



Work Zone Queues Past Advance Signs and the Impact on Safety

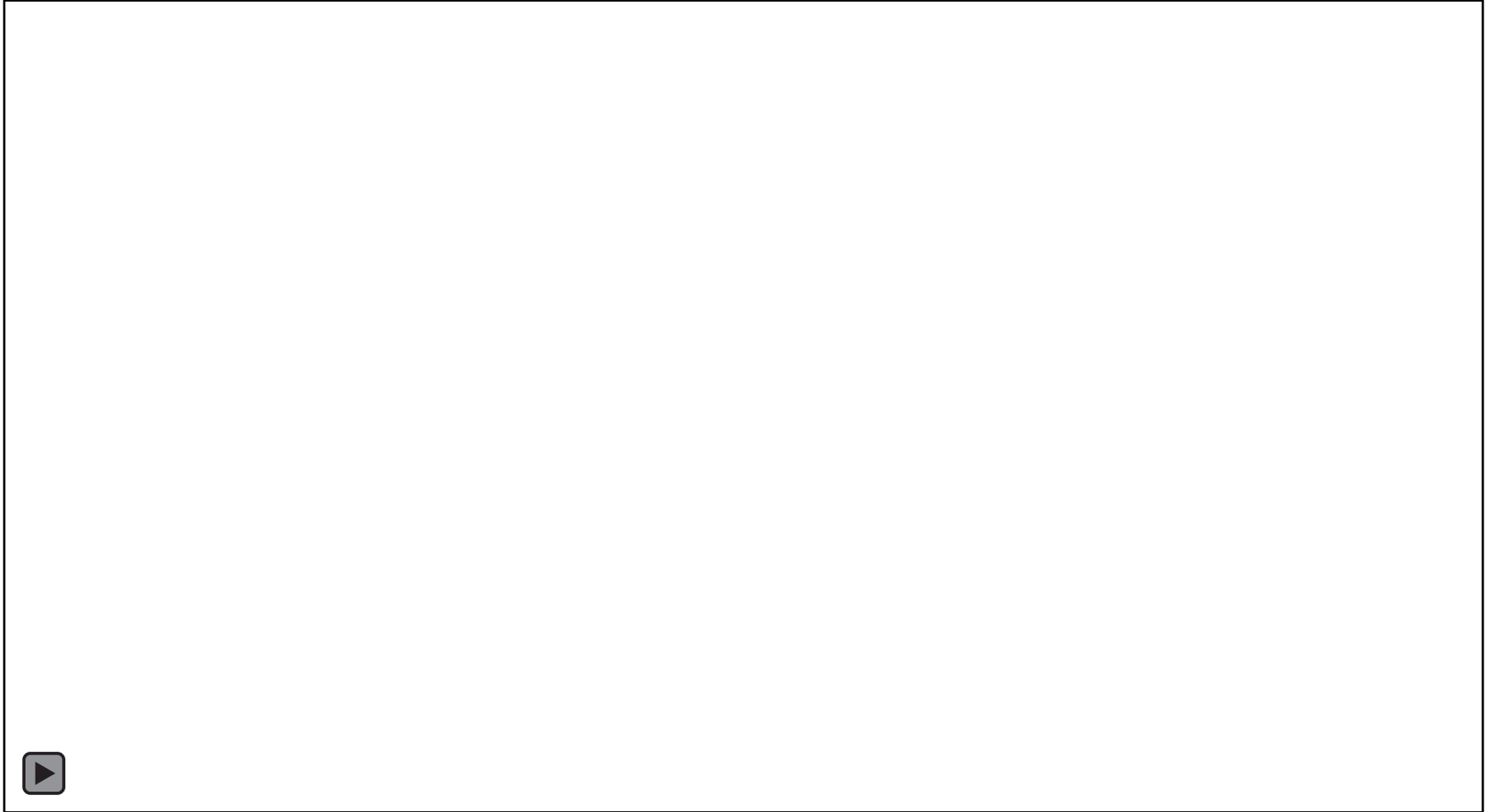
Michelle M. Mekker, Darcy M. Bullock

12/6/2017

Outline

- Motivation
- Statewide Back-of-Queue Crashes
- Data Sources
- Methodology
- Crash Rate Analysis
- Conclusions

Motivation



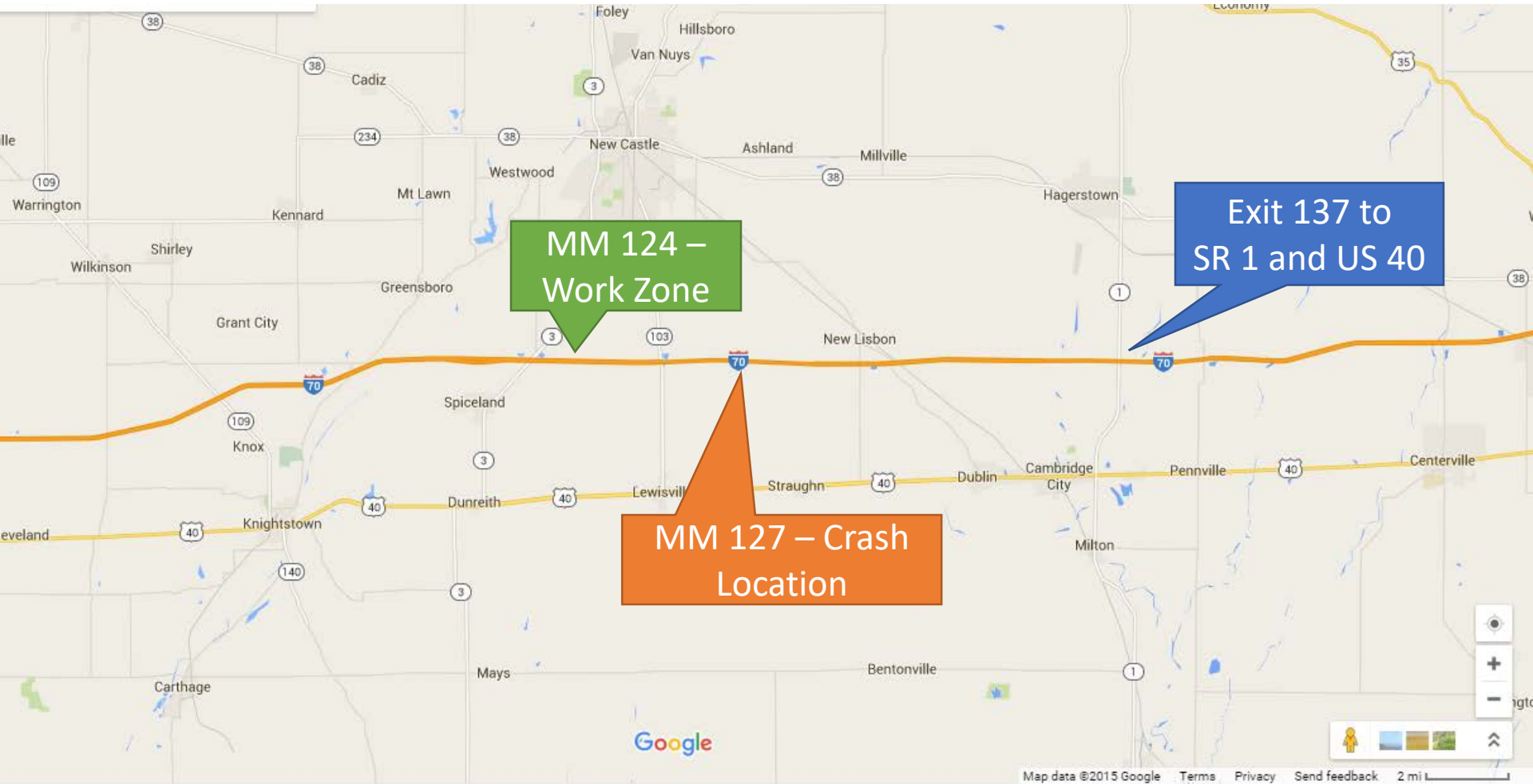
Motivation

Back-of-Queue Crash Nov. 13, 2015



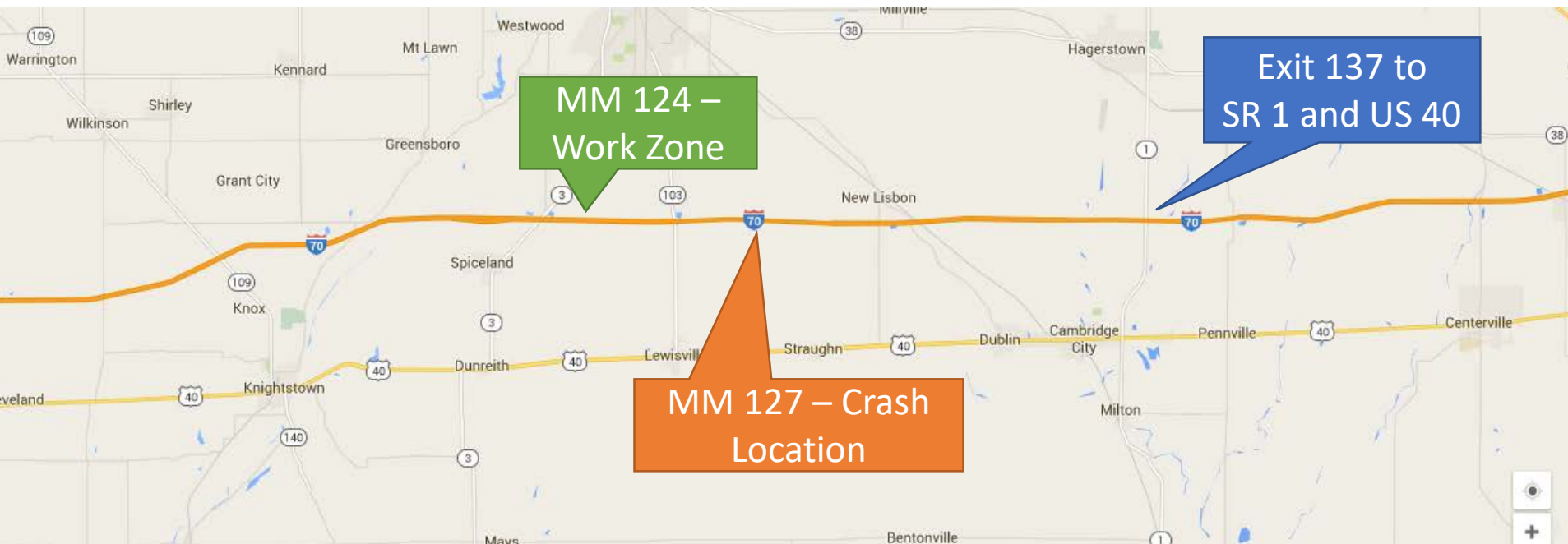
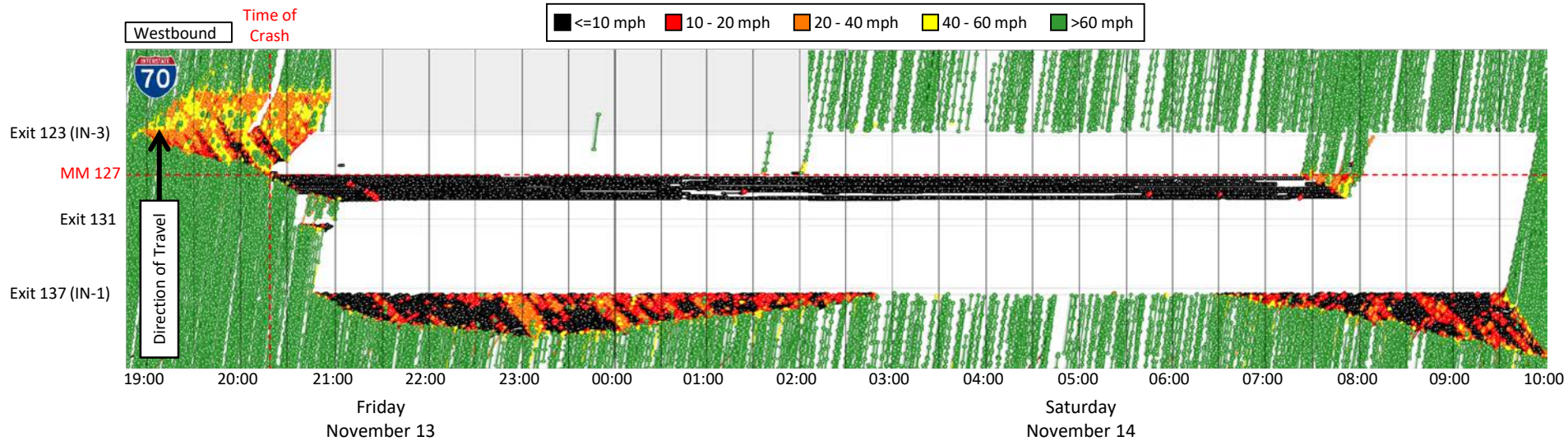
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Back-of-Queue Crash Nov. 13, 2015



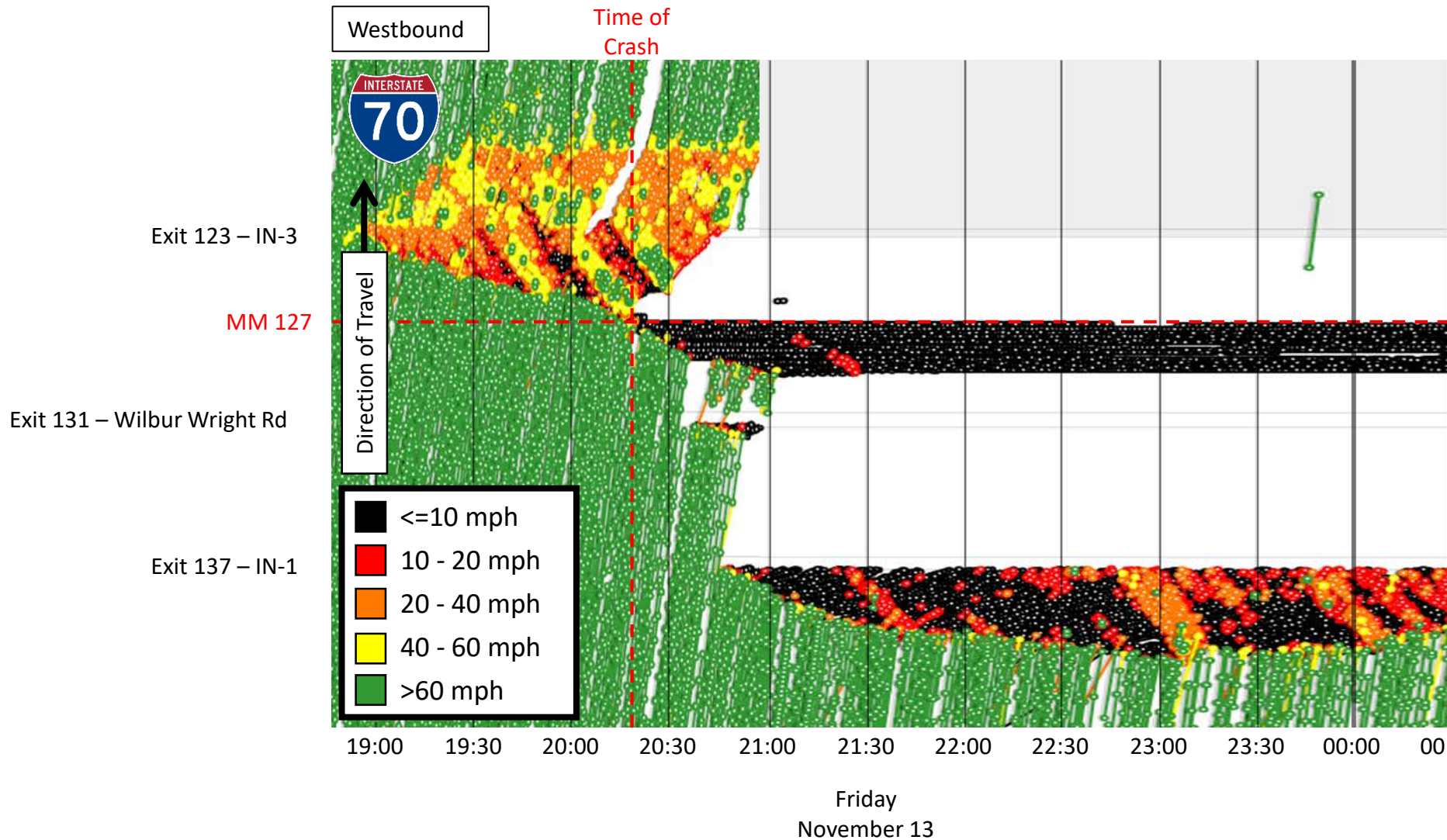
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Motivation

