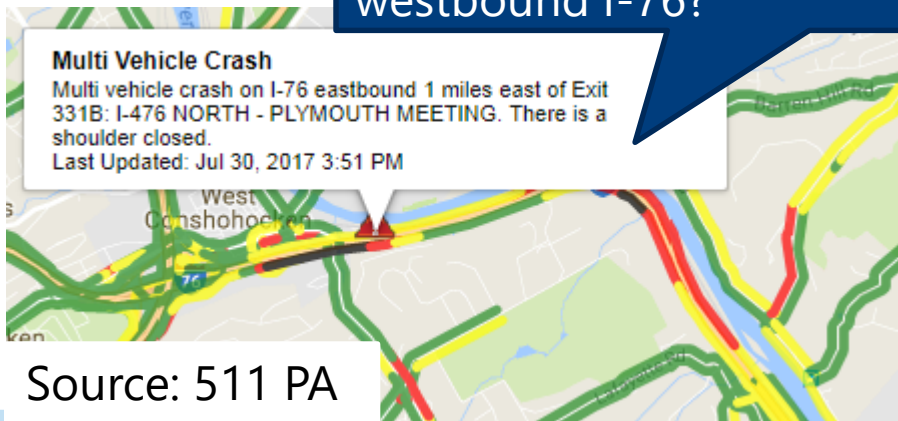between US-1 and I-476
Sun 7/30/17 @ 5:00 p.m.
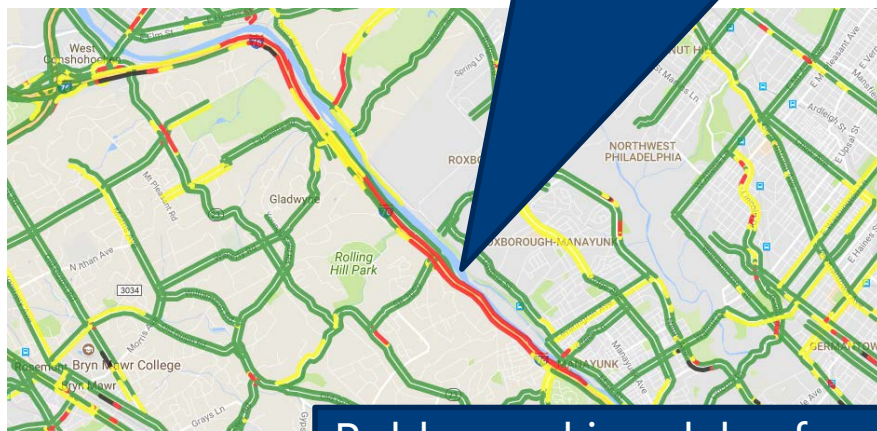
Rubbernecking delay for westbound I-76?

Multi Vehicle Crash
Multi vehicle crash on I-76 eastbound 1 miles east of Exit 331B: I-476 NORTH - PLYMOUTH MEETING. There is a shoulder closed.
Last Updated: Jul 30, 2017 3:51 PM

Source: 511 PA

- Process of elimination
- Is there recurring congestion at this location at this time of day/day of week?
  – If yes, bottleneck is a factor
  – If arterial, could be poor signal timing
- Inclement weather?
  – Any precipitation? (Radar)
  – Any fog detected? (Visibility)
- Was there an incident?
  – Crash reports
  – TMC logs

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Mitigate

- DOTs and other agencies use various strategies to address different causes of congestion

- Evaluate how well each strategy works

- Compare congestion
  - With/without strategy
  - Before/after strategy
  - Identify congestion, compare metrics

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Metrics Tools: PDA Suite

- Probe Data Analytics Suite
  - Historic data analysis within RITIS (Regional Integrated Transportation Information System)
  - Operated by University of Maryland CATT Lab
  - Contains several apps to evaluate system performance
  - Formerly known as the Vehicle Probe Project (VPP)

- Gaining Access
  - Use RITIS account
  - Accounts can be requested for PennDOT employees, Planning Partners, and consultants doing work on behalf of PennDOT
  - Agencies must sign data use agreement

http://pda.ritis.org

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Metrics Tools: PDA Suite

What's New 11/9/17

REGION EXPLORER
Explore the relationships between bottlenecks and traffic events in real-time and in the past.

Tutorial Help

MASSIVE DATA DOWNLOADER
Download raw probe data from our archive for offline analysis.

Tutorial Help History

CONGESTION SCAN
Analyze the rise and fall of congested conditions on a stretch of road.

Tutorial Help History

TREND MAP
Create animated maps of roadway conditions.

Tutorial Help History

PERFORMANCE CHARTS
Chart performance metrics over time.

Tutorial Help History

PERFORMANCE SUMMARIES
Report on Buffer Time Index, Planning Time Index, and other performance metrics.

Tutorial Help History

BOTTLENECK RANKING
Rank bottlenecks and discover which ones have the greatest impact.

Tutorial Help History

USER DELAY COST ANALYSIS
Put a dollar amount on how much a road's performance impacts its users.

Tutorial Help History

DASHBOARD
Create your own personal dashboards to monitor corridor performance in regions of interest.
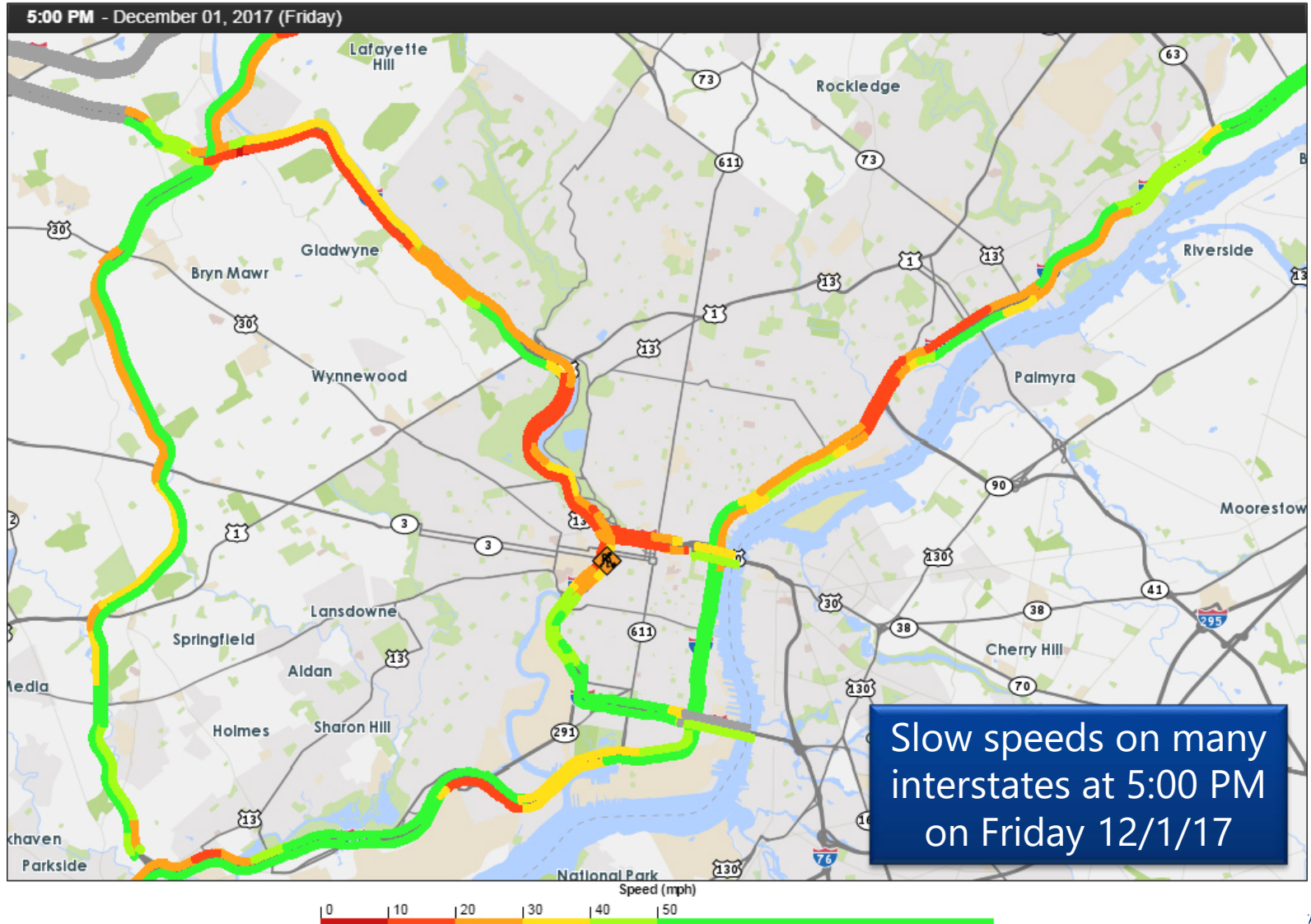
Tutorial Help

TUTORIALS
Learn how to use each of the tools in the suite.

