Transportation Systems Management and Operations Performance Report

3RD EDITION

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TSMO

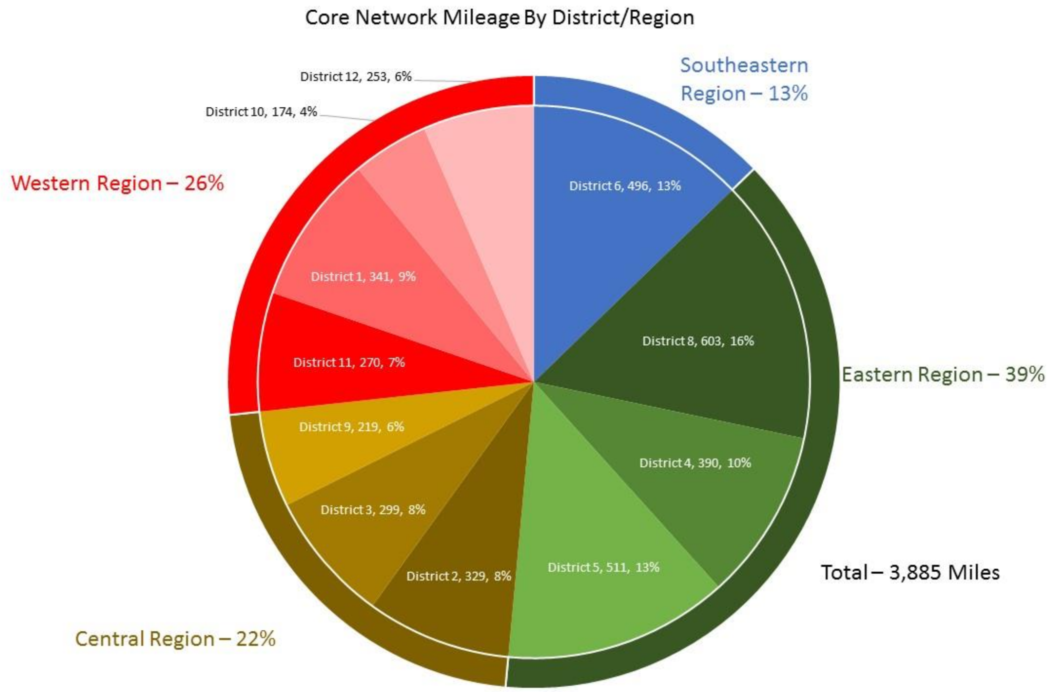




pennsylvania
DEPARTMENT OF TRANSPORTATION

Executive Summary

There were 15,237 reportable crashes on the PennDOT Core Roadway Network[1] in 2017. One third of those crashes, or 5,031, occurred within areas of pre-existed congestion. These crashes led to 30 fatalities and over 3,000 injuries. Traffic Management Centers are focused to improve congestion-related crashes by providing accurate, timely, and relevant information to the motoring public through 511PA alerts, messages on dynamic warning signs, utilization of Traffic Incident Management (TIM) strategies, implementation of freeway service patrols, and coordination between other agencies. The PennDOT Core Roadway Network mileage is broken down by District and Region as shown below:



This 3rd Edition of the TSMO Performance Report is designed to provide information for PennDOT Operations about where and how the Department can evaluate and improve the effectiveness of PennDOT's response to incidents on the Core Roadway Network. This report will evaluate and provide current information regarding the following focus areas:

Table 1: Reportable Crashes by Contributing Congestion Type

- While 47% of the crashes identified are unknown as to the congestion type, 19% were secondary crashes and 23% of secondary crashes occurred in work zones.
- 9% of the crashes were identified as recurring congestion with 63% with of those occurring in the Southeastern (D6) region.

Table 2: Injuries Resulting from Congestion-Related Crashes

- Congestion-related crashes resulted in 30 fatalities and over 3,000 injuries in 2017.

[1] Pennsylvania's "Core Roadway Network" was established in 2011 for 511PA, and includes state owned interstates, limited access roads, and other major routes throughout the Commonwealth (http://www.511pa.com/pdfs/PA511IncidentandFlowNetwork.pdf).

Table 3: Secondary Crashes by District and Region

- 986 secondary crashes occurred statewide in 2017, which is 7% of all crashes.
- 75% of secondary crashes occurred in the Eastern and Southeastern regions.

Table 4: Timing of Secondary Crashes Relative to Primary Crash

- Over 40% of secondary crashes occurred more than 60 minutes after the primary crash.

Table 5: Length of Congestion from Primary Crash to a Secondary Crash

- 46% of secondary crashes occurred more than 2 miles away from the primary crash, and over 20% occurred more than 5 miles away.