Back-of-Queue Crash Nov. 13, 2015

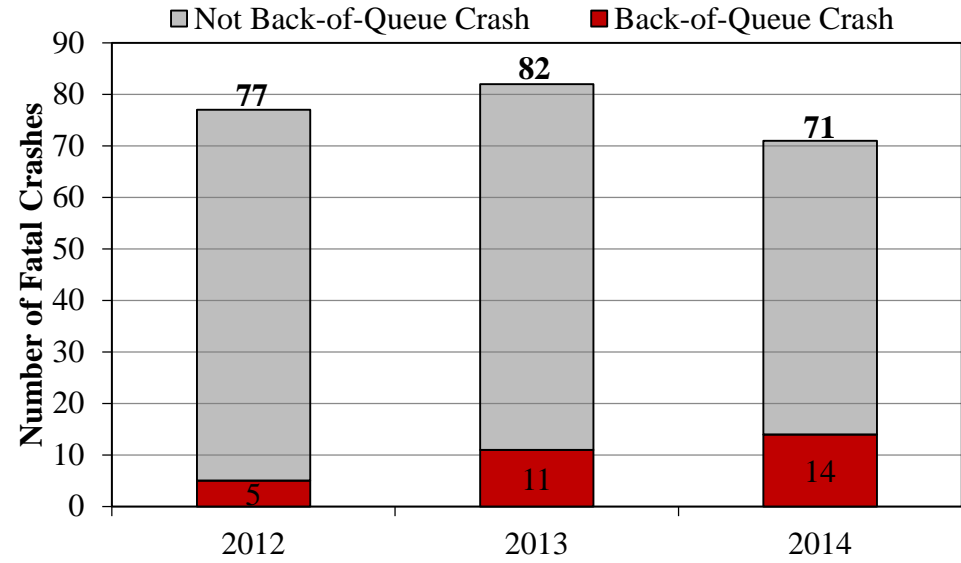


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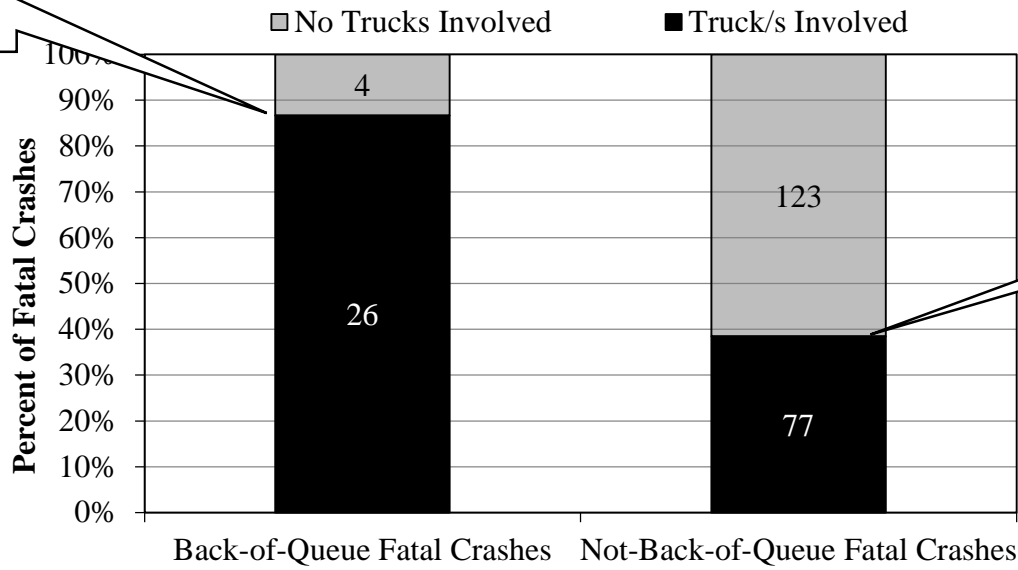
Statewide Back-of-Queue Crashes

Fatal Interstate Crashes, 2012-2014



30 out of 230 fatal crashes occurred at the back of a queue

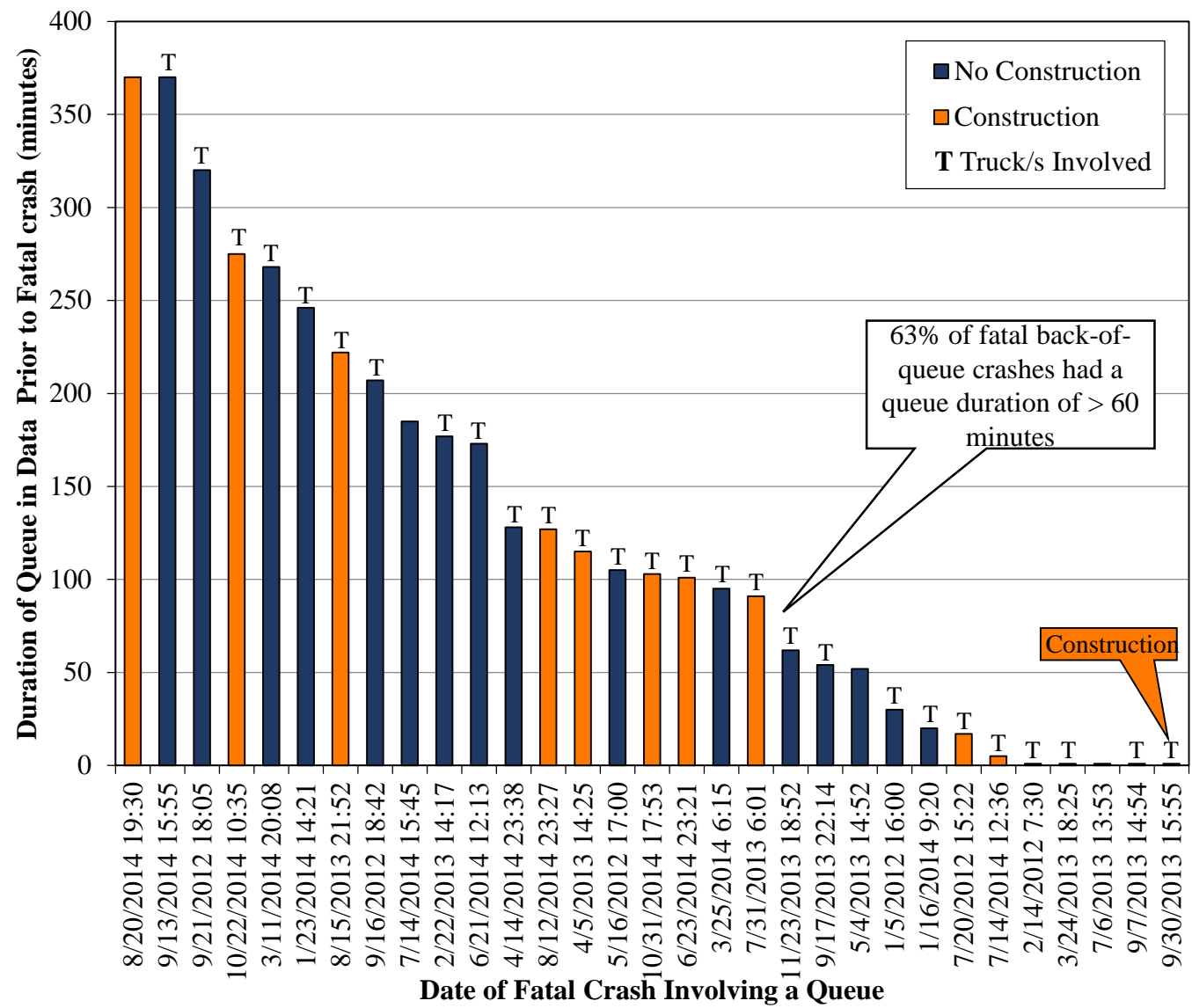
87% of fatal back-of-queue crashes involved trucks



39% of fatal non-back-of-queue crashes involved trucks

Statewide Back-of-Queue Crashes

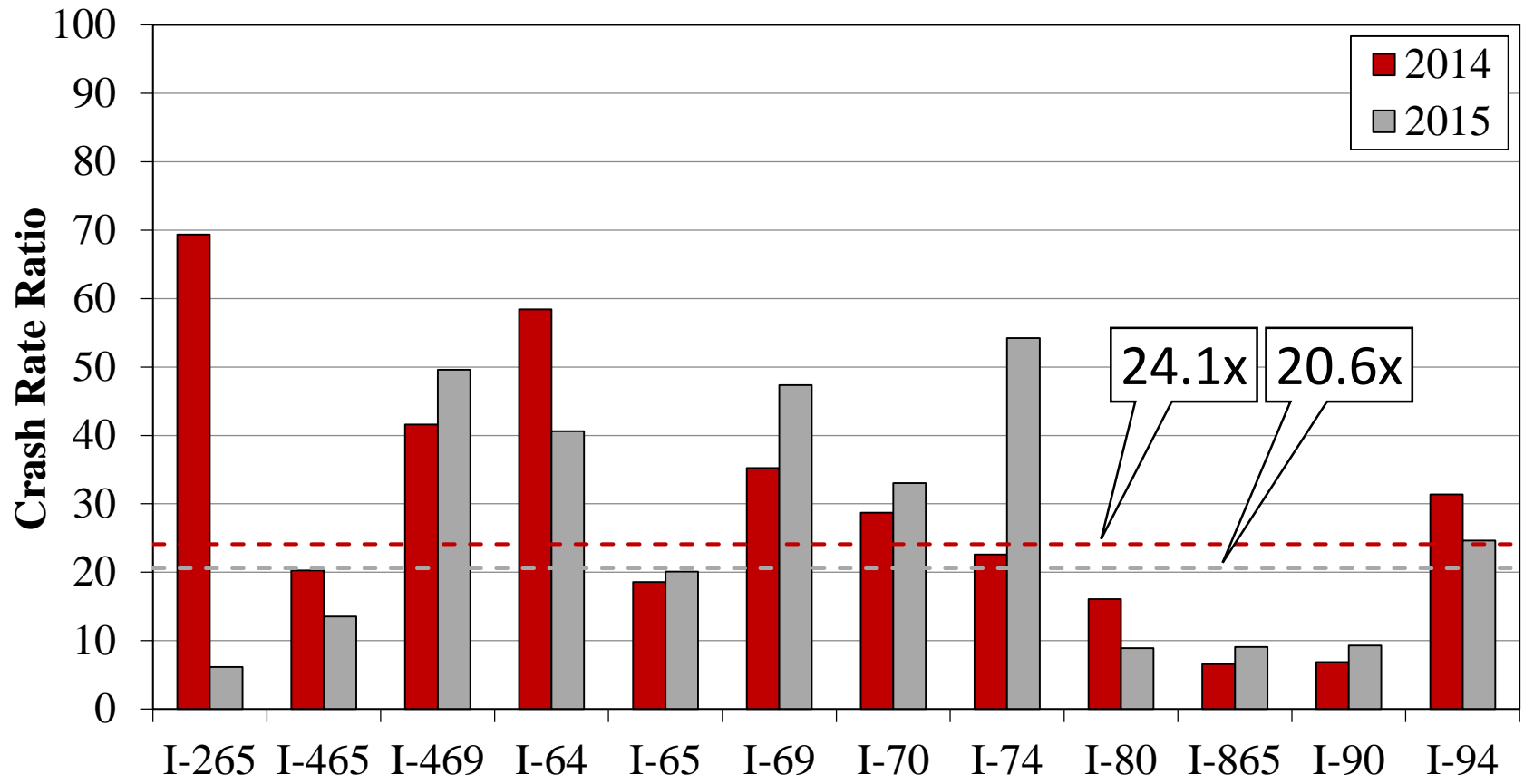
Fatal Interstate Crashes, 2012-2014 – Queue Duration



Statewide Back-of-Queue Crashes

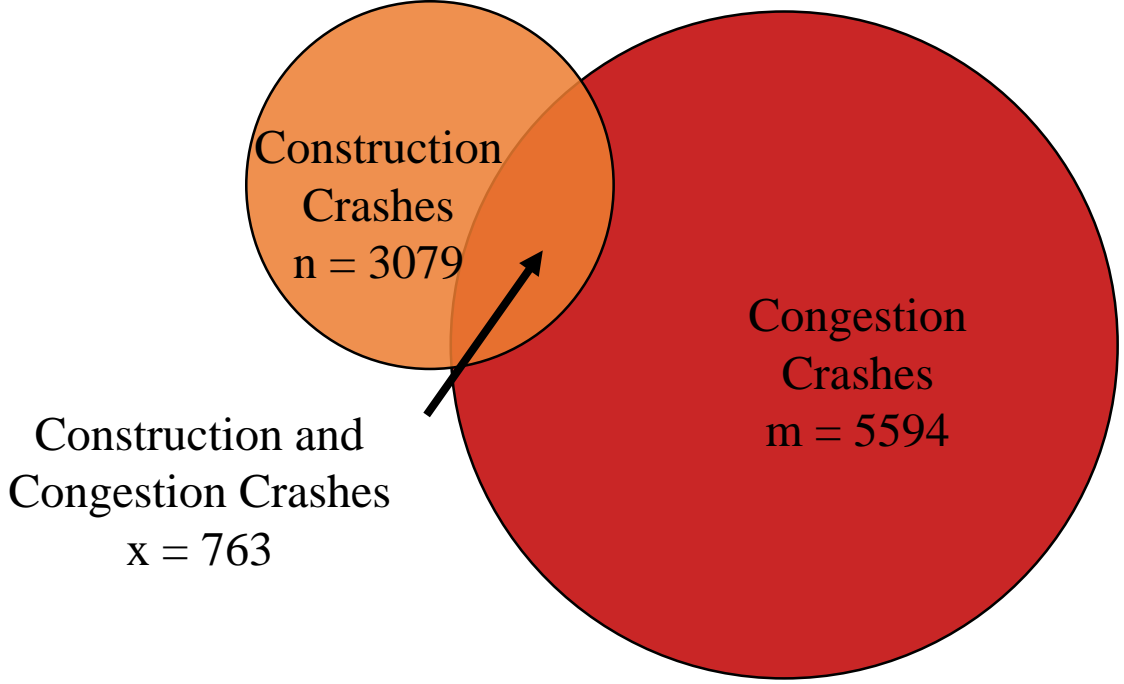
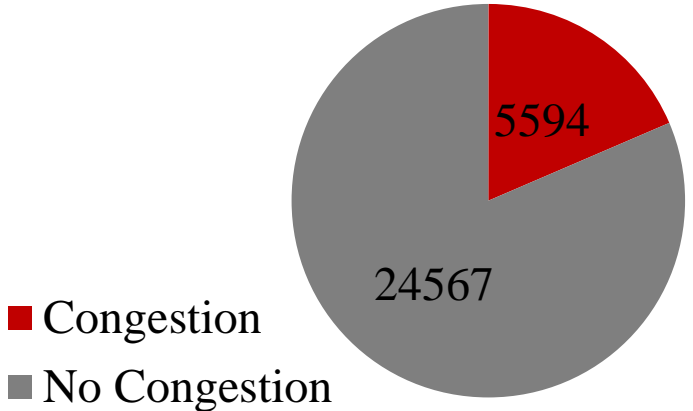
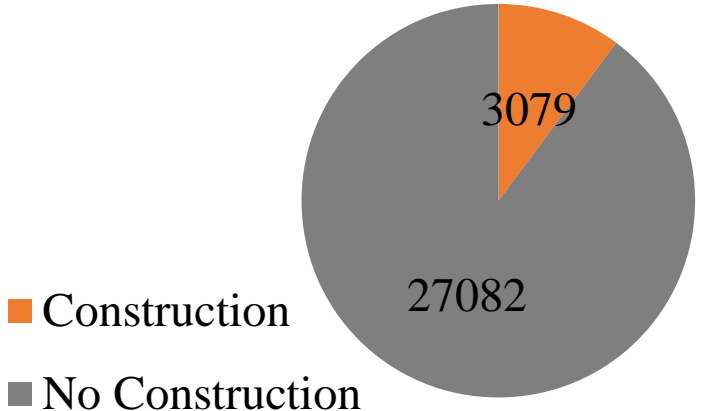
Congested vs. Uncongested Crash Rates, 2014-2015

$$\text{Crash Rate Ratio} = \frac{\text{Congested Crash Rate}}{\text{Uncongested Crash Rate}}$$