- Additional graphics options for chart exports (fonts, colors, labels, sizes, etc.)

- Additional metrics
  - Bottleneck attributes
  - Travel Time Index, Buffer Time Index, Planning Time Index
  - Delay Costs

- Application Programming Interface (API)
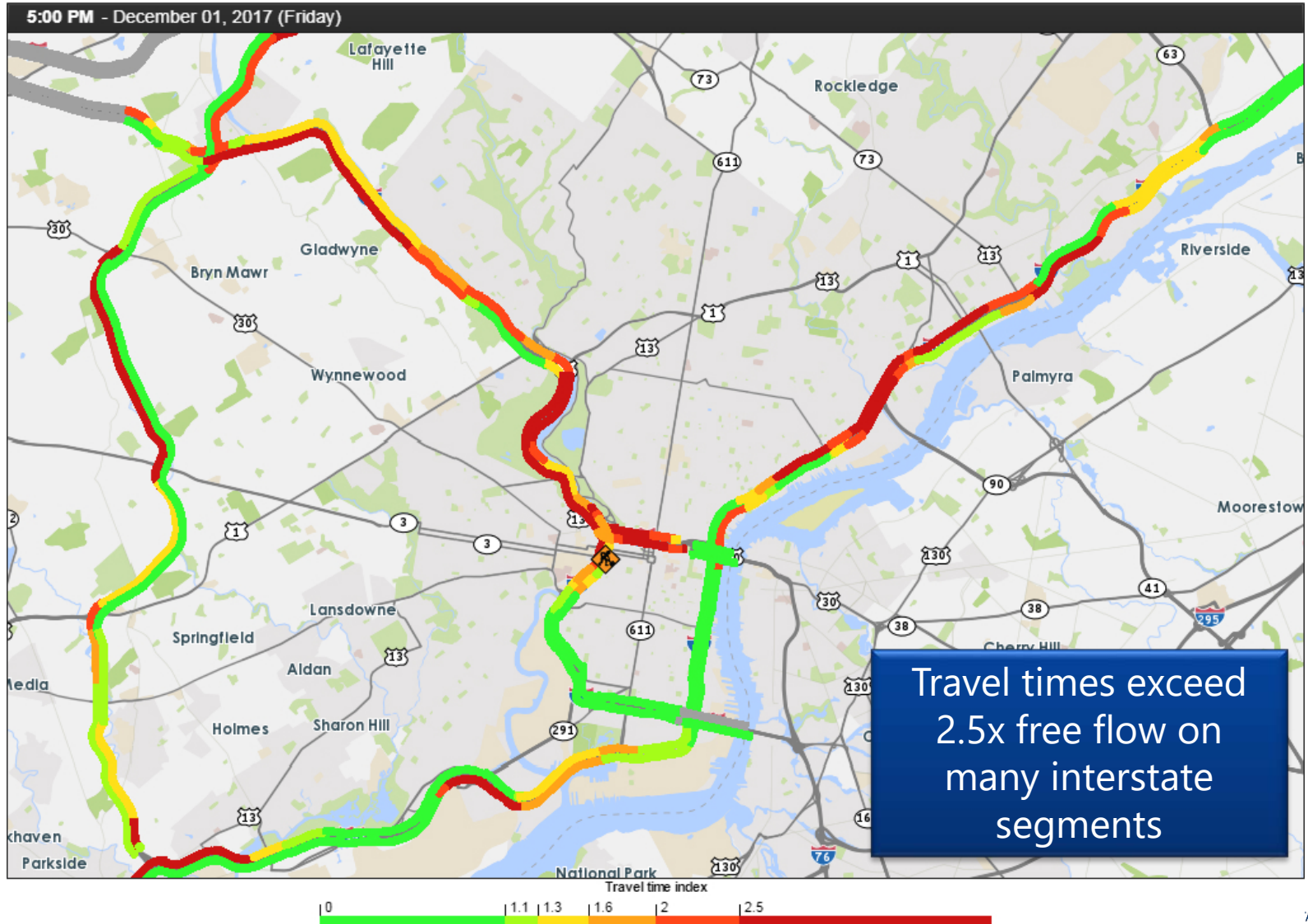 - Anything that can be produced in PDA Suite can be automated and run on a recurring basis through API

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PDA Suite: Trend Map

- Allows the following metrics to be shown visually on a map by time of day
  - Speed
  - Travel Time Index
  - Buffer Time Index
  - Planning Time Index
- Time of day grouped in buckets from 1 minute to 1 hour
- Multiple days can be selected to compare results

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Interstates in Pennsylvania (2427 TMCs) using INRIX data

Slow speeds on many interstates at 5:00 PM on Friday 12/1/17

Interstates in Pennsylvania (2427 TMCs) using INRIX data

5:00 PM - December 01, 2017 (Friday)

Travel times exceed 2.5x free flow on many interstate segments

Travel time index

0   1.1 1.3   1.6   2   2.5

Interstates in Pennsylvania (2427 TMCs) using INRIX data

5:00 PM - December 01, 2017 (Friday)

Plan for >3x free flow travel time to arrive on time 95% of the time on dark red segments