Table 6: Work Zone Congestion-Related Crashes by District/Region

- 1,181 congestion-related crashes were in a work zone in 2017.
- 89% of crashes in work zones were captured in RCRS.

Table 7: Distance of Work Zone Congestion-Related Crashes from the Work Zone

- 66% of all work zone crashes and 64% of injuries occurred within a ½ mile of the work zone.

Table 8: Severity of Unidentified Congestion that Contributed to a Crash

- A large number of crashes with unknown congestion (62%) were classified as major, with a significant number of less severe congestion events contributing to crashes.

The Department will continue to evaluate the detailed data and provide recommendations on how to make improvements in these areas. The offices responsible for the operation of the Core Roadway Network will be able to make recommendations as well, after the report is released.

Congestion-Related Crashes on the Core Network

Dangerous slowdowns due to a growing incident queue, work zone, or a recurring bottleneck are known to be a factor in crashes. While it is difficult to determine if each individual incident was directly caused by congestion, the types of crashes that are seen within this dataset are consistent with drivers running into the back of a queue or swerving off the road to avoid stopped or slowed vehicles. 65% of these crashes are rear end collisions, and an additional 19% are instances where a car hit a fixed object. These percentages are consistent with someone failing to appropriately realize the speed reductions ahead of them.

The following pie charts indicate the breakdown of crashes by the contributing cause of congestion. The first chart shows all causes, including those crashes in which the cause of congestion could not be identified. Future efforts will bring in additional data sources, such as weather and planned special event data, to better identify the causes of these congested areas. The second chart shows only those crashes where the cause of the contributing congestion is known. Following those charts is table that breaks these crashes down by the districts and regions in which the occurred.

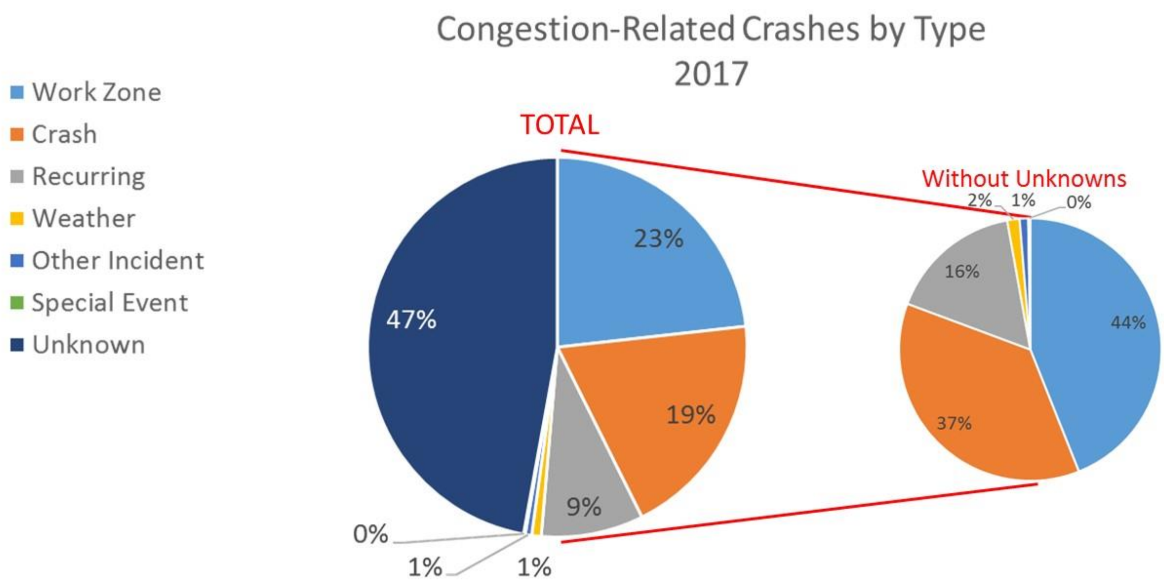


Table 1. Reportable Crashes by Contributing Congestion Type

District/Region	Crash[2]	Workzone[3]	Weather[4]	Special Event[5]	Other[6]	Unknown[7]	Recurring[8]
Southeastern Region (D6)	***385***	***406***	***6***	***7***	***16***	***953***	***277***
Eastern Region	***366***	***485***	***23***	***0***	***3***	***822***	***89***
District 4	50	102	5	0	0	66	3
District 5	145	85	8	0	2	398	29
District 8	171	298	10	0	1	358	57
Central Region	***50***	***93***	***8***	***0***	***2***	***131***	***3***
District 2	34	30	6	0	2	51	0
District 3	11	41	2	0	0	51	3
District 9	5	22	0	0	0	29	0
Western Region	***185***	***197***	***4***	***0***	***7***	***490***	***74***
District 1	15	18	4	0	0	27	0
District 10	17	19	0	0	1	26	0
District 11	135	127	0	0	6	336	71
District 12	18	33	0	0	0	101	3
Statewide	***986***	***1181***	***41***	***7***	***28***	***2396***	***443***

These congestion-related crashes led to a significant number of injuries and fatalities. The table on the following page indicates the number and type of injuries that resulted from congestion-related crashes on the Core Roadway Network in 2017.