Statewide Back-of-Queue Crashes

Congested vs. Construction Crashes, 2014-2015

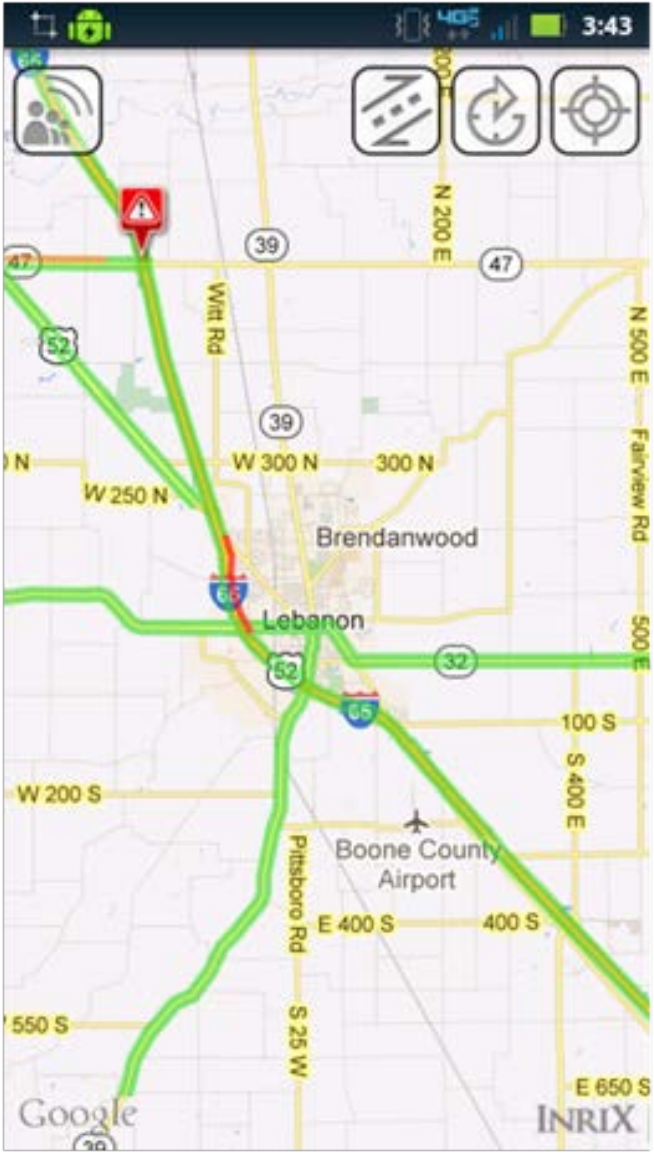
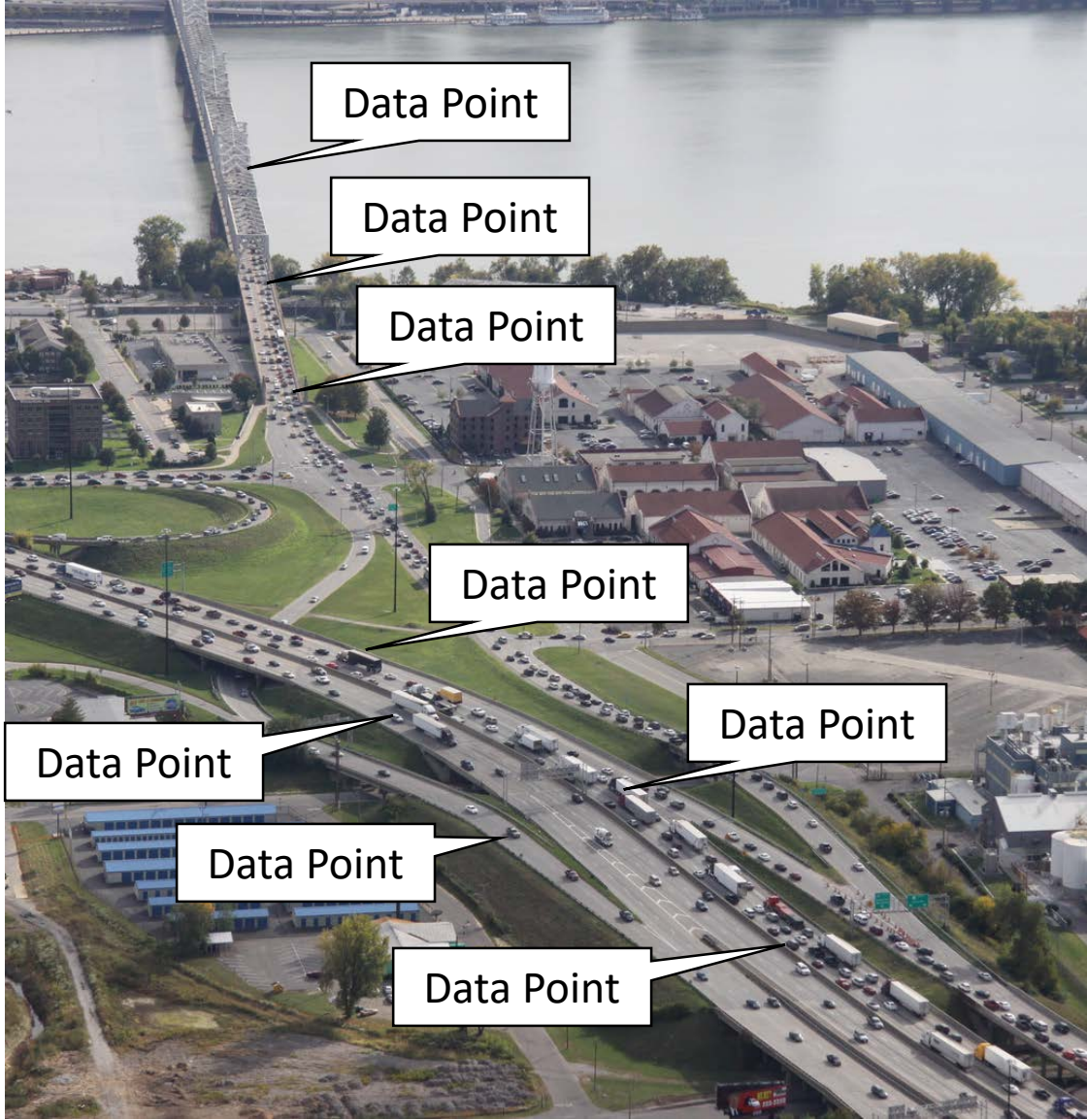


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Data Sources

Crowd Sourced Probe Vehicle Data



Data Sources

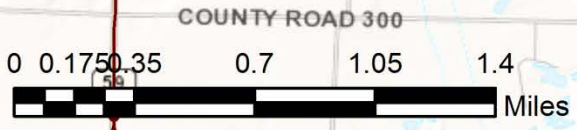
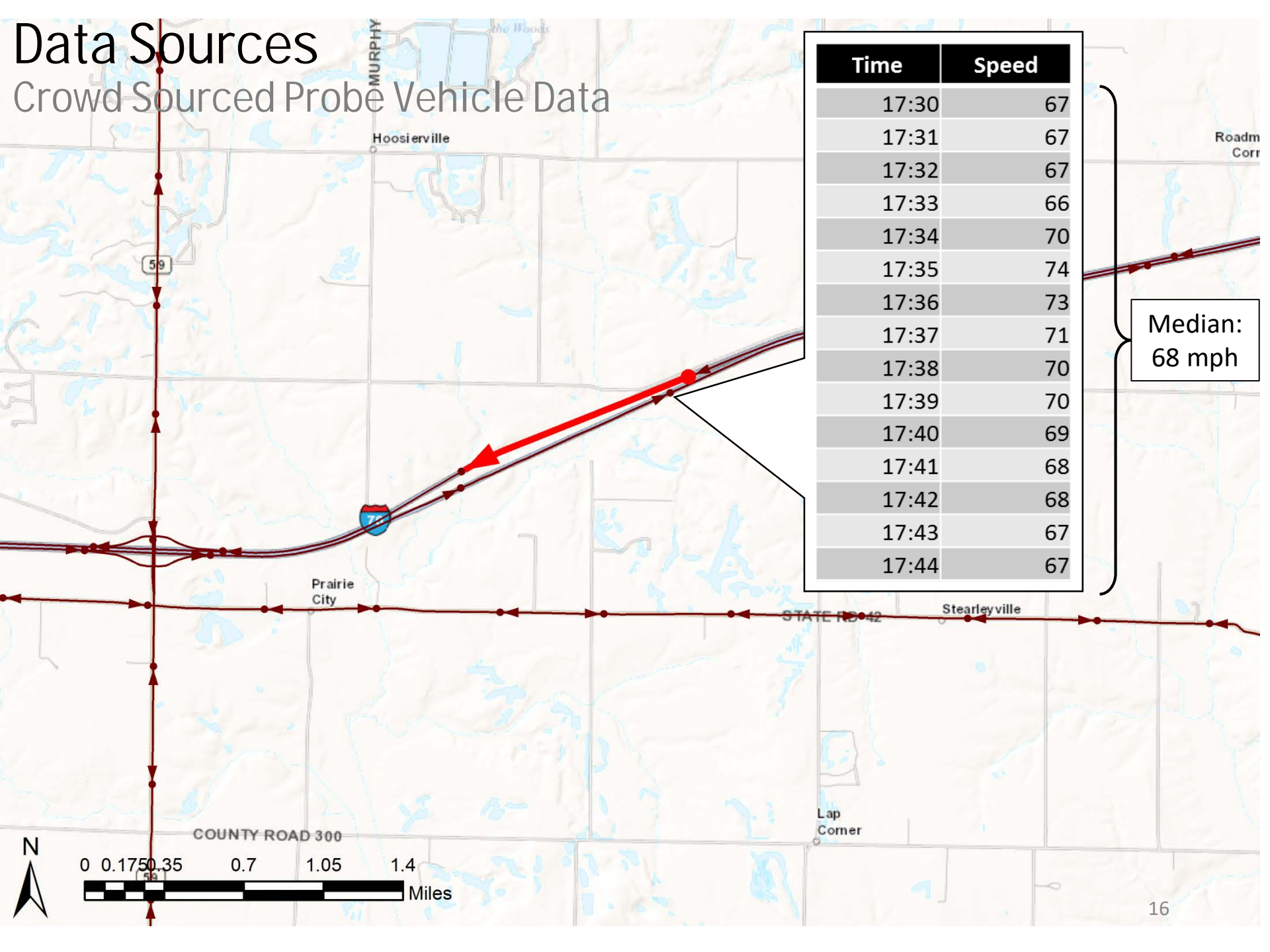
Crowd Sourced Probe Vehicle Data



- 1886 miles of Interstates in Indiana
- ~996 Million Interstate Records on 2677 segments in 2015 so far
- 23,314,131,597 records in the 2010 to 2014 INRIX data for Indiana.
- Without good graphics and analysis techniques this is Data Rich Information Poor (DRIP)

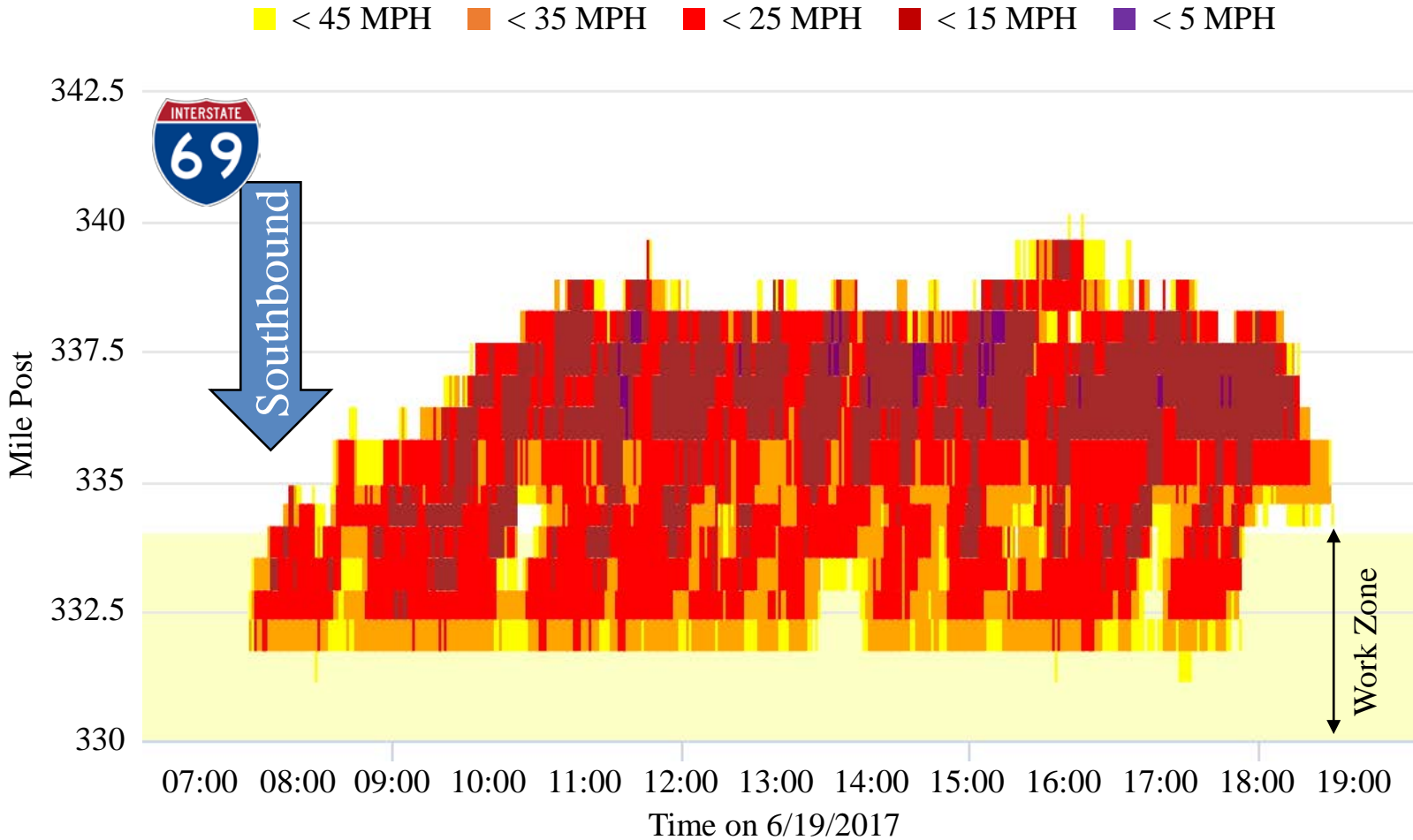
Data Sources

Crowd Sourced Probe Vehicle Data



Data Sources

Crowd Sourced Probe Vehicle Data



Data Sources

Crash Data

Date of Crash	Day of Week	Actual Local Time	County	Township	# Motor Vehicles	# Injured	# Dead	# Commercial Vehicles	# Deer
10/22/2016	Sat	2:00 PM	CLAY	POSEY	3	1	0	3	0
Road Crash Occurred On			Nearest/Intersecting Road/MileMarker/Interchange		If not an intersection, number of feet from	Direction	Road Classification		
170			19.5		500	E	INTERSTATE		
Inside Corporate Limits?	City/Town or Nearest City/Town			Property?	Crash Latitude		Crash Longitude		
NO	BRAZIL			OTHER					