Planning time index

0   1.3   1.6   2   2.5   3

Interstates in Pennsylvania (2427 TMCs) using INRIX data

Fairly normal Friday afternoon on most segments.
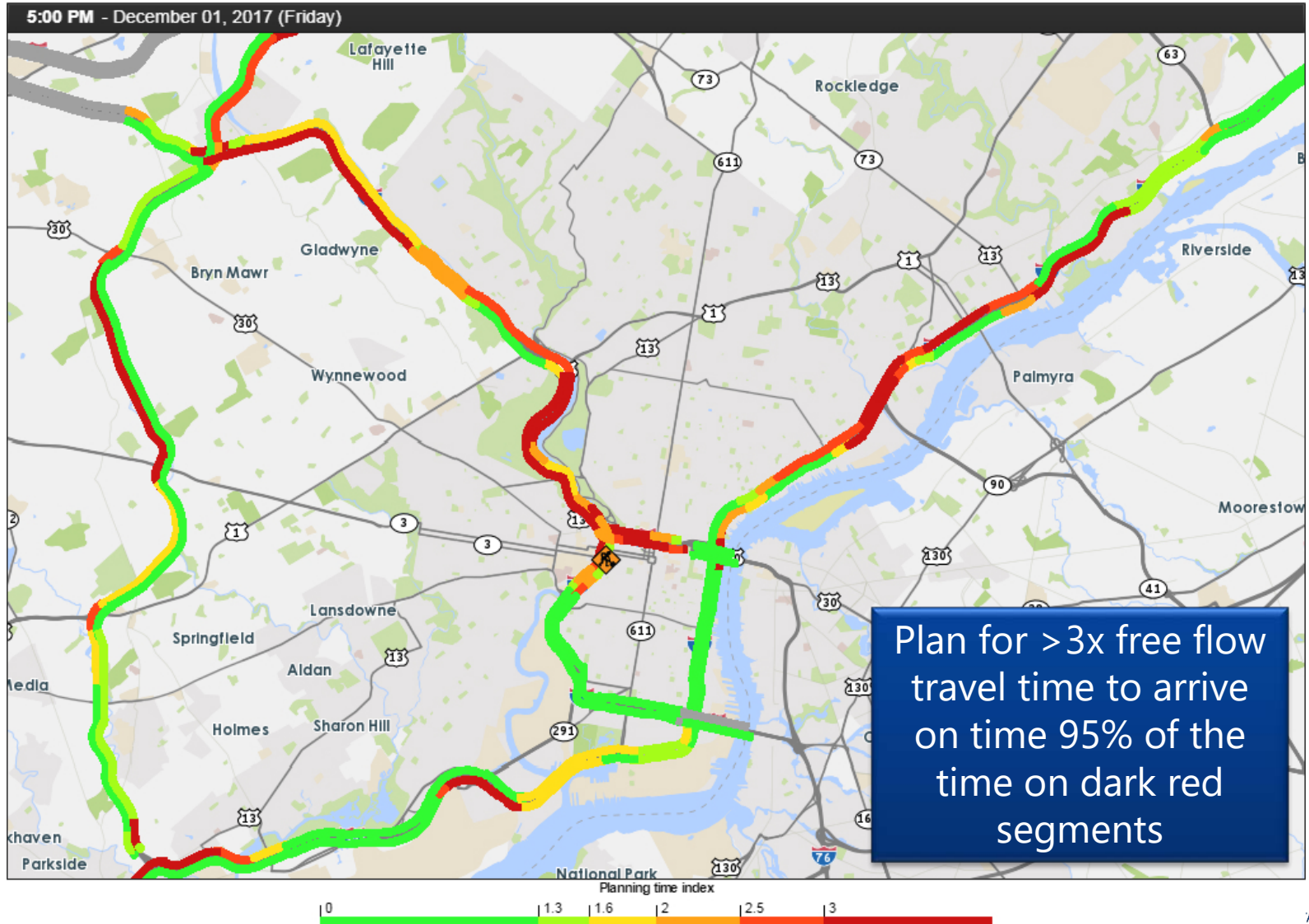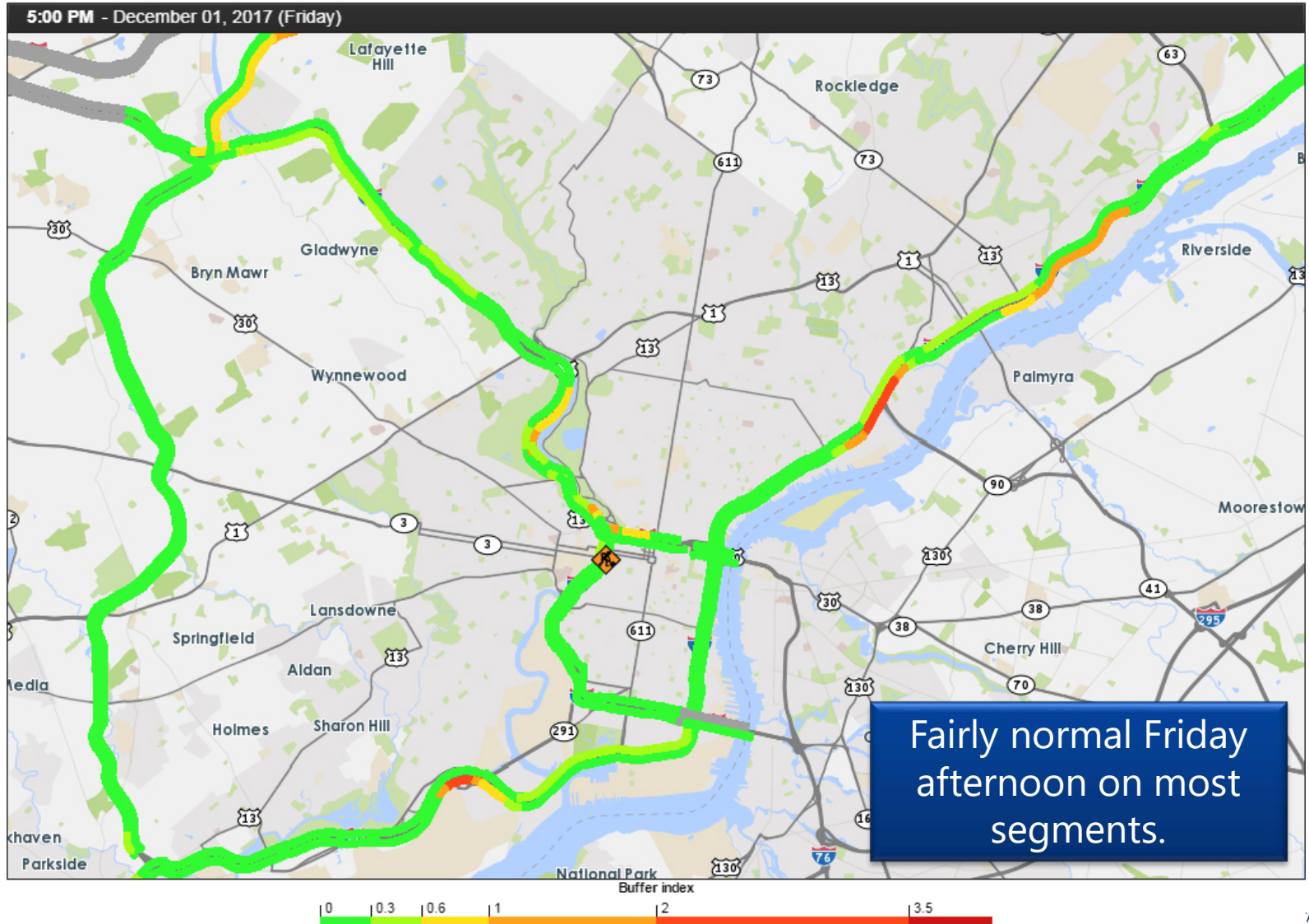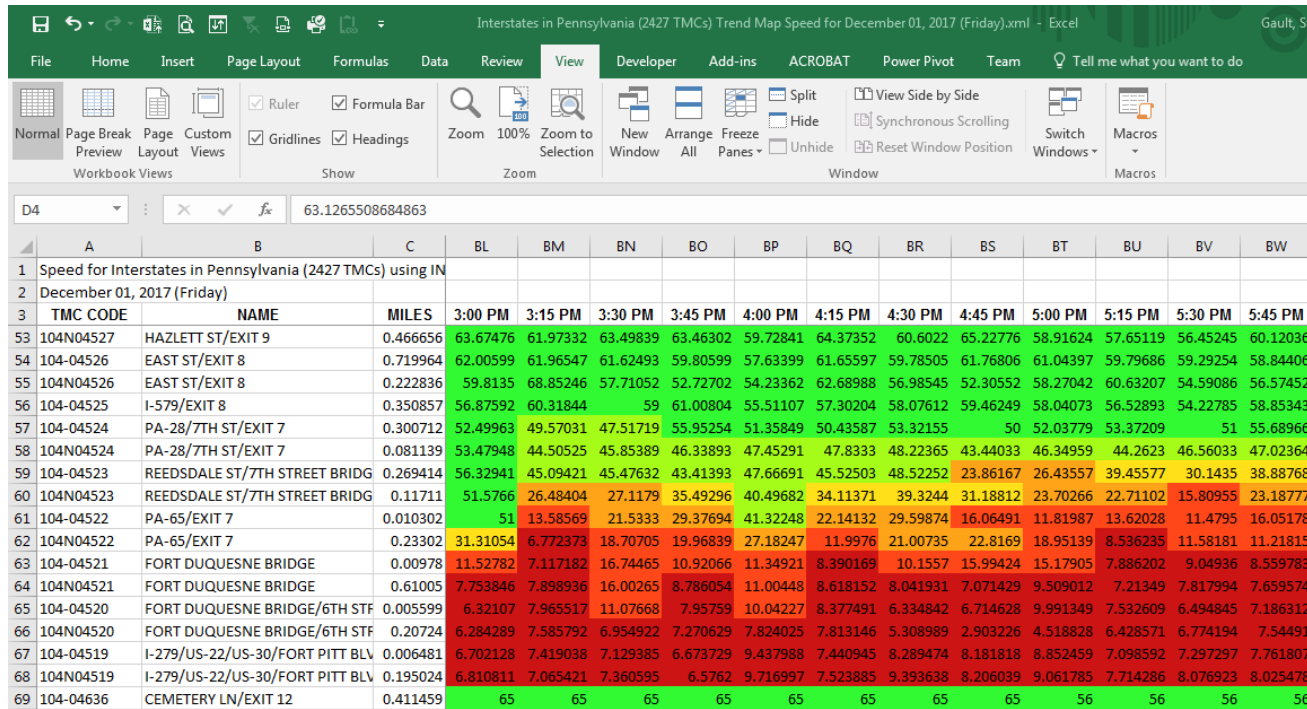
- Export options
  - Excel file (XML document: Open With→Excel) ⭐
    - Will export whatever metric is current selected with results for every segment shown on the map, with color-coding of cells

  - Screenshot image of map
  - Video (animated GIF or MP4)

- Performance charts can be generated for:
  - Speed
  - Travel Time Index
  - Buffer Time Index
  - Planning Time Index
- Can choose to aggregate certain days of the week and hours of the day, for example just look at weekday peak periods

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PDA Suite: Performance Charts

Planning time index for Interstates in Pennsylvania (2427 TMCs)

