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
Motivation
Back-of-Queue Crash Nov. 13, 2015

Exit 137 to SR 1 and US 40
Motivation

Back-of-Queue Crash Nov. 13, 2015

Exit 137 to SR 1 and US 40

Time of Crash

Westbound

MM 124 – Work Zone

MM 127 – Crash Location
Motivation
Back-of-Queue Crash Nov. 13, 2015

Friday
November 13

Westbound

Time of Crash

Direction of Travel

Exit 123 – IN-3

MM 127

Exit 131 – Wilbur Wright Rd

Exit 137 – IN-1

<=10 mph
10 - 20 mph
20 - 40 mph
40 - 60 mph
>60 mph

Friday
November 13
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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

63% of fatal back-of-queue crashes had a queue duration of > 60 minutes

Date of Fatal Crash Involving a Queue
Duration of Queue in Data Prior to Fatal crash (minutes)
Statewide Back-of-Queue Crashes
Congested vs. Uncongested Crash Rates, 2014-2015

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

24.1x 20.6x
Statewide Back-of-Queue Crashes
Congested vs. Construction Crashes, 2014-2015

Construction: 3079
No Construction: 27082

Congestion: 5594
No Congestion: 24567

Construction Crashes: n = 3079
Congestion Crashes: m = 5594
Construction and Congestion Crashes: x = 763
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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

<table>
<thead>
<tr>
<th>Time</th>
<th>Speed</th>
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<tbody>
<tr>
<td>17:30</td>
<td>67</td>
</tr>
<tr>
<td>17:31</td>
<td>67</td>
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<td>17:32</td>
<td>67</td>
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<td>17:33</td>
<td>66</td>
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<td>17:35</td>
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<td>17:41</td>
<td>68</td>
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<td>68</td>
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<td>17:43</td>
<td>67</td>
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<tr>
<td>17:44</td>
<td>67</td>
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</table>

Median: 68 mph
Data Sources
Crowd Sourced Probe Vehicle Data

Time on 6/19/2017

Mile Post

330 335 340 342.5

332.5

337.5

INTERSTATE
69

Southbound

Work Zone

< 45 MPH  < 35 MPH  < 25 MPH  < 15 MPH  < 5 MPH
Data Sources
Crash Data

<table>
<thead>
<tr>
<th>Date of Crash</th>
<th>Day of Week</th>
<th>Actual Local Time</th>
<th>County</th>
<th>Township</th>
<th># Motor Vehicles</th>
<th># Injured</th>
<th># Dead</th>
<th># Commercial Vehicles</th>
<th># Deer</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/22/2016</td>
<td>Sat</td>
<td>2:00 PM</td>
<td>CLAY</td>
<td>POSEY</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
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</table>

Road Crash Occurred On
I-70

Nearest/Intersecting Road/Mile Marker/Interchange
19.5

If not an intersection, number of feet from
500

Direction
E

Road Classification
INTERSTATE

Inside Corporate Limits?
NO

City/Town or Nearest City/Town
BRAZIL

Property?
OTHER

Crash Latitude

Crash Longitude

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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.
Outline

- Motivation
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- Methodology
- Crash Rate Analysis
- Conclusions
Methodology
Selected Work Zones

5/15/2017 – 6/18/2017
Methodology

Definition of “In” vs. “Upstream of” WZ

5/15/2017 – 6/18/2017
Methodology
Definition of “In” vs. “Upstream of ” WZ
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Crash Rate Analysis
BOQ Crashes vs. Hours of Congestion

5/15/2017 – 6/18/2017
Crash Rate Analysis
BOQ Crashes vs. Days with Congestion

Days with Congestion

Average Hours/Day with Congestion

Upstream of WZ

5/15/2017 – 6/18/2017
Crash Rate Analysis
BOQ Crashes vs. Length of Congestion

5/15/2017 – 6/18/2017

Max Length of Congestion (Miles)

Average Length of Congestion (miles)