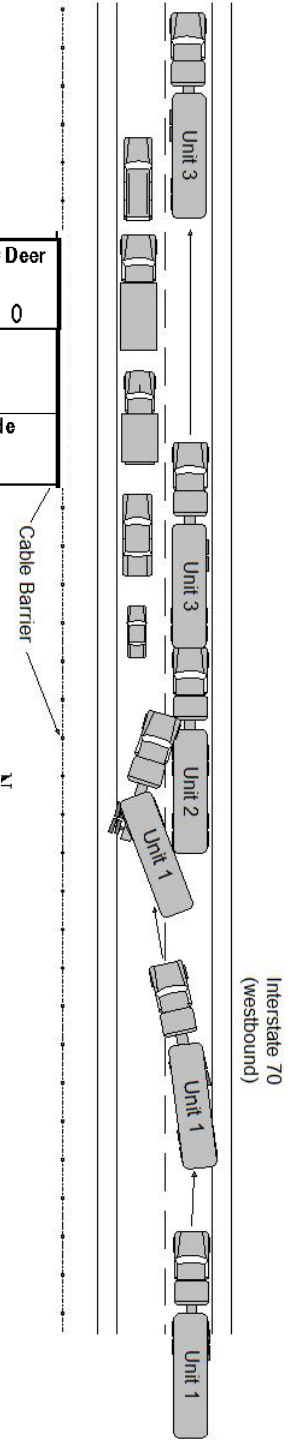
Narrative

D1 stated that he was driving in the right lane of Interstate 70 (westbound), at approximately the 19 mile marker when he struck V2 that was stopped due to a back-up of traffic trying to merge into the right lane due to the left lane being closed for construction.

D1 stated that he was driving in the right lane looking down, reaching for a drink when he looked back up and saw that V2 was stopped. D1 told me that he merged into the left lane and saw that traffic in that lane was also stopped. D1 continued to say that when he applied his brakes, his trailer started to jack-knife and he then hit V2, just behind the cab in the area of the fuel tanks. D1 stated that a fire started between the two trucks and he exited his vehicle when it caught fire.

D2 stated that he was stopped in traffic in the right lane of Interstate 70 (westbound) when he was struck by V1. D2 told me that he could see V1 approaching behind him in the right lane at a high rate of speed and knew he wasn't going to be able to stop without hitting him. D2 told me that when V1 attempted to change lanes, V2 braked, but due to stopped traffic in that lane, V1 started to jack-knife. D2 told me that is when V1 hit him behind his cab and a fire broke out, engulfing his truck.

D3 stated that he was stopped in the right lane of Interstate 70 (westbound) when he was struck by V2. D3 told me that he was stopped due to traffic trying to merge into the right lane due to the left lane being closed for construction. D3 stated he heard the crash behind him and when he looked in the mirror, he was struck by V2. D3 stated that when he saw the fire break out, he pulled his vehicle forward about 100 feet to avoid being engulfed by fire from the crash behind him.



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Methodology

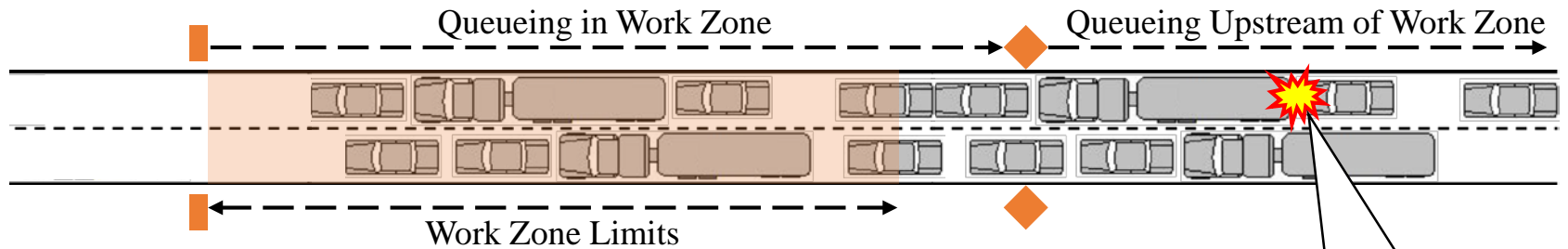
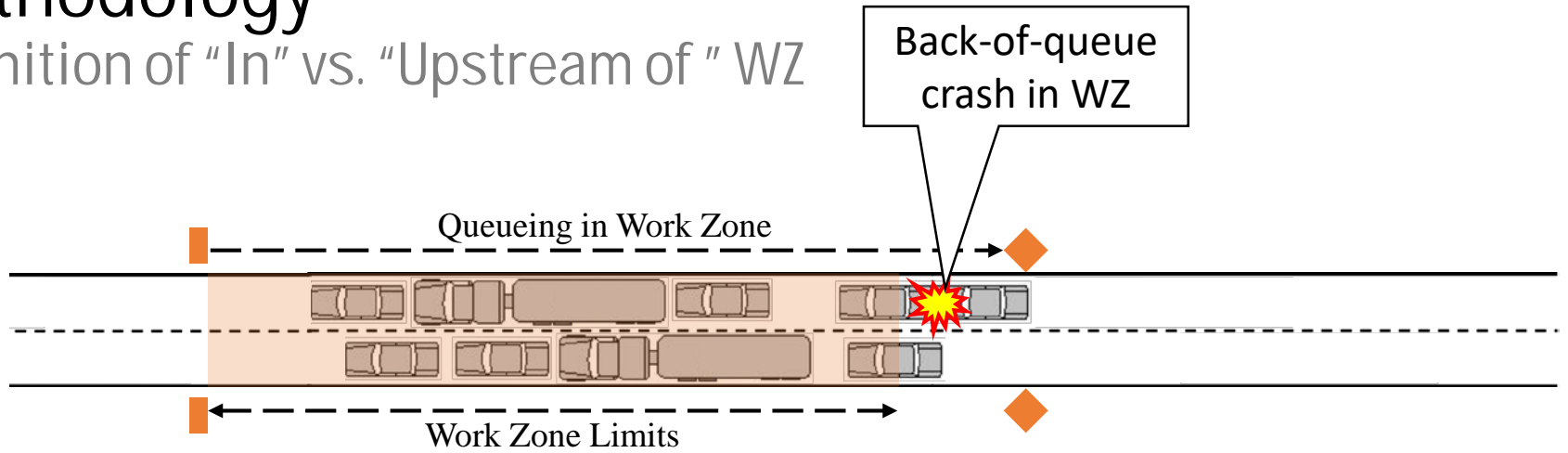
Selected Work Zones

5/15/2017 – 6/18/2017



Methodology

Definition of "In" vs. "Upstream of" WZ

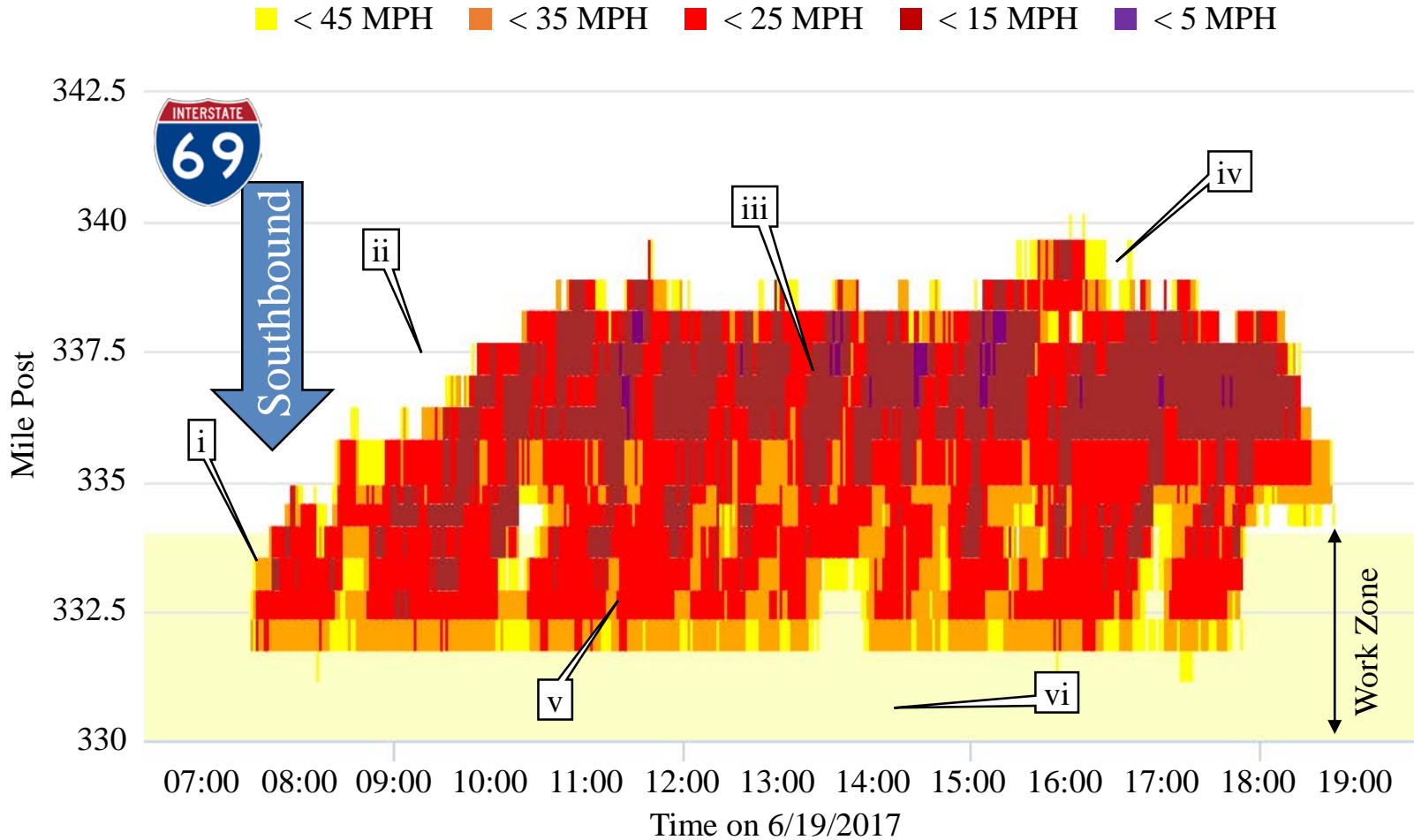


5/15/2017 – 6/18/2017

Back-of-queue crash
upstream of WZ

Methodology

Definition of "In" vs. "Upstream of " WZ



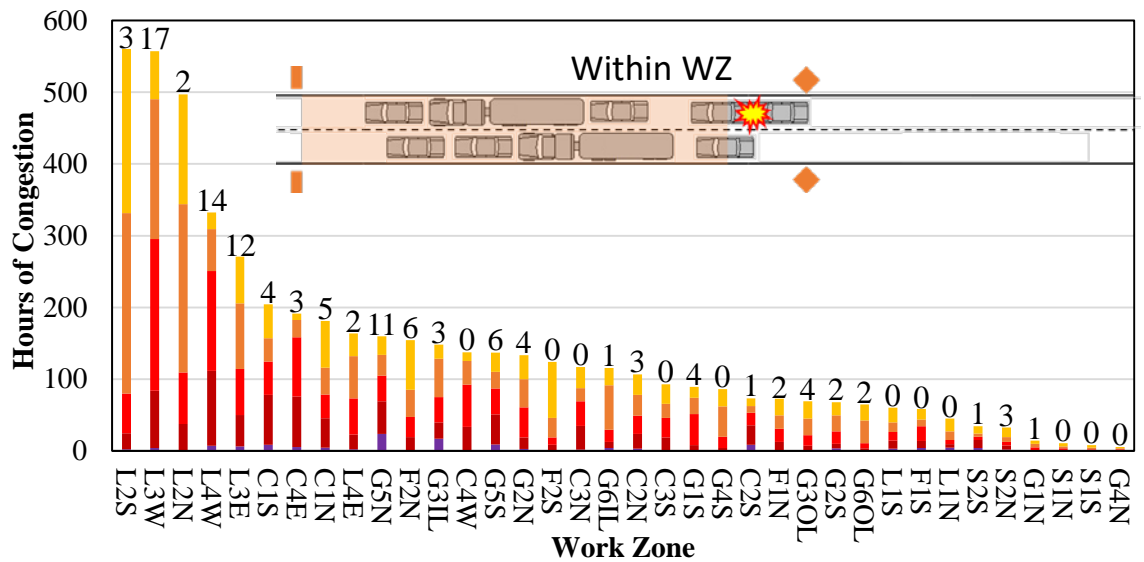
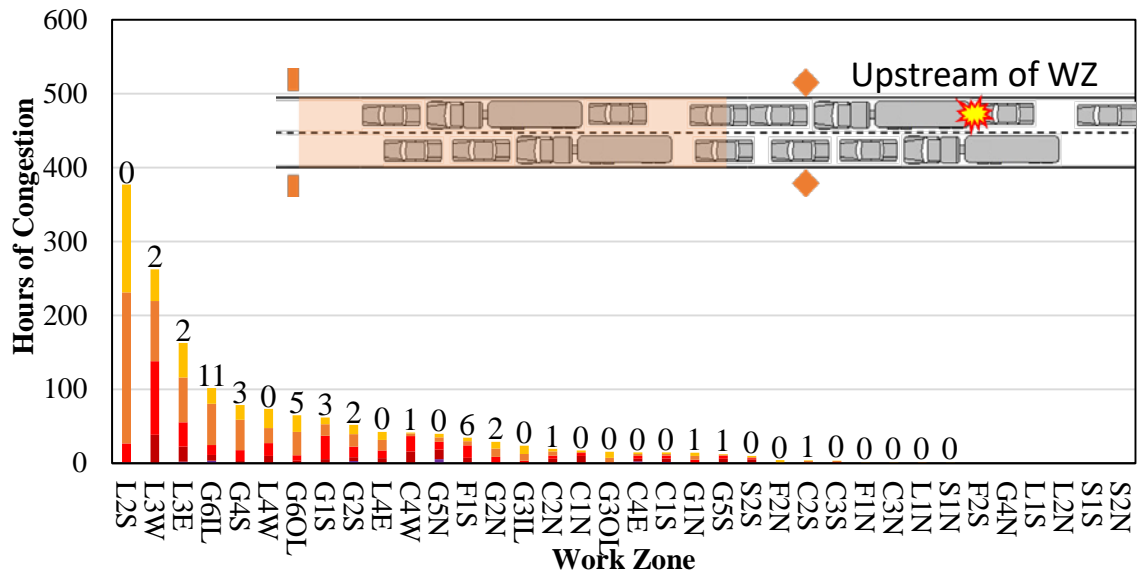
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Crash Rate Analysis