Averaged per fifteen minutes for December 01, 2017

Northbound

Plan an extra 20% average statewide for interstate travel during Friday PM peak
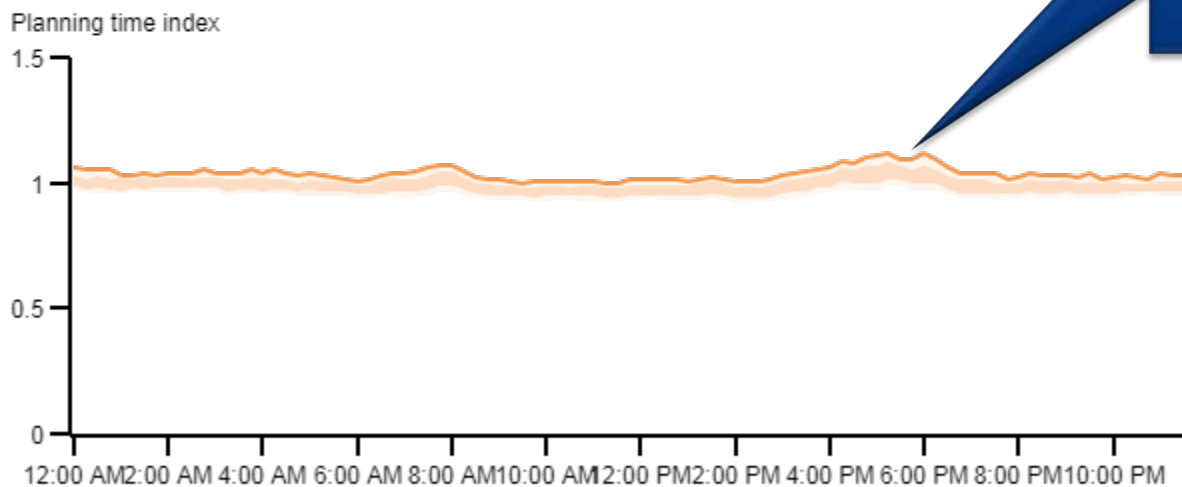
December 01, 2017 - INRIX
December 01, 2017 25th and 75th percentile - INRIX
December 01, 2017 5th and 95th percentile - INRIX

- Can use large pixel size so it will print well
- Can adjust colors & font sizes
- Can choose chart titles
- Recommend using transparent background

Buffer index for Interstates in Pennsylvania (2427 TMCs)
Averaged per fifteen minutes for December 01, 2017
Northbound
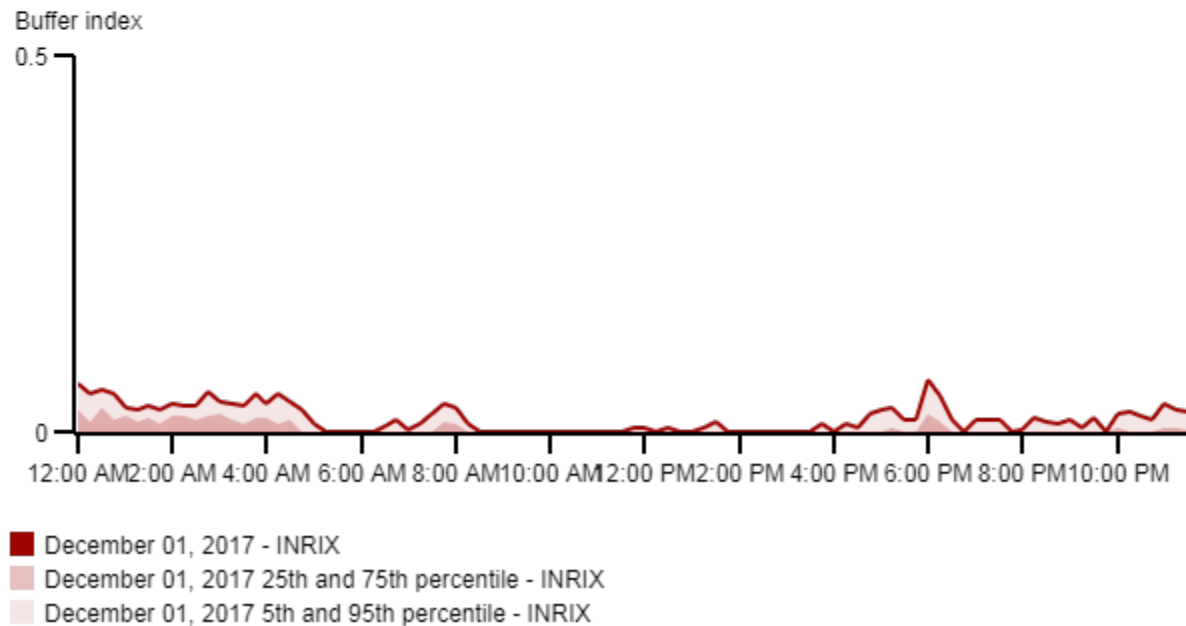
Planning time index for Interstates in Pennsylvania (2427 TMCs)

Averaged per day of week for January 02, 2017 through December 01, 2017 (Every weekday)

January 02, 2017 through December 01, 2017 (Every weekday) 4 PM - 6 PM
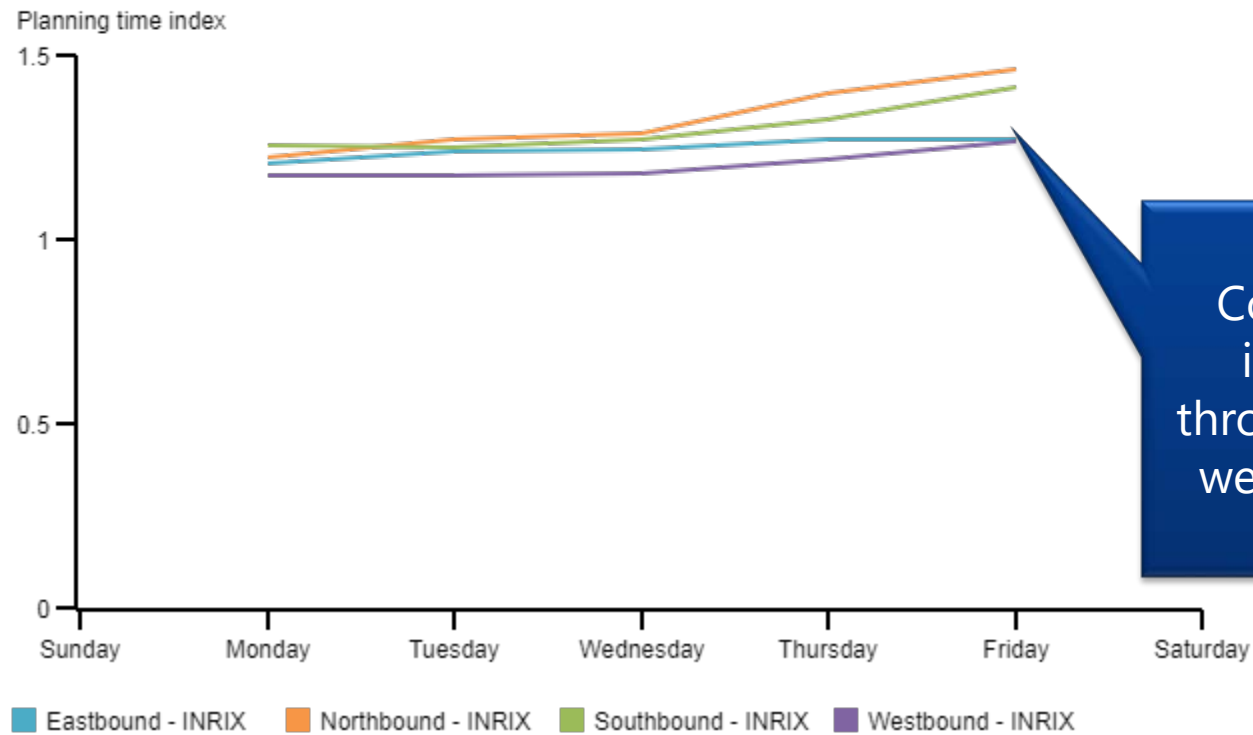
Congestion increases throughout the week in 2017

Buffer index for Interstates in Pennsylvania (2427 TMCs)

Averaged per day of week for January 02, 2017 through December 01, 2017 (Every weekday)