[2] A reportable crash or a non-reportable crash that was captured in RCRS
[3] A workzone captured in RCRS or the maintenance database
[4] An RCRS event that is weather related (winter weather, flooding, downed tree/utlity)
[5] A special event that was entered into RCRS
[6] An RCRS event that does not fall into any of the previous categories
[7] The cause of congestion cannot be determined from any the data sources that have currently be integrated
[8] Recurring congestion is identified where there is congestion, but traffic speeds are not below the average speed for that day of week and time of day, as reported by INRIX

Table 2. Injuries Resulting From Congestion Related Crashes

District/Region	Fatality	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Unknown Severity	Unknown If Injured
Southeastern Region (D6)	***4***	***21***	***535***	***258***	***570***	***126***
Eastern Region	***15***	***34***	***512***	***230***	***262***	***74***
District 4	2	3	69	21	36	16
District 5	7	12	209	84	110	27
District 8	6	19	234	125	116	31
Central Region	***4***	***12***	***90***	***38***	***36***	***8***
District 2	4	8	40	8	12	3
District 3	0	3	41	9	15	1
District 9	0	1	9	21	9	4
Western Region	***7***	***21***	***267***	***112***	***169***	***45***
District 1	1	5	19	4	13	1
District 10	3	4	37	7	12	2
District 11	1	5	165	87	133	38
District 12	2	7	46	14	11	4
Statewide	***30***	***88***	***1404***	***638***	***1037***	***253***

Secondary Crashes

For the purposes of this report, a secondary crash is a subsequent crash that occurs within the backlog or queue of a prior crash. Congestion from a primary crash contributed to 986 secondary crashes[9] on the Core Network in 2017, meaning about 7% of all reportable crashes contributed to a secondary crash.

The following tables provide a breakdown of these secondary crashes by the district and region, the fatalities and total injuries associated with these crashes, if the primary crash was in RCRS, how often the primary crash was in RCRS prior to the secondary crash, and if there was a DMS present within 5 miles or less before secondary crash location.

[9] Due to data processing limitations, for purposes of this analysis congestion was linked to a crash up to 8 miles behind the crash. Crashes that occurred in congestion further behind the primary crash would not be flagged as a secondary crash.

Table 3. Secondary Crashes by District and Region

District/Region	Secondary Crashes	Primary Crash in RCRS	%	RCRS Entry Prior to Secondary Crash	%	DMS [9]	%	Fatalities	Injury Total
Southeastern Region (D6)	***385***	***175***	***45%***	***152***	***39%***	***355***	***92%***	***0***	***267***
Eastern Region	***366***	***176***	***48%***	***119***	***33%***	***307***	***84%***	***3***	***239***
District 4	50	15	30%	10	20%	50	100%	0	36
District 5	145	62	43%	37	26%	128	88%	0	93
District 8	171	99	58%	72	42%	129	75%	3	110
Central Region	***50***	***29***	***58%***	***10***	***20%***	***37***	***74%***	***2***	***38***
District 2	34	20	59%	8	24%	28	82%	2	29
District 3	11	8	73%	2	18%	6	55%	0	5
District 9	5	1	20%	0	0%	3	60%	0	4
Western Region	***185***	***83***	***45%***	***62***	***34%***	***155***	***84%***	***2***	***135***
District 1	15	3	20%	2	13%	8	53%	1	9
District 10	17	11	65%	3	18%	16	94%	1	33
District 11	135	63	47%	52	39%	120	89%	0	77
District 12	18	6	33%	5	28%	11	61%	0	16
Statewide	***986***	***463***	***47%***	***343***	***35%***	***854***	***87%***	***7***	***679***

As detailed above, 47% of primary crashes were captured in RCRS, and 35% of these primary crashes were in RCRS prior to the time that the secondary crash occurs. In other words, 65% of secondary crashes hypothetically did not have Traffic Operations situational awareness of the primary crash. Additionally, 87% of the time there was a DMS present, 5 miles or less upstream of the secondary crash location. As Traffic Operations continues to improve our situational awareness strategies, we need to investigate the time it takes to detect incidents and eventually understand what DMS messages are effective at warning motorist of impending congestion.