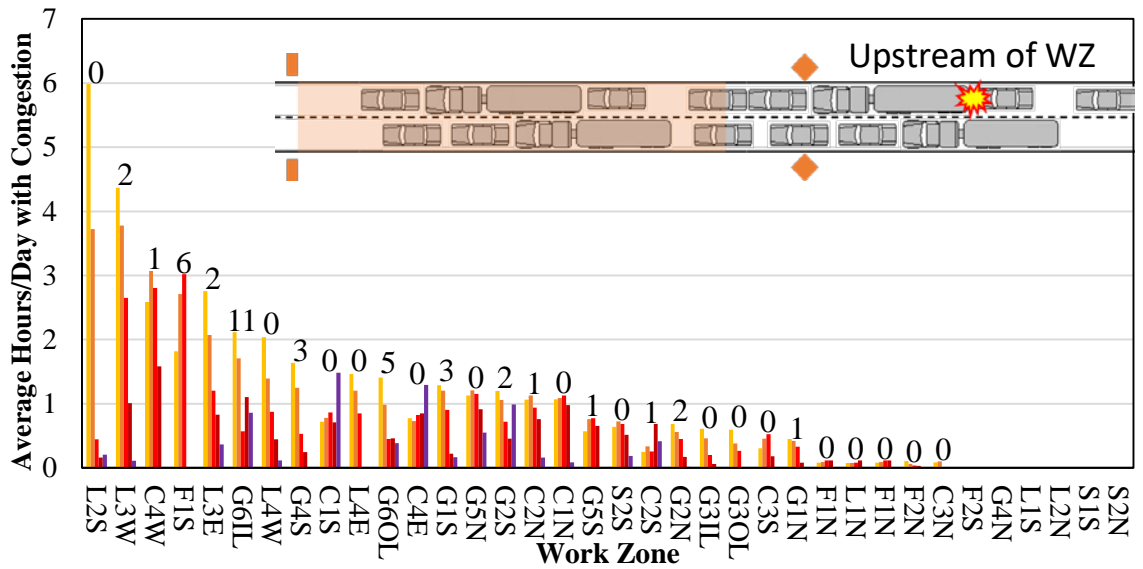
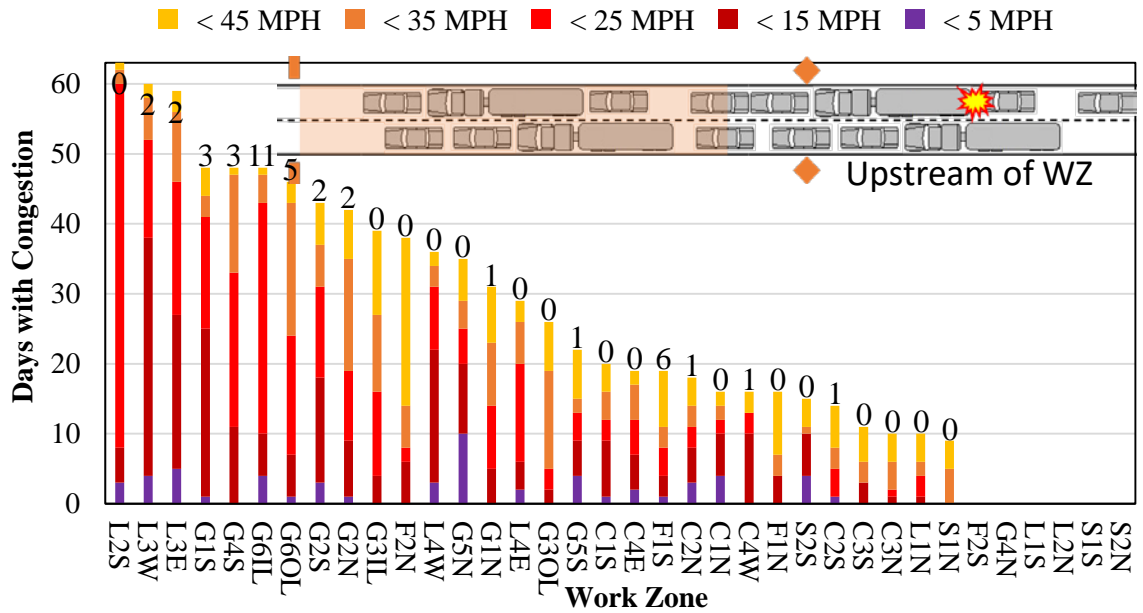
B0Q Crashes vs. Hours of Congestion

■ < 45 MPH
 ■ < 35 MPH
 ■ < 25 MPH
 ■ < 15 MPH
 ■ < 5 MPH



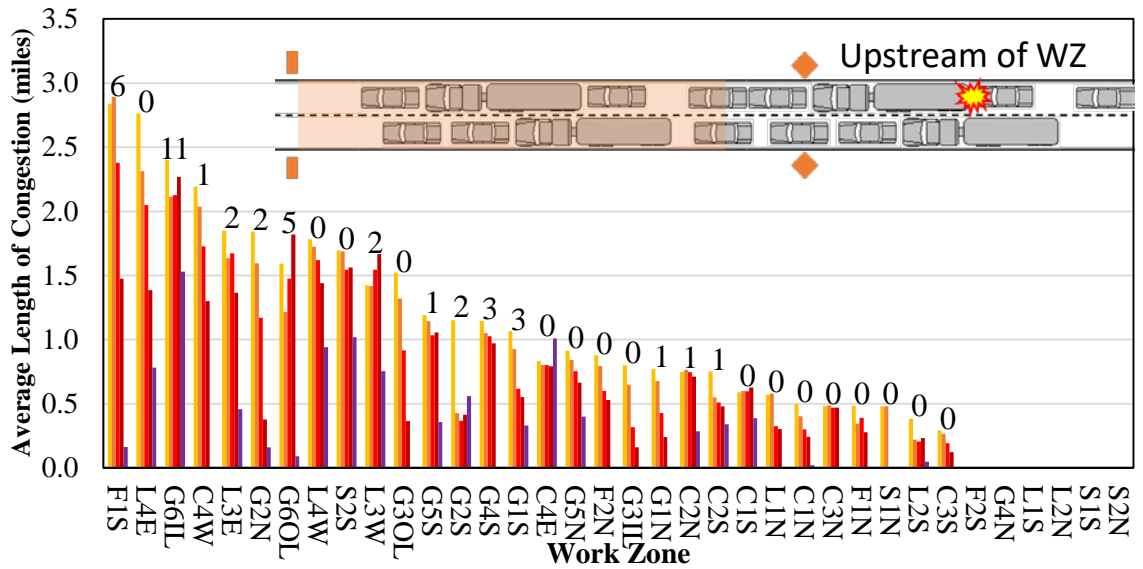
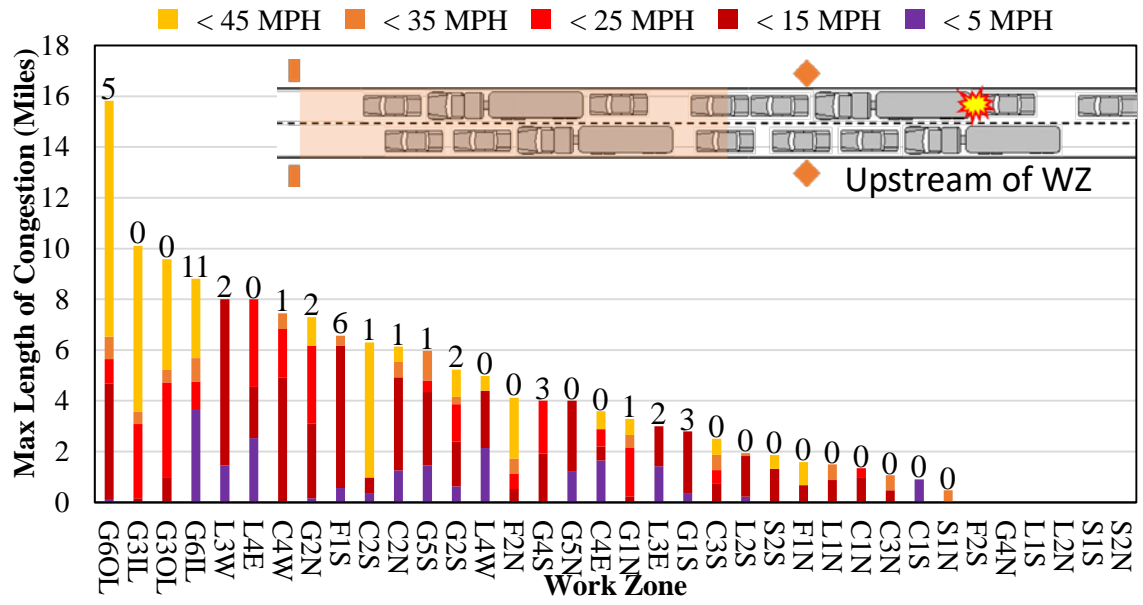
Crash Rate Analysis

B0Q Crashes vs. Days with Congestion



Crash Rate Analysis

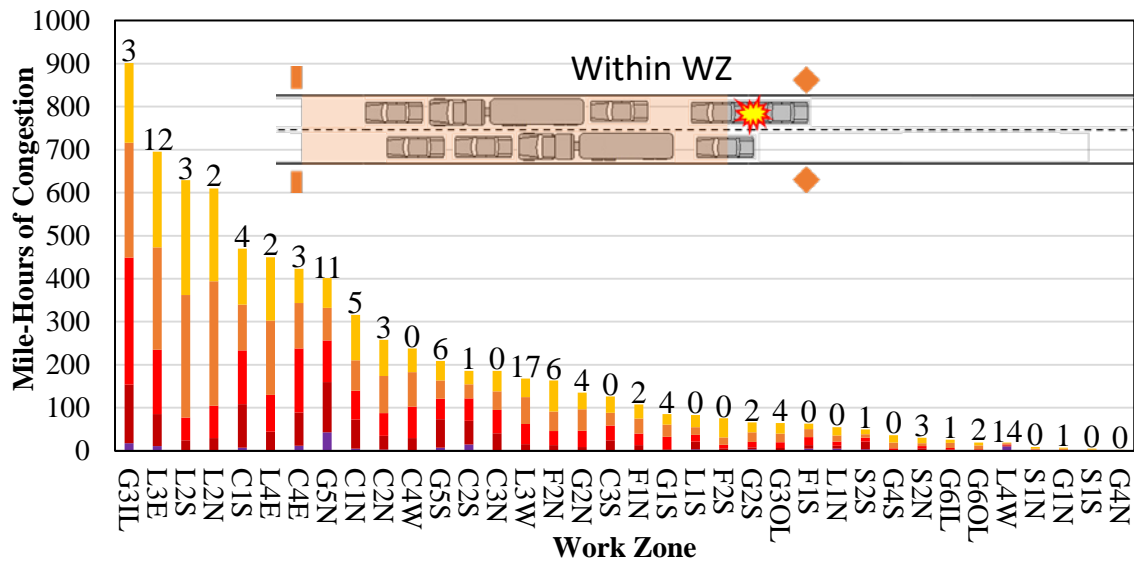
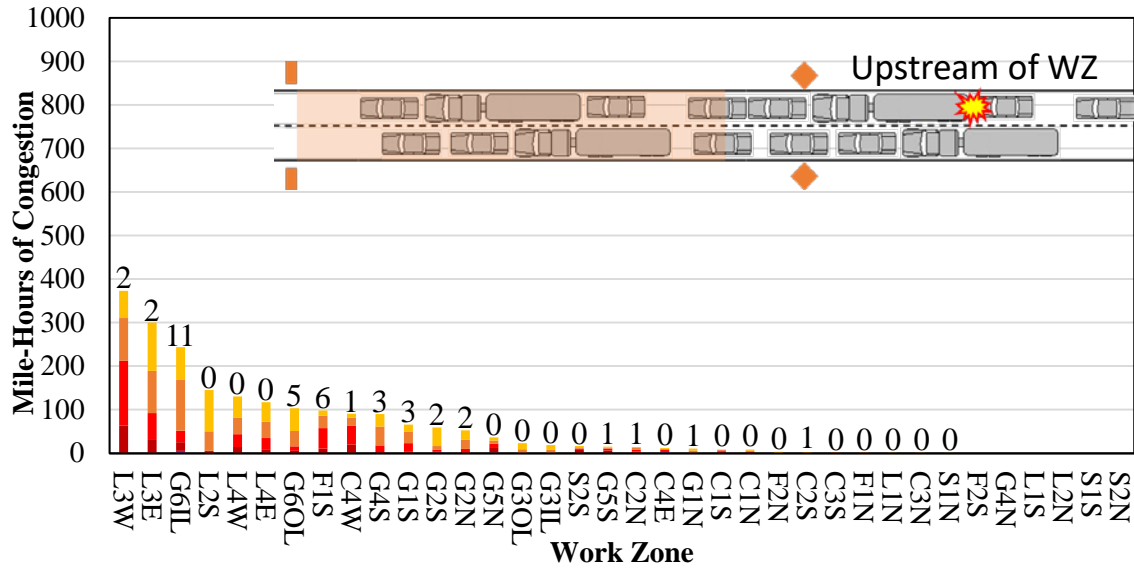
B0Q Crashes vs. Length of Congestion



Crash Rate Analysis

B0Q Crashes vs. Mile-Hours of Congestion

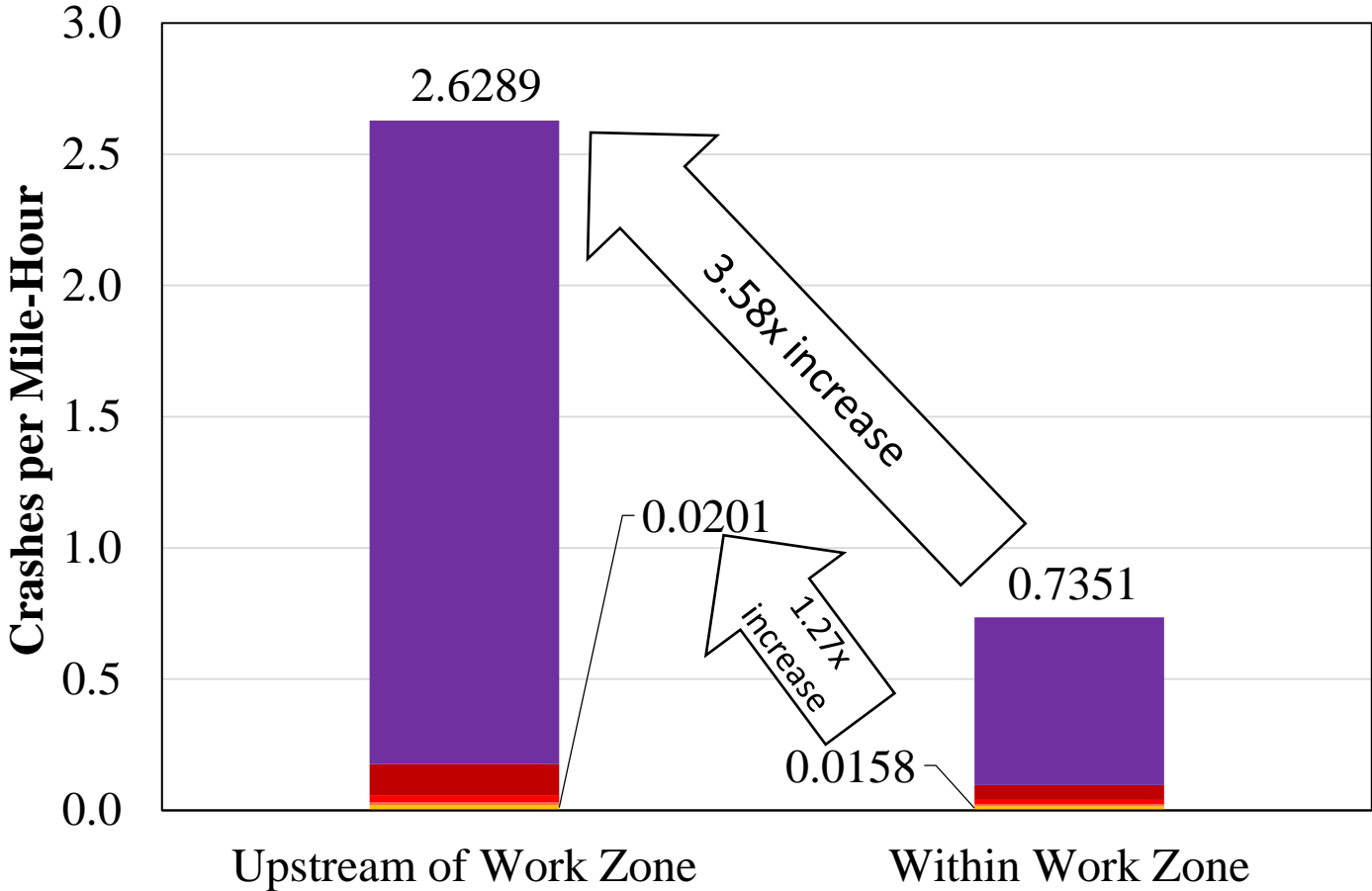
■ < 45 MPH
 ■ < 35 MPH
 ■ < 25 MPH
 ■ < 15 MPH
 ■ < 5 MPH