January 02, 2017 through December 01, 2017 (Every weekday) 4 PM - 6 PM
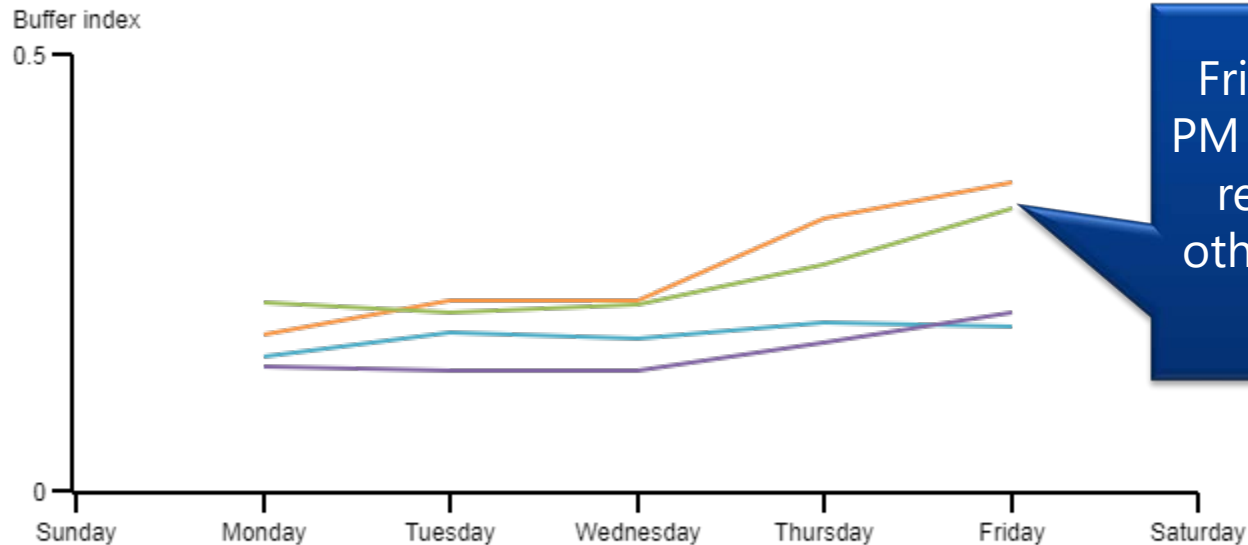
Option to include metric definition in chart export

Fridays during PM peak are less reliable than other weekdays in 2017

Buffer index: The buffer index is expressed as a percentage and its value increases as reliability gets worse ((95% Travel Time - Average Travel Time) / Average Travel Time). For example, a buffer index of .4 (40 percent) means that for a 20-minute average travel time, a traveler should budget an additional 8 minutes (20 minutes x 40 percent = 8 minutes) to ensure on-time arrival most of the time.

Eastbound - INRIX   Northbound - INRIX   Southbound - INRIX   Westbound - INRIX

- Bottlenecks exist whenever speeds drop below 60% of free-flow speed

- Bottlenecks have a head from which extend upstream

- Additional metrics added through PennDOT Project:
  - Base impact weighted by:
    - Speed differential
    - Congestion
    - Total Delay
  - Recommend changing ranking to **TOTAL DELAY** instead of base impact (click on column heading twice to rank with highest total delay first)
  - Total delay considers volume, magnitude of speed drop, and length of queue (not an exact delay measure due to computational complexity to allow results to be calculated in a timely manner)

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Bottleneck Ranking Table for Interstates in Pennsylvania (2427 TMCs) between November 1, 2017 and November 30, 2017 (1124 total)

Rank	Map	Head Location (approximate)	Average max length	Average daily duration	Total duration	All Events/Incidents	Base Impact	Speed differential	Congestion	TOTAL DELAY
1		I-95 S @ GIRARD AVE/EXIT 23	3.72	5 h 28 m	6 d 20 h 25 m	0	37,845.65	1,414,213.86	71,912.26	109,843,404,918.04
2		I-76 E @ BELMONT AVE/EXIT 338	3.94	4 h 37 m	5 d 18 h 54 m	1	43,772.93	1,517,512.32	76,140.80	76,849,858,661.14
3		I-476 S @ BALTIMORE PIKE/EXIT 3	4.27	3 h 26 m	4 d 07 h 14 m	0	26,374.41	912,152.99	40,168.62	46,968,581,531.79
4		I-76 W @ HOLLOW RD/EXIT 337	3.20	3 h 15 m	4 d 02 h 04 m	1	18,445.03	629,990.41	35,124.88	45,298,200,331.81
5		I-76 E @ SOUTH ST/EXIT 346	2.10	3 h 14 m	4 d 01 h 24 m	0	17,696.40	583,106.14	34,041.60	43,614,589,922.91
6		I-95 S @ PA-320/E 6TH ST/EXIT 6	1.13	6 h 14 m	7 d 19 h 30 m	2	16,242.07	593,885.00	29,154.33	40,185,822,342.67
7		I-76 W @ BELMONT AVE/EXIT 338	2.20	3 h 45 m	4 d 16 h 54 m	1	14,815.16	501,556.31	27,719.24	36,203,839,248.02
8		I-76 W @ MATSONFORD RD/EXIT 332	5.22	1 h 30 m	1 d 21 h 31 m	1	14,218.53	463,609.75	22,072.26	33,044,712,371.07
9		I-76 E @ SPRING GARDEN ST/EXIT 343	2.61	2 h 24 m	3 d 00 h 29 m	0	12,402.74	387,423.44	20,689.59	29,037,774,527.56
10		I-76 E @ US-30/US-13/GIRARD AVE/EXIT 342	1.91	3 h 29 m	4 d 09 h 03 m	0	12,282.67	388,039.31	19,863.64	28,664,075,616.21

- Top 10 Interstate Bottlenecks in Pennsylvania (Nov. 2017)

Rank	Map	Head Location (approximate)
1		I-95 S @ GIRARD AVE/EXIT 23
2		I-76 E @ BELMONT AVE/EXIT 338
3		I-476 S @ BALTIMORE PIKE/EXIT 3
4		I-76 W @ HOLLOW RD/EXIT 337
5		I-76 E @ SOUTH ST/EXIT 346
6		I-95 S @ PA-320/E 6TH ST/EXIT 6
7		I-76 W @ BELMONT AVE/EXIT 338
8		I-76 W @ MATSONFORD RD/EXIT 332
9		I-76 E @ SPRING GARDEN ST/EXIT 343
10		I-76 E @ US-30/US-13/GIRARD AVE/EXIT 342

- Top Non-Philadelphia Area Interstate Bottlenecks (Nov. 2017)
  - #12: I-376 N @ Fort Pitt Tunnel
  - #19: I-376 W @ Squirrel Hill Tunnel
  - #31: I-83 S @ 2nd St/Exit 43
  - #32: I-376 E @ Squirrel Hill Tunnel
  - #33: I-83 N @ Union Deposit Road/Exit 48
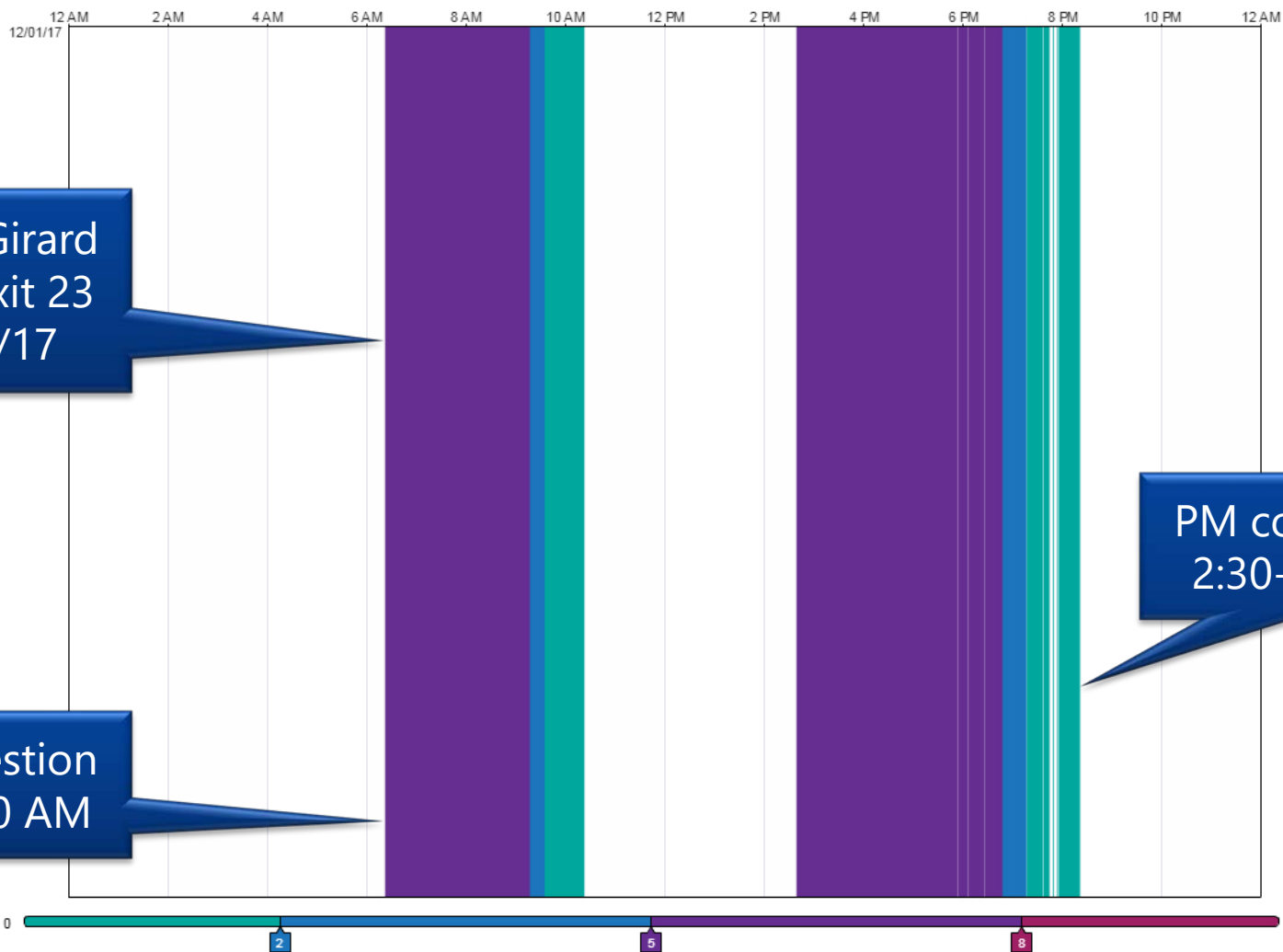
I-95 S @ Girard Avenue/Exit 23 on 12/1/17