Upstream of WZ

Upstream of WZ

< 45 MPH  < 35 MPH  < 25 MPH  < 15 MPH  < 5 MPH
Crash Rate Analysis
BOQ Crashes vs. Mile-Hours of Congestion

5/15/2017 – 6/18/2017

Crash Rate Analysis
BOQ Crashes vs. Mile-Hours of Congestion

5/15/2017 – 6/18/2017
Crash Rate Analysis

BOQ Crash Rate Comparison

5/15/2017 – 6/18/2017

Crash Rate Analysis

BOQ Crash Rate Comparison

Upstream of Work Zone Within Work Zone

Crashes per Mile

- < 45 MPH
- < 35 MPH
- < 25 MPH
- < 15 MPH
- < 5 MPH

5/15/2017 – 6/18/2017

Crashes per Mile-Hour

- Upstream of Work Zone: 2.6289
- Within Work Zone: 0.7351

3.58X increase

1.7X increase

0.0201

0.0158

Crashes per Mile-Hour

Upstream of Work Zone Within Work Zone
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## Conclusions

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<th>Within Work Zone</th>
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<td>Crashes per Mile-Hour</td>
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<td>0.7351</td>
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- **< 45 MPH**
- **< 35 MPH**
- **< 25 MPH**
- **< 15 MPH**
- **< 5 MPH**

![Crashes per Mile-Hour](image)

*Courtesy of Indiana State Police*
We can and should do something about this…
July 18th, 2017: Fatal crash near MM 16 along I-70 W
Crash Diagram

INTERSTATE 70 WEST BOUND 17 MM

Unit 1 = Vehicle 1
Unit 2 = Vehicle 2
Unit 3 = Vehicle 3

CRASH # 201700222292
Driver 1
Driver 2
Driver 3
DATE: 7-18-17 AT 2:46 PM

FINAL RESTING POINT

INTERSTATE 70 EAST BOUND 17 MM

UNIT 3

UNIT 1

REAR TANDEM FROM UNIT 2 TRAILER

GRASSY MEDIAN
If 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)

(1) 2:46 PM – Crash occurs
Congestion summary for I-70 W and E (speed < 45 MPH)

(1) 2:46 PM – Crash occurs
(2) 6:58 PM – Right WB lane opens
(1) 2:46 PM – Crash occurs  
(2) 6:58 PM – Right WB lane opens  
(3) 8:33 PM – All WB lanes open
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**

**Date of Crash**: 10/01/2017  
**Day of Week**: Sun  
**Actual Local Time**: 6:45 PM  
**County**: VIGO  
**Township**: SUGAR CREEK  
**# Motor Vehicles**: 2  
**# Injured**: 0  
**# Dead**: 0  
**# Commercial Vehicles**: 2  
**# Deer**: 0

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<th>If not an intersection, number of feet from 100</th>
<th>Direction</th>
<th>Road Classification</th>
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<tbody>
<tr>
<td>170E</td>
<td>4</td>
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<td>W</td>
<td>INTERSTATE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inside Corporate Limits?</th>
<th>City/Town or Nearest City/Town</th>
<th>Property?</th>
<th>Crash Latitude</th>
<th>Crash Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>WEST TERRE HAUTE</td>
<td></td>
<td></td>
<td></td>
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**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.

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![Diagram of the scene](image-url)
The queue was caused by construction around MM 9, with the maximum queue length being between 7 and 8 miles long.
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 wlf1.com
**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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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.

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.
Crash 10:00

I-70 W closed

Detour

Left lane opened

Work zone queue

Saturday 10/22

Sunday 10/23
Exit 11 – US-40 E/IN-46

Exit 23 – IN-59

Mile Marker 19

Mile Marker 15

Exit 11 – US-40 E/IN-46

Saturday, 10/22

Mile Marker 30

Direction of Travel

Detour

I-70 W closed

Left lane opened

Semi fire (PI)

Work zone queue