Crash Rate Analysis

BOQ Crash Rate Comparison

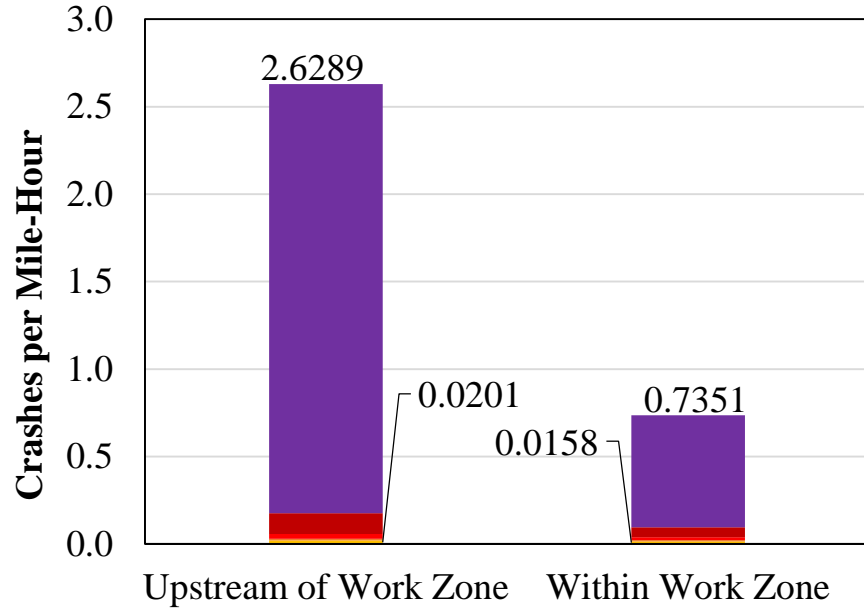
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Conclusions

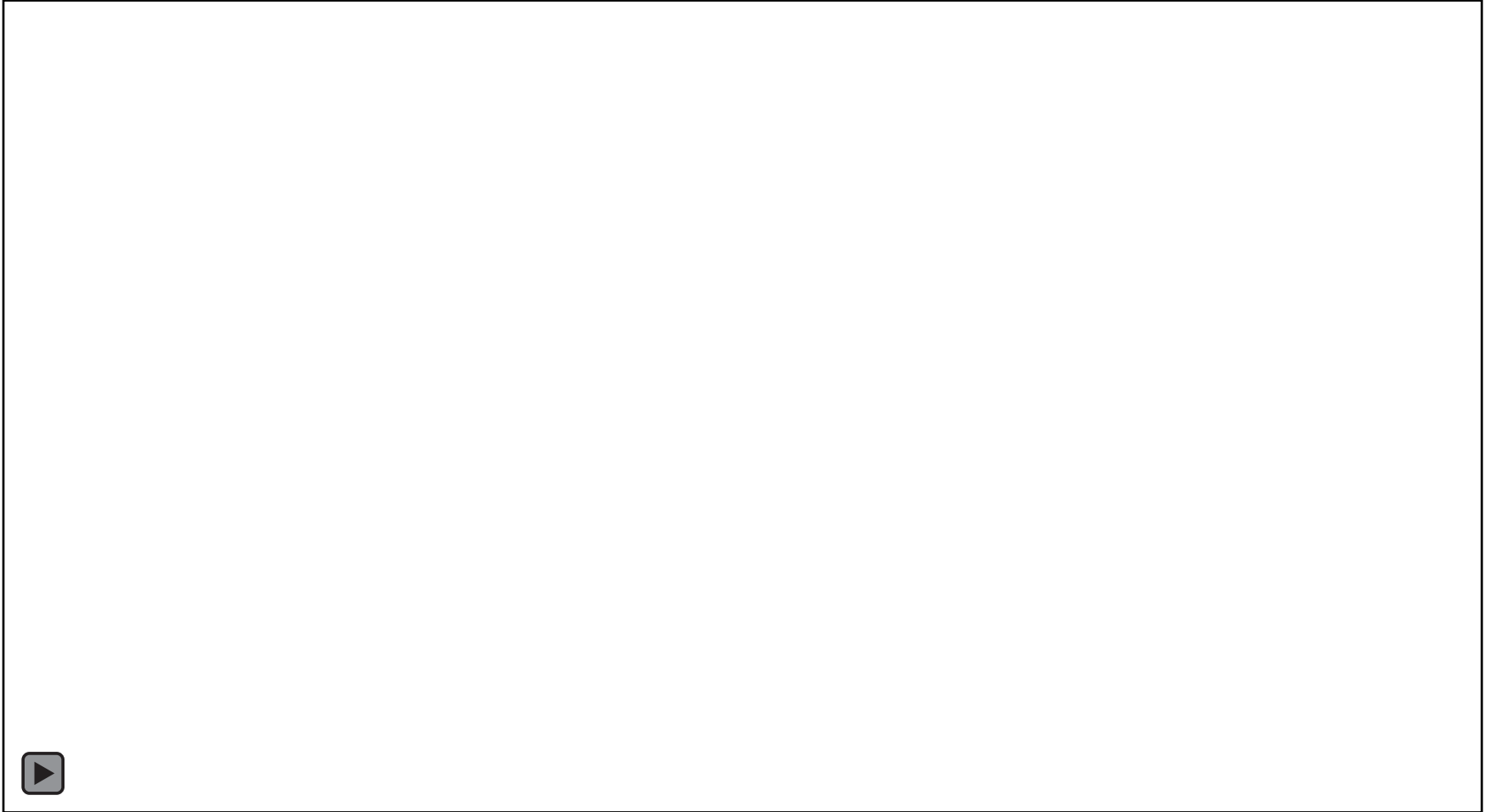


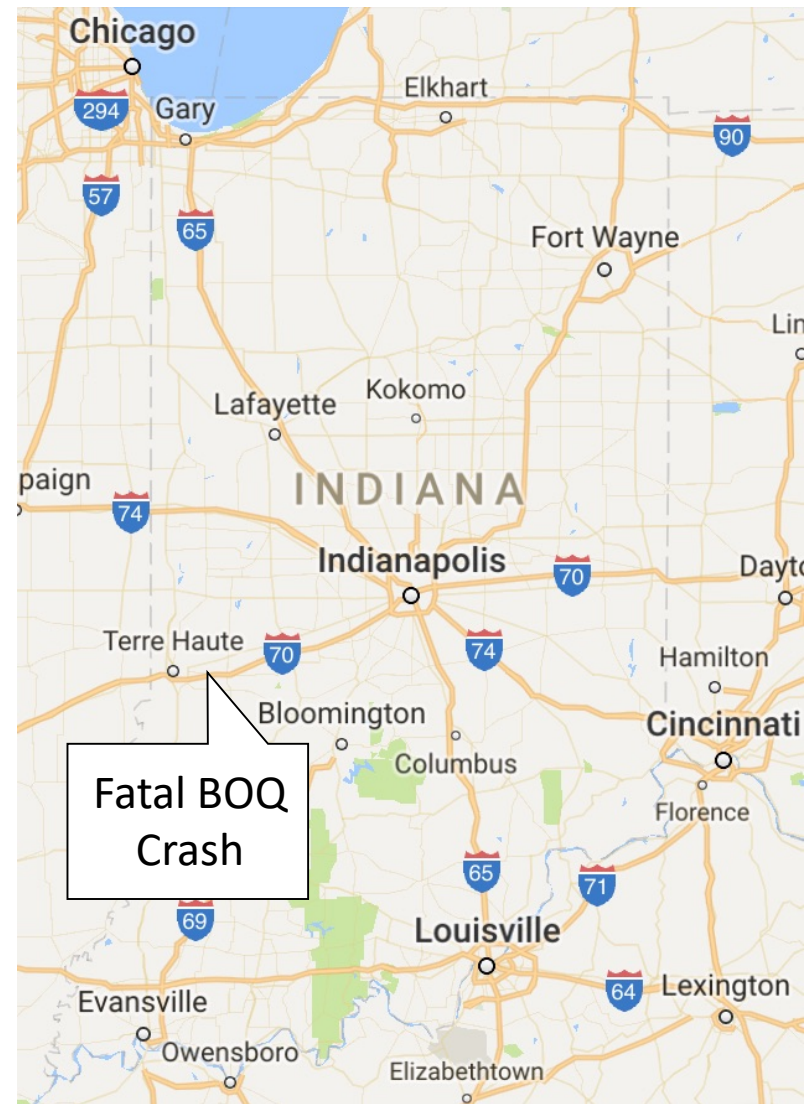
Courtesy of Indiana State Police

■ < 45 MPH ■ < 35 MPH ■ < 25 MPH ■ < 15 MPH ■ < 5 MPH



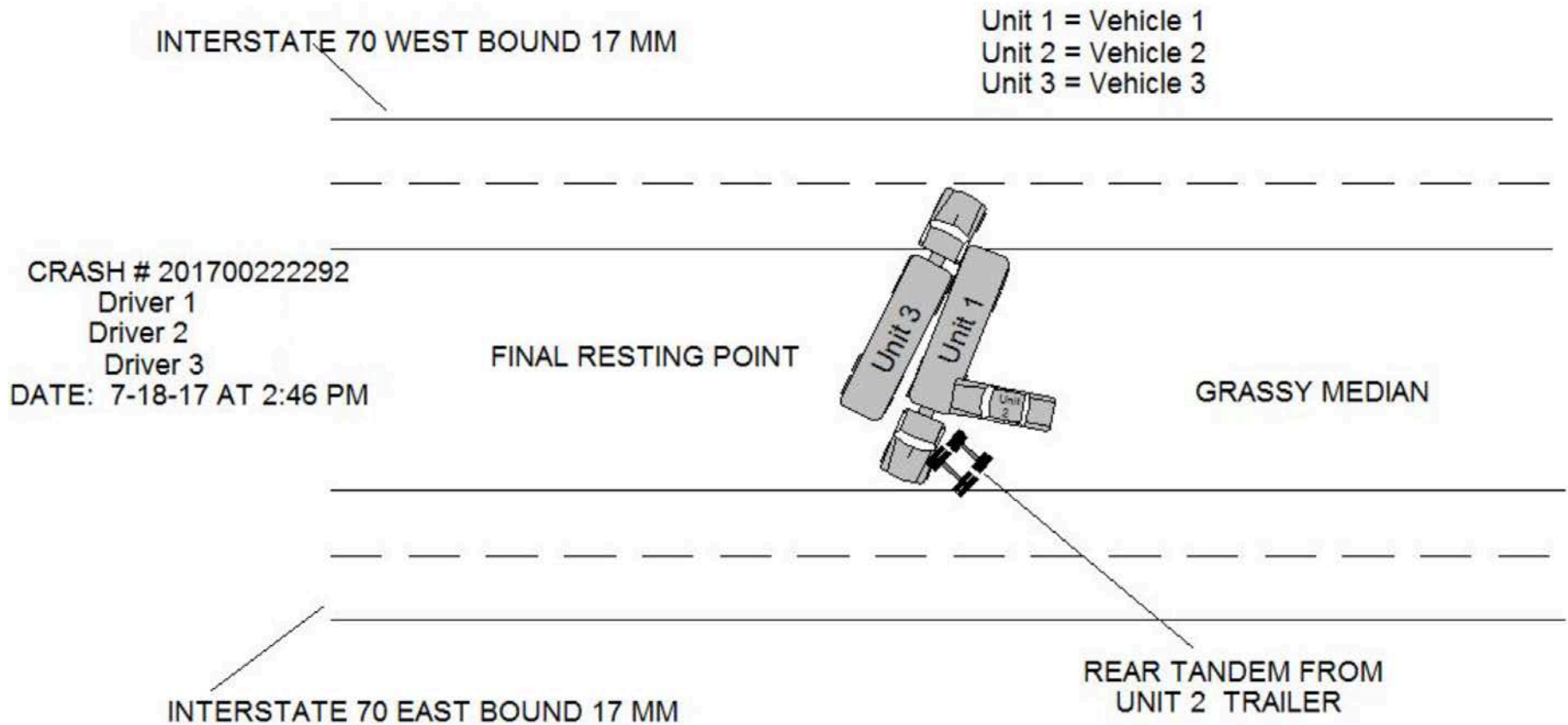
We can and should do something about this...





July 18th, 2017: Fatal crash near MM 16 along I-70 W

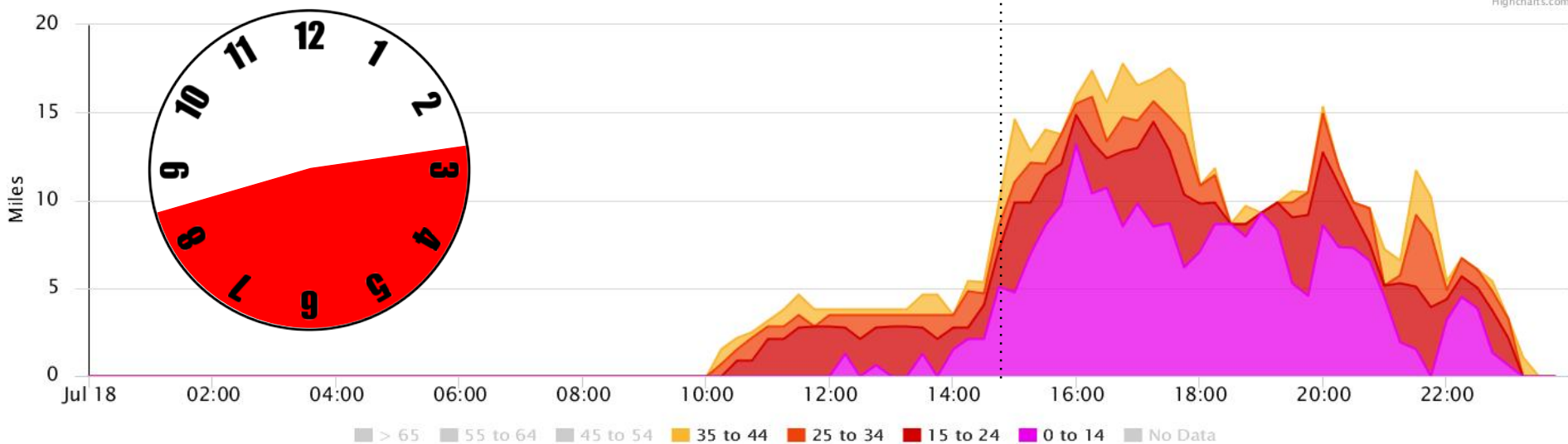
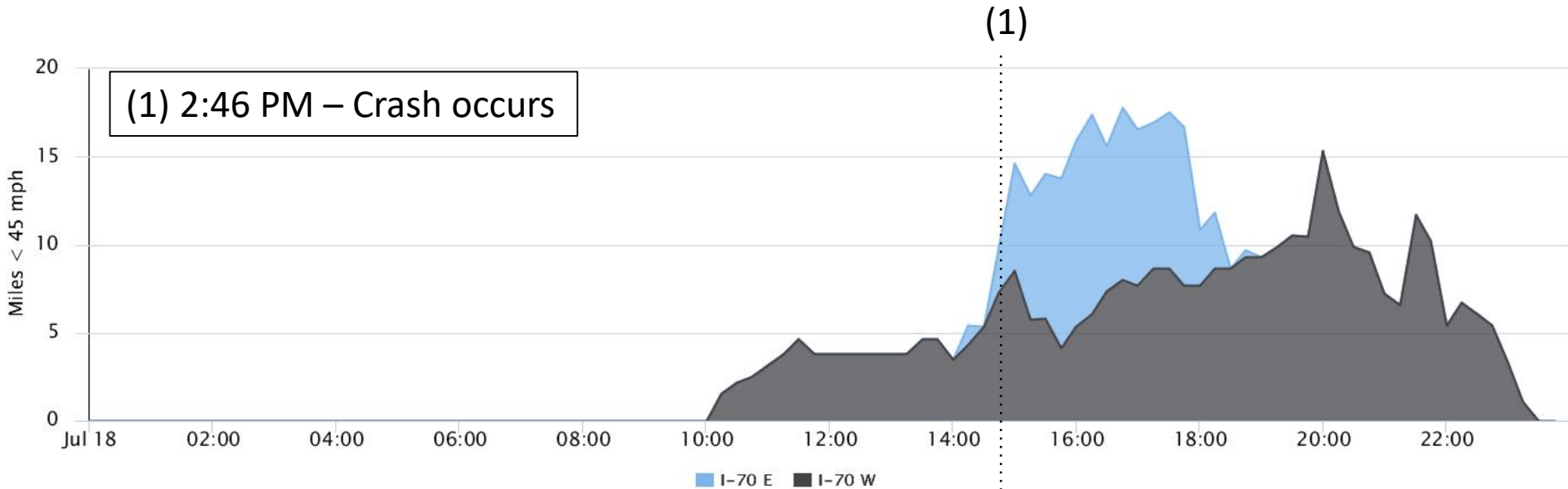
Crash Diagram