PM congestion 2:30-8:30 PM

AM congestion 6:30-10:30 AM

- ## This can also be exported to Excel

I-95 S @ Girard Avenue/Exit 23

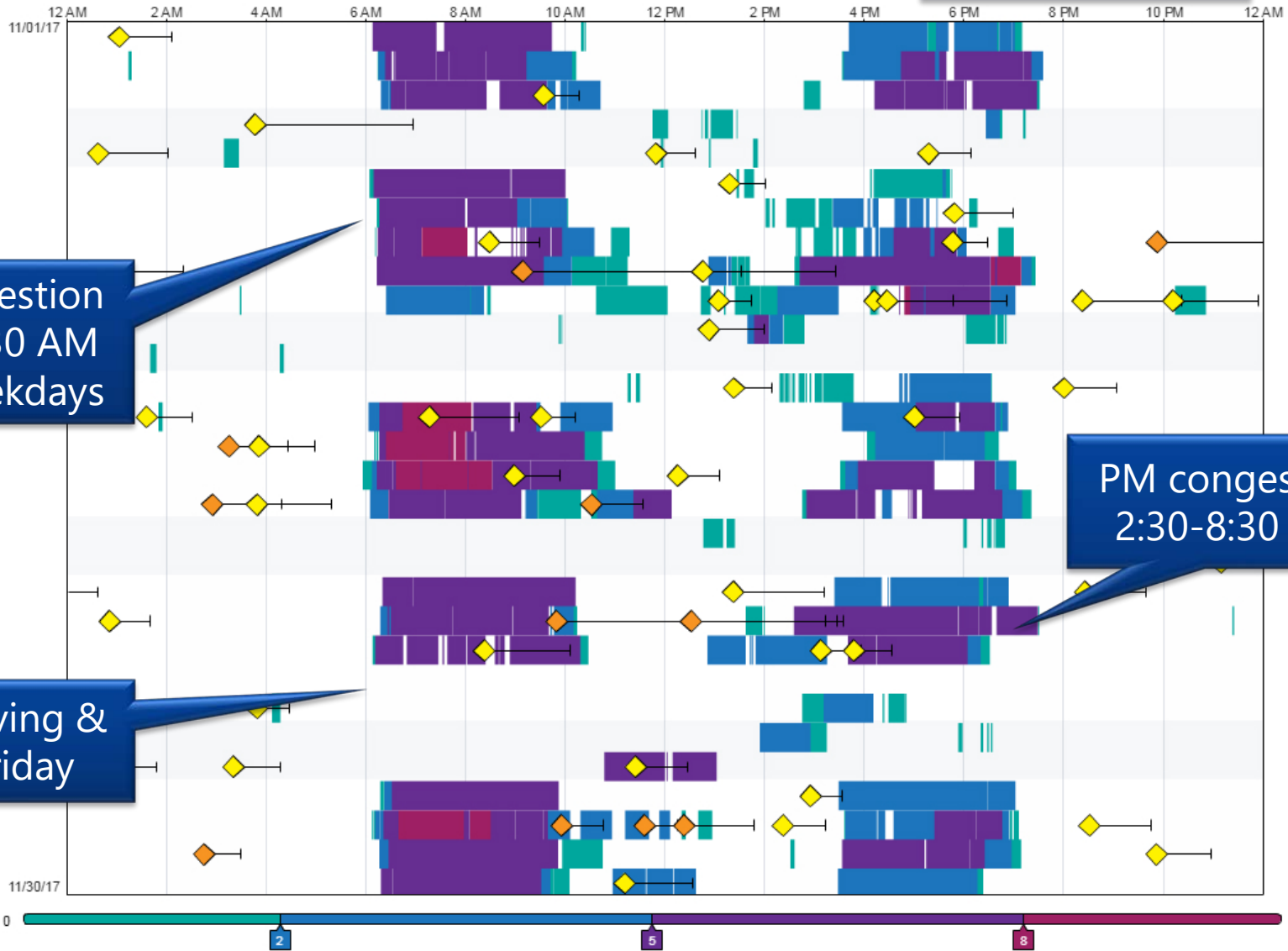| Start time	End time	Duration	Max length (miles)	Impact ⓘ	All events/incidents
Fri, Dec 1, 2017 6:21 AM	Fri, Dec 1, 2017 7:32 AM	1 h 11 m	6.55	421.10	0
Fri, Dec 1, 2017 7:32 AM	Fri, Dec 1, 2017 7:33 AM	1 m	6.39	6.39	0
Fri, Dec 1, 2017 7:33 AM	Fri, Dec 1, 2017 7:50 AM	17 m	6.55	111.34	0
Fri, Dec 1, 2017 7:50 AM	Fri, Dec 1, 2017 7:54 AM	4 m	6.39	25.56	0
Fri, Dec 1, 2017 7:54 AM	Fri, Dec 1, 2017 8:00 AM	6 m	6.55	39.30	0
Fri, Dec 1, 2017 8:00 AM	Fri, Dec 1, 2017 8:01 AM	1 m	6.39	6.39	0
Fri, Dec 1, 2017 8:01 AM	Fri, Dec 1, 2017 8:40 AM	39 m	6.55	245.09	0
Fri, Dec 1, 2017 8:40 AM	Fri, Dec 1, 2017 8:41 AM	1 m	5.60	5.60	0
Fri, Dec 1, 2017 8:41 AM	Fri, Dec 1, 2017 9:16 AM	35 m	5.75	181.87	0
Fri, Dec 1, 2017 9:16 AM	Fri, Dec 1, 2017 9:17 AM	1 m	3.18	3.18	0
Fri, Dec 1, 2017 9:17 AM	Fri, Dec 1, 2017 9:34 AM	17 m	3.34	45.41	0
Fri, Dec 1, 2017 9:34 AM	Fri, Dec 1, 2017 9:37 AM	3 m	1.99	5.98	0
Fri, Dec 1, 2017 9:37 AM	Fri, Dec 1, 2017 10:22 AM	45 m	1.81	47.78	0
Fri, Dec 1, 2017 2:38 PM	Fri, Dec 1, 2017 5:18 PM	2 h 40 m	6.55	642.15	0
Fri, Dec 1, 2017 5:18 PM	Fri, Dec 1, 2017 5:20 PM	2 m	6.39	12.78	0
Fri, Dec 1, 2017 5:20 PM	Fri, Dec 1, 2017 5:22 PM	2 m	6.55	13.10	0
Fri, Dec 1, 2017 5:22 PM			6.39	6.39	0
Fri, Dec 1, 2017 5:23 PM			6.55	19.65	0
Fri, Dec 1, 2017 5:26 PM			6.39	83.08	0
Fri, Dec 1, 2017 5:39 PM			6.55	91.69	0

Each line represents a time when speed dropped below 60% of free flow or queue length changed
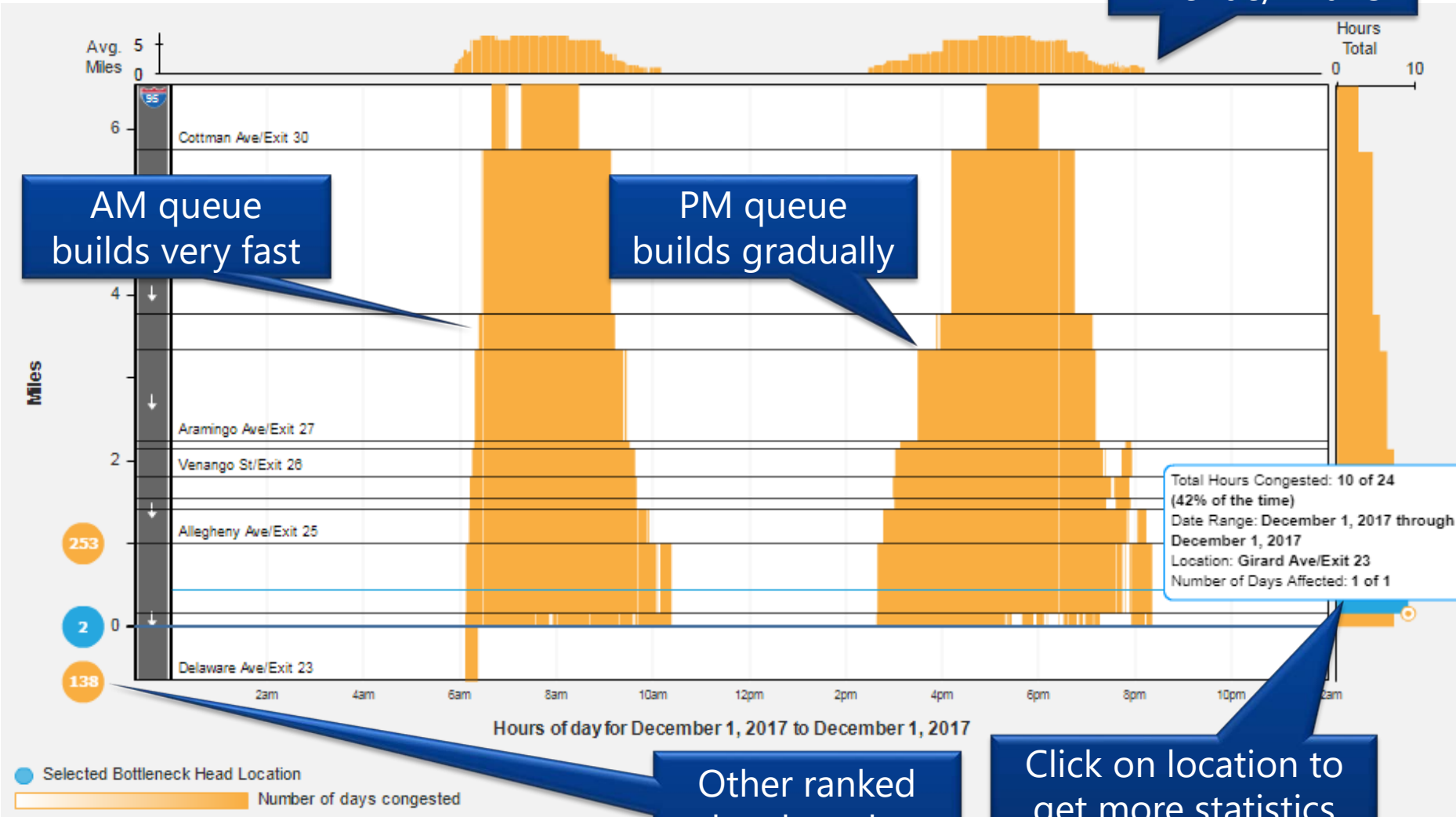
- Road selection
  - **Road** allows a road to be selected by name or number, including the entire length within a state or a partial segment with user-defined beginning and ending points
    - I-81 Entire length (from PA/MD border to PA/NY border)
    - I-81 from Exit 52/US-11/I-76 to Exit 89/I-78
  - **Region** allows all roads meeting certain geographic criteria to be selected, such as county or road classification. Examples:
    - All interstates in Pennsylvania
    - All roads in Centre County, Pennsylvania
- Take advantage of the export options for additional analysis
- For Pennsylvania analysis, INRIX data is recommended
- Compare to historic average speed to differentiate recurring and non-recurring congestion

- Anything which can be generated by the PDA Suite User Interface can be automated through API

- Requests & responses use JSON format with an API Key assigned by UMD that is tied to a RITIS login

```
"id": "G__2159512",
"impact": 390221.73192599975,
"impactPercent": 2.0538367764944407E8,
"impactSpeedDiff": 1.2839190076595997E7,
"totalDuration": 46058.0,
"averageDuration": 225.77450980392157,
"averageDurationPerDay": 125.49863760217984,
"averageMaxLength": 6.0007840294117605,
"headLocation": "PA-477 N @ US-220",
"geometry": "-77.47788 41.08691,-77.477 41.08
41.08683,-77.47395 41.08667,-77.47368 41.0866
41.08602,-77.47187 41.08598,-77.47174 41.0859
41.08543,-77.46971 41.08518,-77.46945 41.0850
41.08477,-77.46822 41.08481,-77.46813 41.0848
41.08576,-77.46639 41.08587,-77.46631 41.0859
41.08582,-77.46565 41.08573,-77.46551 41.0856
"headGeometry": "-77.47788 41.08691",
"state": null,
"tmcs": ["103P17360", "103+17360", "103P17359"],
"volumeEstimate": 0,
"delaySurrogate": 0.0
```

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Metrics Tools: PDA Suite API

- Anything which can be generated in PDA Suite User Interface can be automated with API

- Each API has a request and response JSON message

- Some APIs require checking status repeatedly due to the time required to run the analysis

- APIs available:
  - Segment Search
  - Bottleneck Search
    - Returns Bottlenecks
    - Can also request the elements associated with each bottleneck
  - Jobs (submit request, check status, then request results)
    - Export (massive data downloader)
    - Performance Metrics
    - User Delay Cost

PDA Suite API: Bottlenecks

Example Bottleneck Data

"id": "G__2159927",
"impact": 14673.715390999972,
"impactPercent": 19322.120737999998,
"impactSpeedDiff": 457396.20020300016,
"totalDuration": 2653.95,
"averageDuration": 7.4549157303370785,
"averageDurationPerDay": 7.231471389645776,
"averageMaxLength": 5.567096648876389,
"headLocation": "I-99 N @ ATHERTON ST/GRAYS WOODS BLVD/28TH DIVISION HWY",
"geometry": "-77.93855 40.81776,-77.93938 40.81799,-77.93988 40.81812,-77.94026 40.81823,...
"headGeometry": "-77.93855 40.81776",
"state": null,
"tmcs": ["103P14825", "103+14825", "103P15511", "103+15511", "103P14824", "103+14824", "104+11701", "104P04897", "104+04897", "104P04896", "104+04896", "104P04895", "104+04895"],
"volumeEstimate": 9070,
"delaySurrogate": 4.1485835358412113E9

Example Bottleneck Element

"startTime": 1452639644,
"endTime": 1452640221,
"impact": 79.395101,
"impactPercent": 103.819355,
"impactSpeedDiff": 2012.071281,
"maxQueueLength": 8.958403,
"tmcs": ["103+06809", "103P07209"]

PDA Suite API: Performance Measures

```
"tmcGroupIndex": 165,
"periodId": 0,
"timeRangeIndex": 0,
"interval": 0,
"intervalString": null,
"requestIntervalIndex": 0,
"period": "January 01, 2016 through January 01,
2017",
"timeRange": "0-1440",
"tmcGroupAlias": "104P04850",
"speed": 67.27223156909943,
"averageSpeed": 66.21899337851922,
"referenceSpeed": 67.209296834809,
"length": 0.700397,
"bufferIndex": 0.034671771539362635,
"bufferTime": 0.02200335903511254,
"planningTimeIndex": 1.0501452630438903,
"planningTime": 0.6566221875,
"travelTimeIndex": 0.9990644767860006,
"travelTime": 0.6246830084242823,
"congestion": 100.0,
"averageCongestion": 98.52653798964181,
"compSpeed": 100.0,
"percentile95": 64.0,

"travelTimePercentiles": {
        "85": 0.6367245454545455,
        "95": 0.6566221875 },
"speedPercentiles": {
        "85": 71.0,
        "95": 73.0 },
"compSpeedPercentiles": {
        "85": 100.0,
        "95": 100.0 },
"bufferIndexPercentiles": {
        "85": 0.003318081492715282,
        "95": 0.034671771539362635 },
"bufferTimePercentiles": {
        "85": 0.002105716989657997,
        "95": 0.02200335903511254 },
"planningTimeIndexPercentiles": {
        "85": 1.0183226793152877,
        "95": 1.0501452630438903 },
"planningTimePercentiles": {
        "85": 0.6367245454545455,
        "95": 0.6566221875 },
"travelTimeIndexPercentiles": {
        "85": 1.0183226793152877,
        "95": 1.0501452630438903 },
"congestionPercentiles": {
        "85": 100.0,
        "95": 100.0 },
```

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PDA Suite API: User Delay Cost