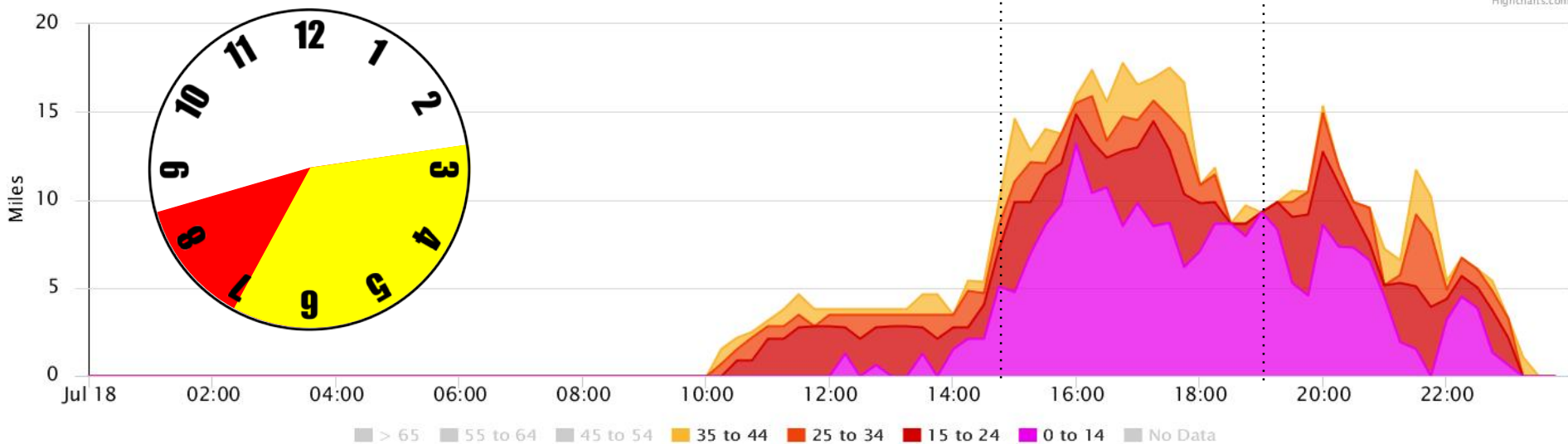
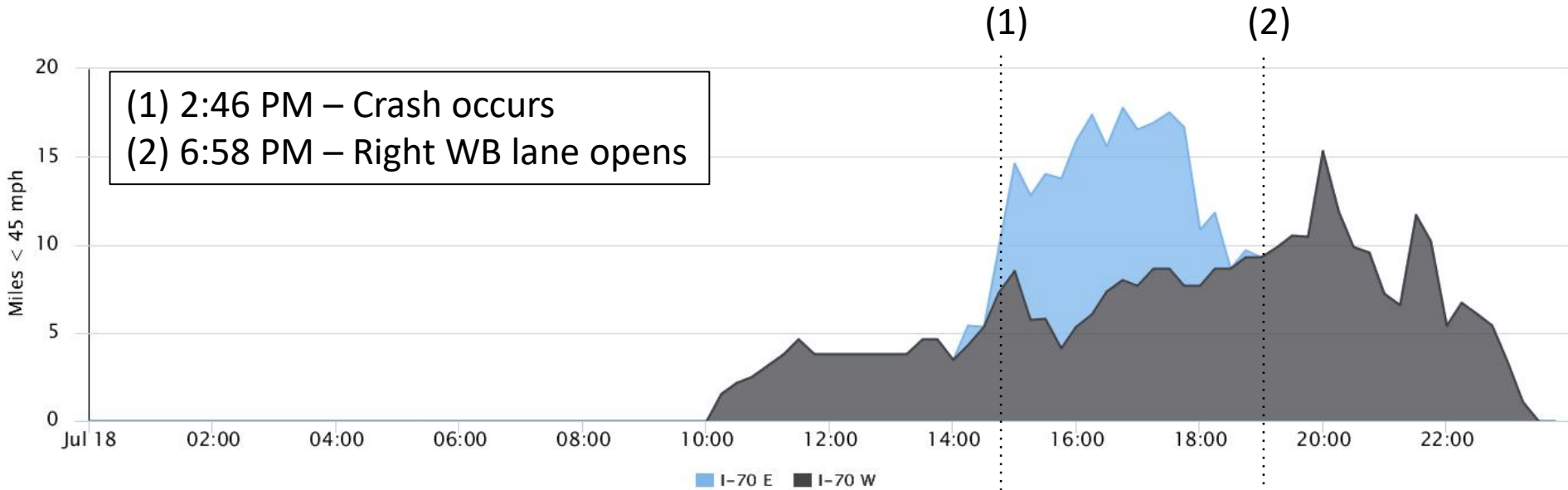
// live traffic data was accessible on vehicle dashboards, this crash may have *never* happened...



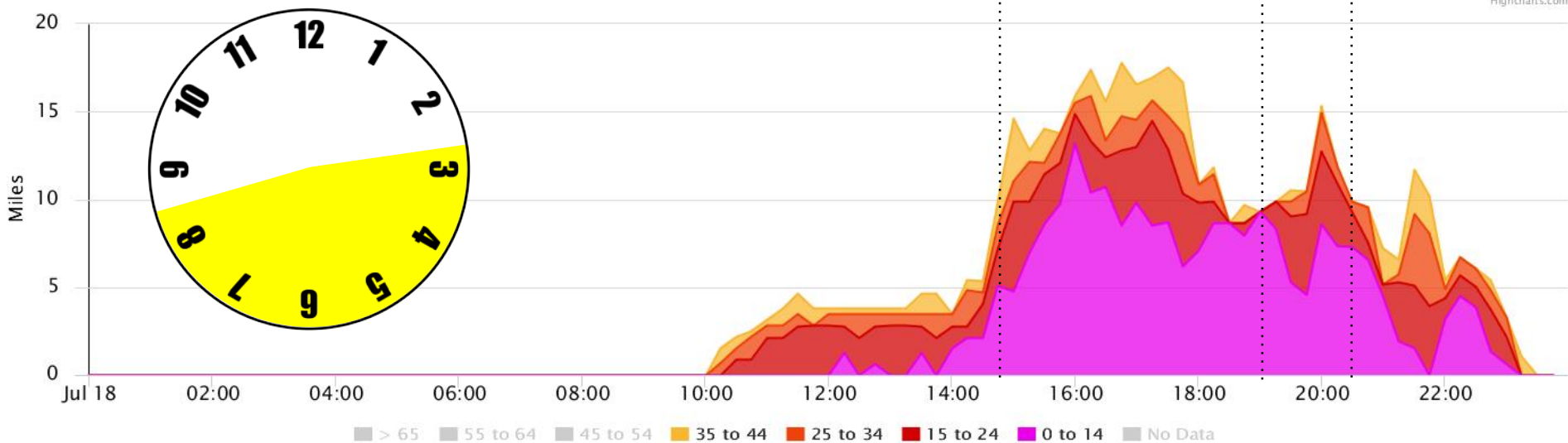
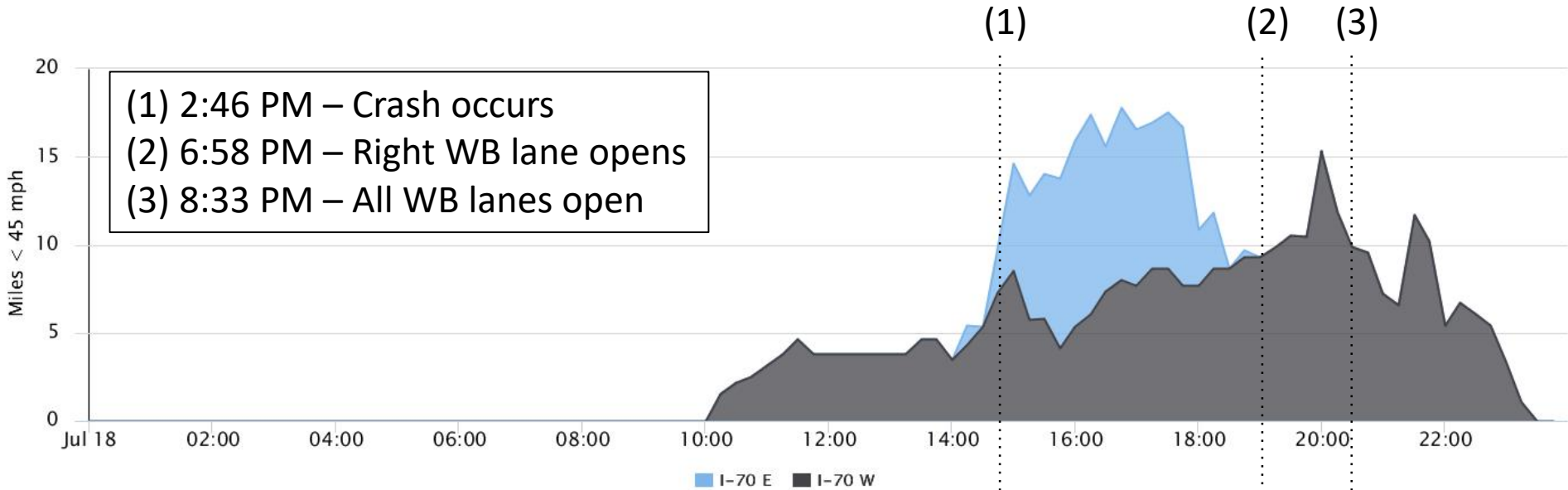
Congestion summary for I-70 W and E (speed < 45 MPH)



Congestion summary for I-70 W and E (speed < 45 MPH)

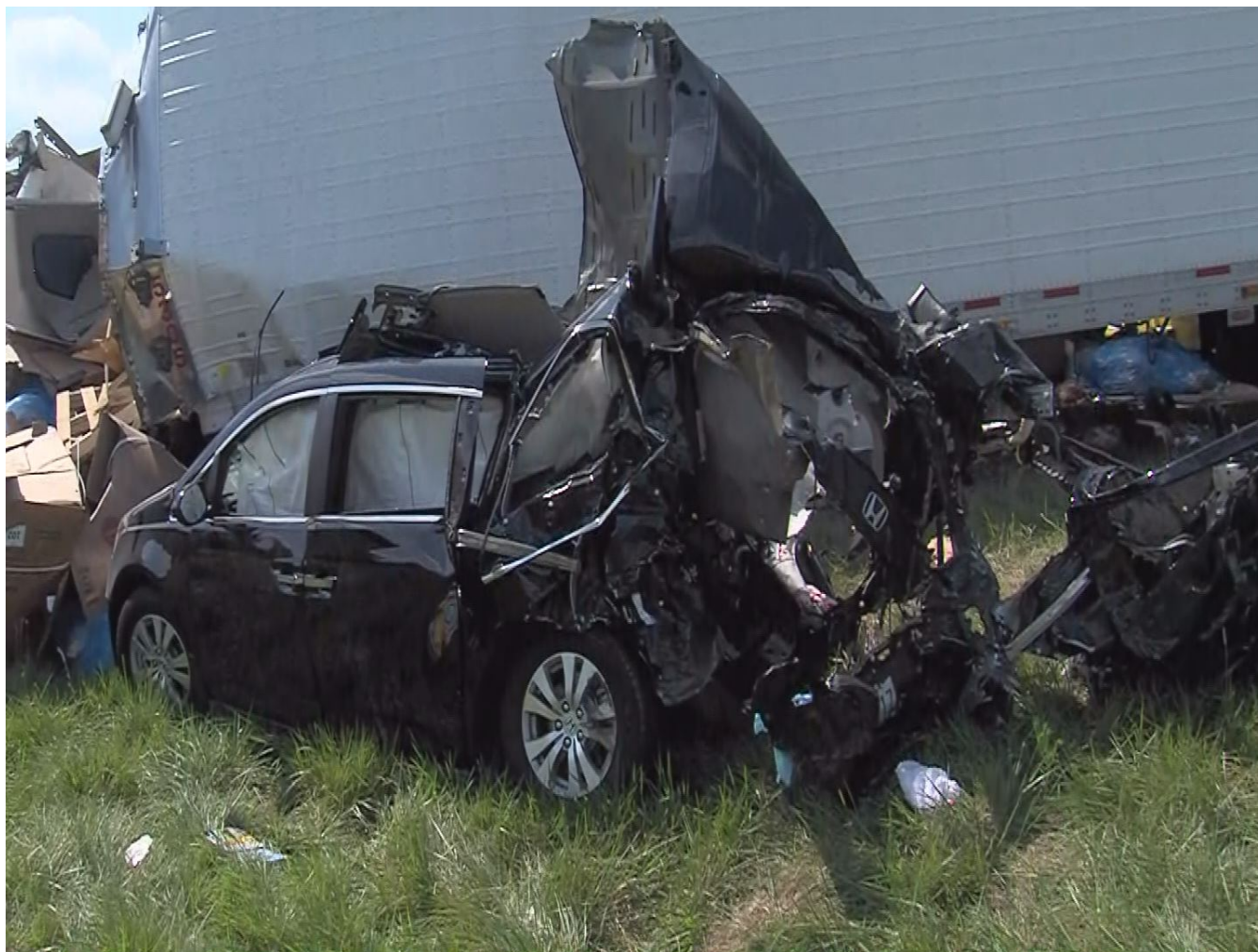


Congestion summary for I-70 W and E (speed < 45 MPH)



In conclusion...