Daily

```
"daily_totals": {
"commercial": {
        "volume": 523056.025360,
        "delay_cost_per_vmt": 0.020683,
        "delay_person_hours": 176.379462,
        "delay_cost": 17724.372179,
        "delay_vehicle_hours": 176.379462,
        "cdi": 0.01234907,
        "vmt": 856968.865854
},
"passenger": {
        [same data format]
},
"combined": {
        "volume": 5230560.253603,
        "coverage": 100.00,
        "expected_weight": 1560926.688480,
        "delay_cost_per_vmt": 0.005386,
        "delay_person_hours": 2160.648415,
        "delay_cost": 53262.629114,
        "delay_vehicle_hours": 1763.794624,
        "cdi": 0.01234907,
        "vmt": 8569688.658536,
        "expected_received_weight": 0.000000
},
"date": "January 01, 2016"
```

Hourly

```
"commercial": {
        "volume": 21794.000000,
        "delay_cost_per_vmt": 0.026065,
        "delay_person_hours": 9.261554,
        "delay_cost": 930.693585,
        "delay_vehicle_hours": 9.261554,
        "cdi": 0.01556257,
        "vmt": 35707.029619 },
"passenger": {
        [same data format] },
"combined": {
        "volume": 217940.000000,
        "coverage": 100.00,
        "expected_weight": 65038.612020,
        "delay_cost_per_vmt": 0.006787,
        "delay_person_hours": 113.454039,
        "delay_cost": 2796.780995,
        "delay_vehicle_hours": 92.615542,
        "cdi": 0.01556257,
        "vmt": 357070.296188,
        "expected_received_weight":
0.000000
},
"date": "January 01, 2016 00:00:00",
"hour": 0
```

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TSMO Layers

- Top Bottlenecks
- Traffic Signals
- V/C Ratio
- Shoulder Width
- AADT
- Crash Clusters
- Rear-End Crash Clusters
- Intersection Crash Clusters
- Curved Road Crash Clusters
- TIP
- ITS Devices
- RCRS Road Closures*
- Crash Rates
- Incident Factor*
- Truck Percentage
- Detour Routes*
- Police Departments*
- RTMC Boundaries
- Rumble Strips
- Cable Median Barriers
- Guiderails
- Bridge Locations
- CM Rating*
- High Volume HOPs
- RCRS Road Conditions*
- Special Events*

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- Base Maps
  - Recurring Congestion
  - Non-Recurring Congestion (Planned Events)
    - Work Zones
    - Special Events
  - Non-Recurring Congestion (Unplanned Events)
    - Traffic Incidents
    - Weather
- Base Maps have predefined layers
- Can add layers and turn on/off layers as desired
- Filters allow showing only locations with a certain criteria (example: Planning Time Index > 2.0)
- Operations Metrics for previous 12-month period

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- ## Bottlenecks
  - Previous 12 months of data, mapped to the TMC segment at the head of the bottleneck
  - All attributes from PDA Suite API
  - Also include ranking by delay surrogate
    - Rank within RTMC region
    - Rank within District
    - Rank within Planning Partner region

- ## Performance Measures
  - Previous 12 months of data calculated for each hour of the day for each TMC
  - Attributes for worst hour of day, AM & PM
    - Buffer Time Index
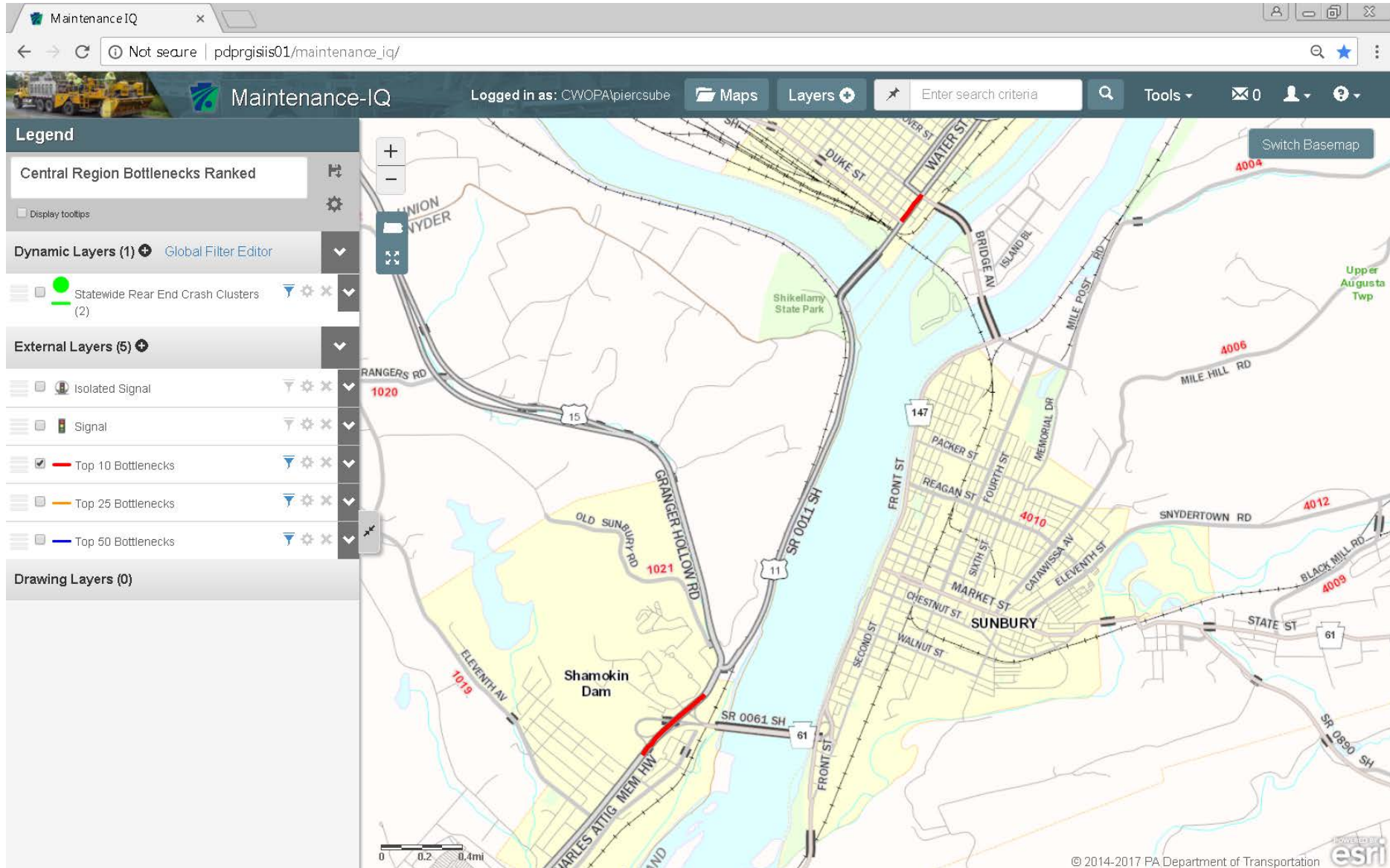   - Planning Time Index
    - Travel Time Index

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TSMO Solutions	Causes of Congestion					
	Bottlenecks	Traffic Incidents	Inclement Weather	Work Zones	Poor Signal Timing	Special Events
Integrated Corridor Management	x	x	x	x	x	x
Hard Shoulder Running	x	x				x
Managed Lanes	x	x	x			x
TIM Teams		x				
Freeway Service Patrols		x		x		x
Smart Work Zones				x		
Traffic Signal Enhancements					x	
Transit Signal Priority					x	
Traveler Information		x	x	x		x
Ramp Metering	x	x				x
Bridge De-icing			x			
Commercial Vehicle Operations						
Dynamic Lane Assignment	x	x		x		x
Junction Control	x	x		x		x
Queue Warning	x	x		x		x
Variable Speed Displays		x	x	x		
Dynamic Rerouting		x		x		x
RWIS			x			
Dynamic Curve Warning						
Traffic Management Center Operations	x	x	x	x	x	x
Traffic Incident Detection		x				
DMS		x		x		x
CCTV	x	x	x	x		x

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- Traffic operations/congestion related measures
  - Interstate Travel Time Reliability
  - Non-Interstate Travel Time Reliability
  - Freight Reliability
  - Peak Hour Excessive Delay
  - Percent of Non-SOV Travel
- Calculated using NPMRDS data set

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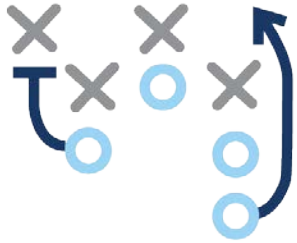
TSMO Purpose

A way to address reliability, mobility, and congestion by using various strategies rather than just trying to build our way out.

TSMO Mission

Move people and goods, from Point A to Point B, as efficiently, safely, and reliably as possible.

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