With the addition of connected vehicle dashboards,

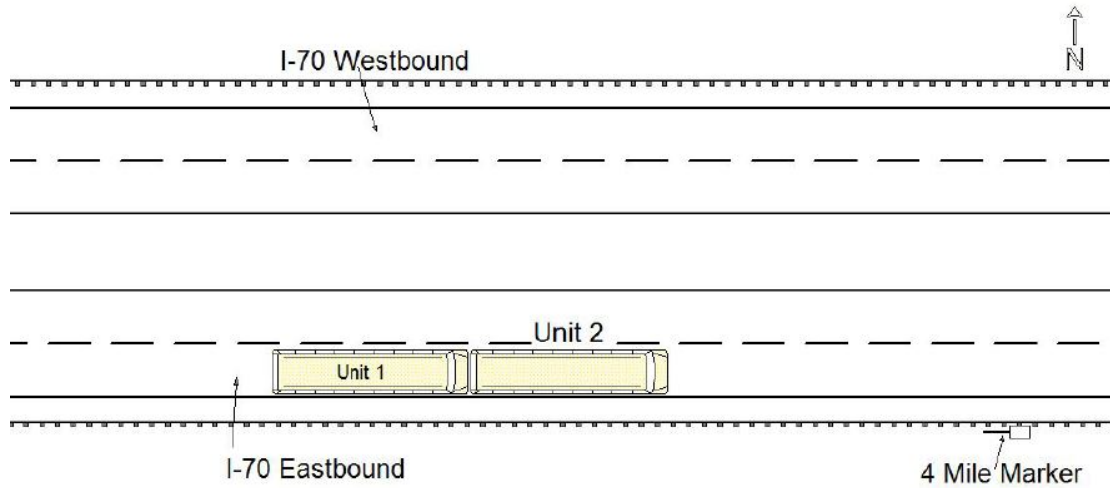


Crashes like this can be prevented.



I-70 EB at MM 4

10/01/2017





INDIANA OFFICER'S STANDARD CRASH REPORT

Electronic Version

Page

1

of

4

903008178

Local ID

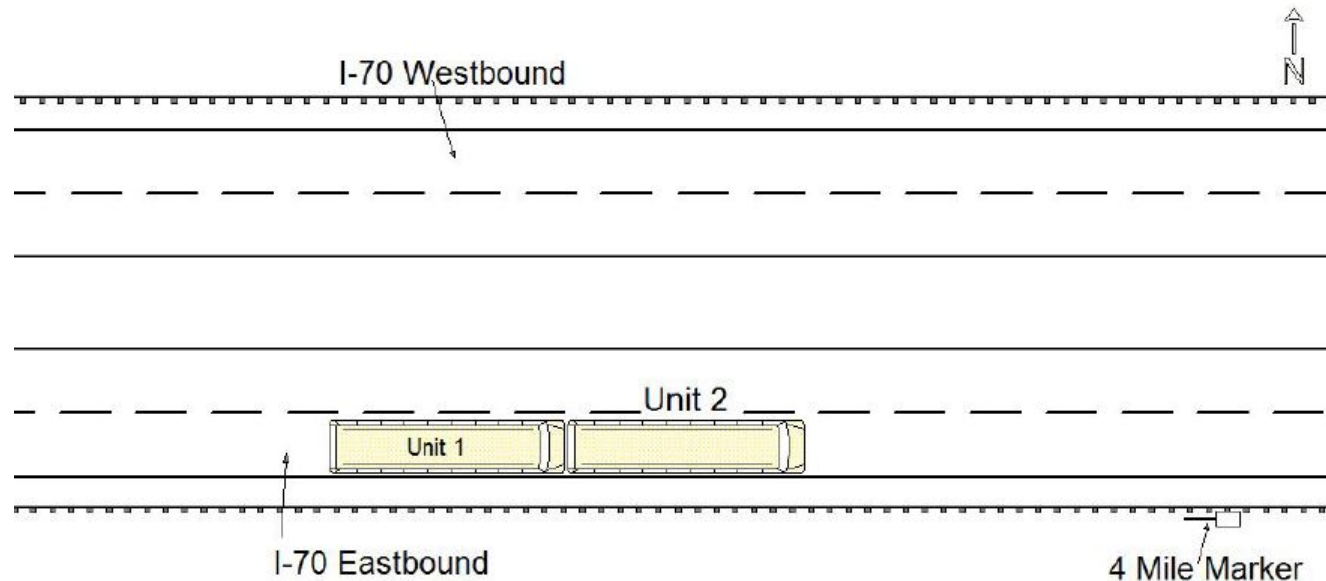
201700108247

Date of Crash	Day of Week	Actual Local Time	County	Township	# Motor Vehicles	# Injured	# Dead	# Commercial Vehicles	# Deer
10/01/2017	Sun	6:45 PM	VIGO	SUGAR CREEK	2	0	0	2	0
Road Crash Occurred On			Nearest/Intersecting Road/MileMarker/Interchange		If not an intersection, number of feet from	Direction	Road Classification		
I70E			4		100	W	INTERSTATE		
Inside Corporate Limits?	City/Town or Nearest City/Town			Property?		Crash Latitude		Crash Longitude	
NO	WEST TERRE HAUTE								

Narrative

Unit 1 was traveling eastbound on Interstate 70 near the 4 mile marker. Driver 1 said that he saw traffic stop but was not able to stop fast enough to avoid hitting the school bus in front of him.

Unit 2 was traveling eastbound on Interstate 70 near the 4 mile marker. Driver 2 said a car stopped in front of him and slammed on his brakes, then the other bus following him hit him in the rear end.



Route Builder

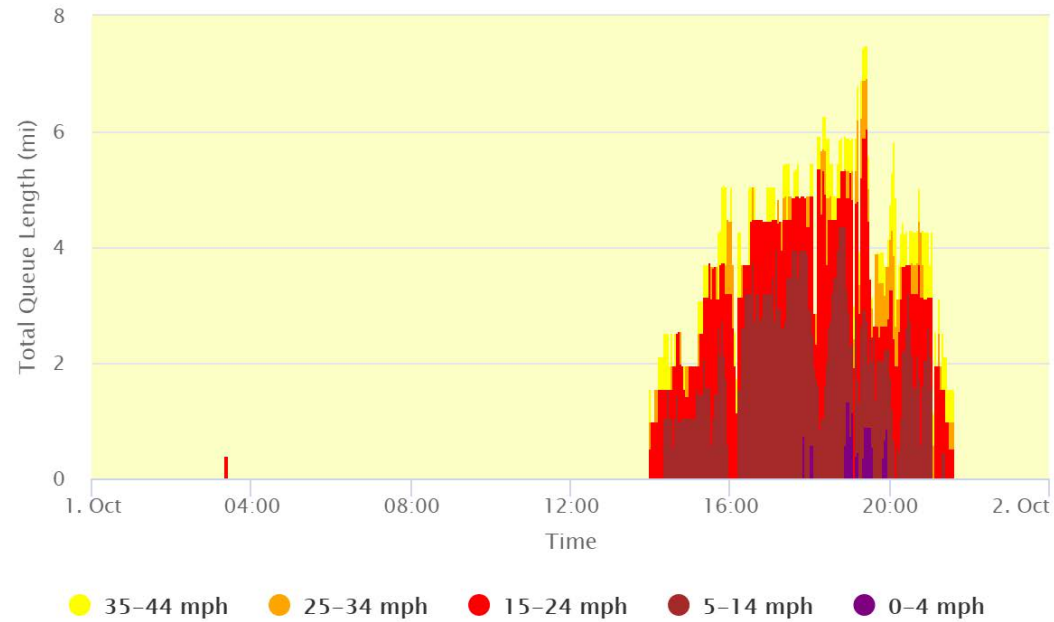
10/01/2017

MM 0-10

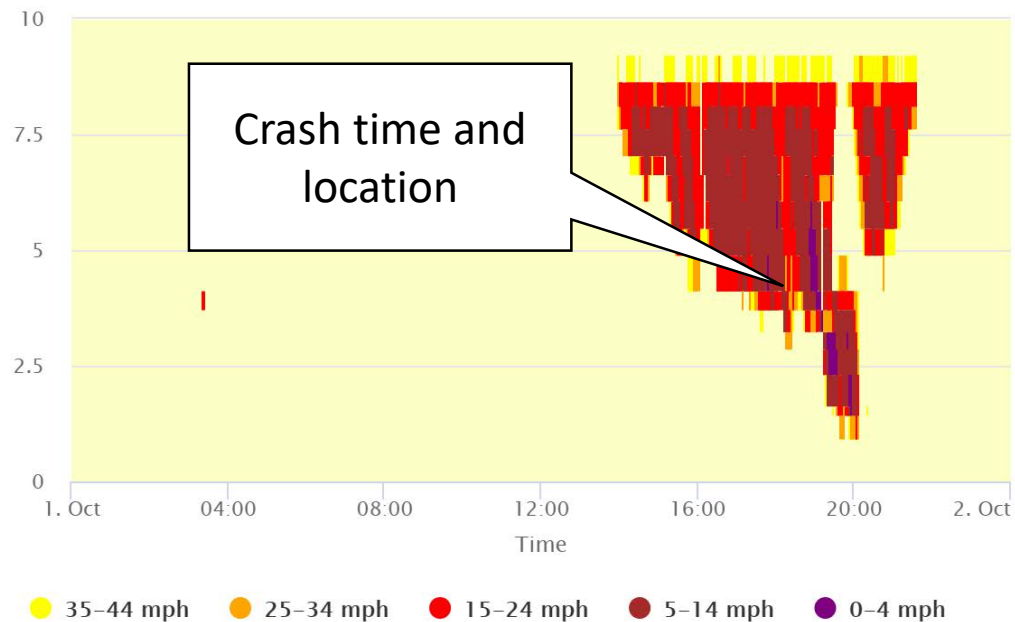
The queue was caused by construction around MM 9, with the maximum queue length being between 7 and 8 miles long



Total Queue Length over Area of Analysis vs. Time



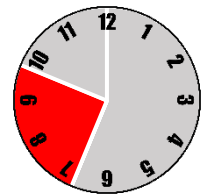
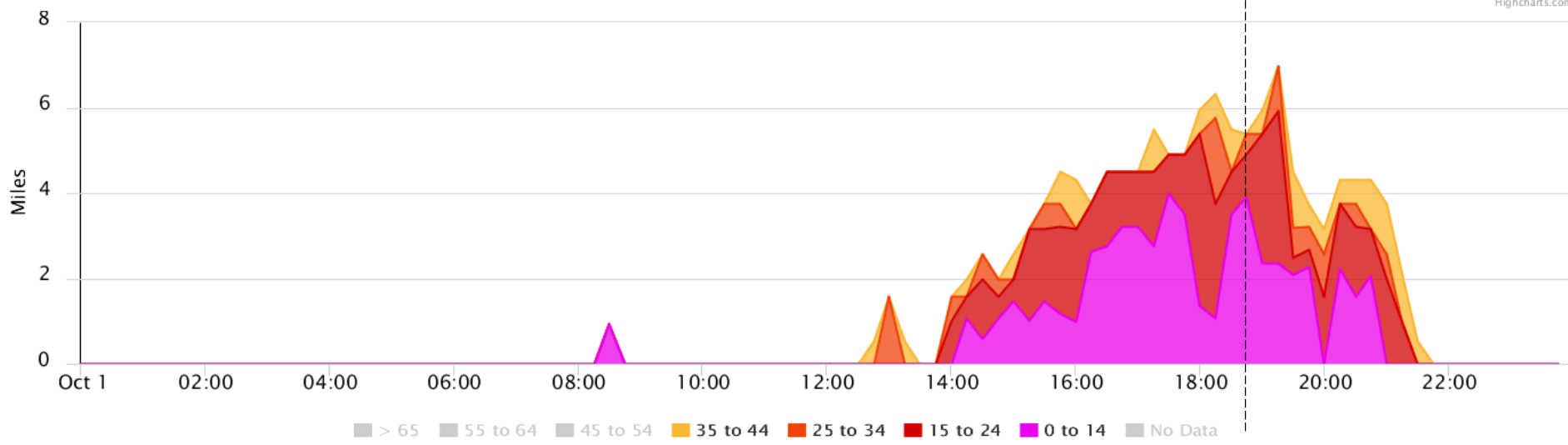
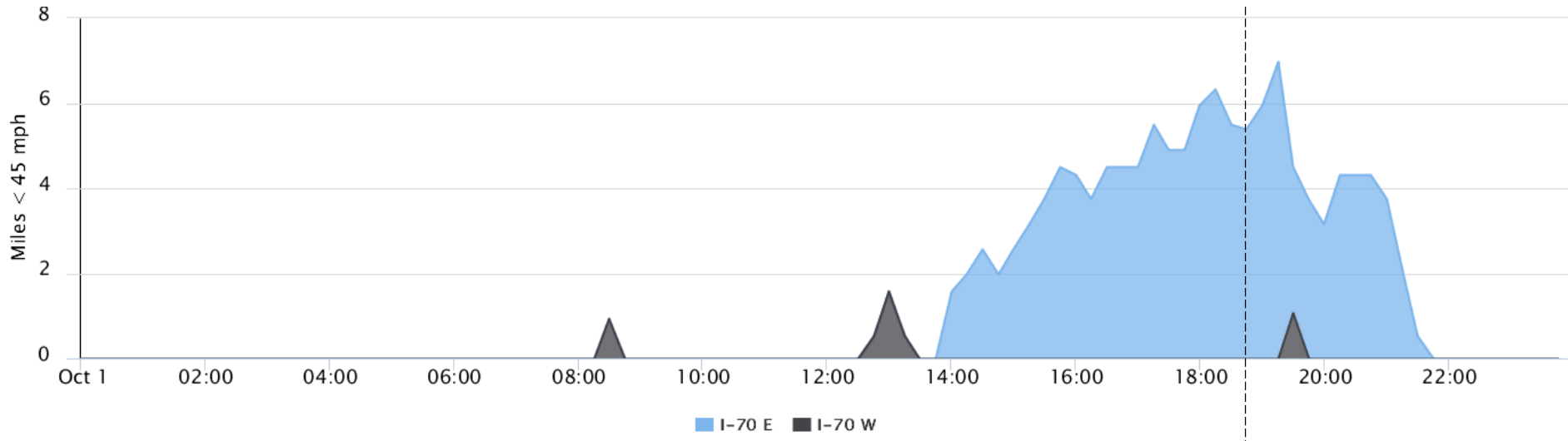
Queues by Mile Marker vs. Time



Highcharts.com

Highcharts.com

BOQ incident occurs at 18:45





Back-of-Queue Crash: Semi Fire on I-70 W

10/22/2016 @ 14:00

I-70 W @ MM 19



Courtesy of Indiana State Police

Date of Crash	Day of Week	Actual Local Time	County	Township	# Motor Vehicles	# Injured	# Dead	# Commercial Vehicles	# Deer
10/22/2016	Sat	2:00 PM	CLAY	POSEY	3	1	0	3	0
Road Crash Occurred On			Nearest/Intersecting Road/Mile Marker/Interchange		If not an intersection, number of feet from	Direction			
I70			19.5		500	E			
Inside Corporate Limits?	City/Town or Nearest City/Town			Property?	Crash Latitude				
NO	BRAZIL			OTHER					

Narrative

D1 stated that he was driving in the right lane of Interstate 70 (westbound), at approximately the 19 mile marker when he struck V2 that was stopped due to a back-up of traffic trying to merge into the right lane due to the left lane being closed for construction.

D1 stated that he was driving in the right lane looking down, reaching for a drink when he looked back up and saw that V2 was stopped. D1 told me that he merged into the left lane and saw that traffic in that lane was also stopped. D1 continued to say that when he applied his brakes, his trailer started to jack-knife and he then hit V2, just behind the cab in the area of the fuel tanks. D1 stated that a fire started between the two trucks and he exited his vehicle when it caught fire.

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The only visual damage done to V3 was to the crash bar on the trailer. It was bent forward. D3 was released and he went to the Pilot station where he met his company representatives.

D1 was taken by ambulance to Terre Haute Regional Hospital for his injuries. Trooper Ted Robertson was present when D1's toxicology screen came back negative.

There was severe damage done to a 100' X 30' section of Interstate 70 where both trucks were completely destroyed by fire. An INDOT supervisor was present to open the roadway to traffic, but the asphalt must be replaced.



Cable Barrier