Table 4. Timing of Secondary Crashes Relative to Primary Crash

Time (Minutes)	Secondary Crashes	Primary Crash in RCRS	%	RCRS Entry Prior to Secondary Crash	%	DMS[10]	%	Fatalities	Total Injured
0-15	251	101	40%	29	12%	216	86%	4	191
16-30	124	67	54%	42	34%	106	85%	0	72
31-60	210	112	53%	103	49%	181	86%	1	156
61+	401	183	46%	173	43%	351	88%	2	260
Total	**986**	**463**	**47%**	**347**	**35%**	**854**	**87%**	**7**	**679**

[10] A DMS is considered present if there was one within 5 miles upstream of the secondary crash

Table 4 outlines the length of time after the primary crash that secondary crashes tend to occur. Of note, 25% percent of secondary crashes occurred within 15 minutes of the primary crashes. Crashes that occur that quickly after the primary crash do not realistically provide TMCs enough time to verify, prepare, and execute an operational response. However, nearly 75% of secondary crashes occur after more than 15 minutes, and over 40% occur one hour or more after the primary crash. These timeframes are where TMCs should place their focus to target better operational response times and highlight the importance of promoting the efforts in FHWA's "Best Practice in TIM" DMS guidance for continuing effective messaging throughout the duration of incident's timeline, congestion, and queue adjustments.

Table 5. Length of Congestion from Primary Crash to a Secondary Crash

Distance (Miles)	Secondary Crashes	DMS[9]	%	Fatalities	Total Injured
<.5	293	257	88%	3	178
.5 - 2	238	203	85%	2	164
2 to 5	235	203	86%	1	189
> 5	220	191	87%	1	148
Total	**986**	**854**	**87%**	**7**	**679**

Table 5 outlines the length of congestion that was queued behind a primary crash when a secondary crash occurred. While slightly more crashes (just under 30%) occur within the first half mile, secondary crashes are very evenly spread along a variety of distances from the primary crash, with 46% occurring more than 2 miles away from the primary crash, and over 20% occurring more than 5 miles away. This information highlights the importance of continuing to manage an active event as the queue grows.

With this information, TMCs will have better supporting information for the use of upstream congestion messaging and data to take to TIM teams to help mitigating the congestion more quickly. Regardless of time and distance from the primary crash, there is a DMS close enough to alert approaching motorists of the congestion in over 85% of secondary crashes. Future analysis will focus the effectiveness of DMS messaging in preventing secondary crashes.

Work Zone Congestion-Related Crashes

Congestion from work zones is another significant contributing factor in crashes. In 2017, there were 1181 reportable crashes on the Core Roadway Network that occurred in congestion originating from a work zone[11].

The following tables provide a breakdown of District work zone congestion-related crashes and injuries, whether a work zone with a related crash was recorded in RCRS and/or the PennDOT maintenance database, and whether or not there was a permanent DMS within the 5 miles leading up to the work zone congestion-related crash. It is noteworthy that when comparing RCRS with PennDOT's

[11] Due to data processing limitations, congestion was linked to a work zone up to a maximum of 8 miles behind the work zone. Crashes that occurred in congestion further from the work zone would not be flagged as being caused by the work zone.

Maintenance Database, 89% of the work zones where congestion-related crashes occurred were captured in RCRS.

Table 6. Breakdown of Work Zone Congestion-Related Crashes by District/Region

District/Region	Work Zone Crashes	Work Zone In RCRS	%	DMS [12]	%	Fatalities	Injury Total
Southeastern (D6)	***406***	***341***	***84%***	***358***	***88%***	***2***	***316***
Eastern Region	***485***	***456***	***94%***	***440***	***90%***	***6***	***319***
District 4	102	100	98%	101	99%	1	78
District 5	85	75	88%	79	91%	3	57
District 8	298	281	94%	260	87%	2	184
Central Region	***93***	***82***	***88%***	***75***	***79%***	***1***	***71***
District 2	30	21	70%	26	84%	1	22
District 3	41	40	98%	31	74%	0	27
District 9	22	21	95%	18	82%	0	22
Western Region	***197***	***176***	***89%***	***148***	***74%***	***3***	***110***
District 1	18	16	89%	10	56%	0	9
District 10	19	15	79%	18	95%	2	17
District 11	127	119	94%	105	82%	0	66
District 12	33	26	79%	15	44%	1	18
Statewide	***1181***	***1055***	***89%***	***1021***	***86%***	***12***	***816***

However, the 11% of work zones only captured in the maintenance database represents an opportunity for improved communications between county maintenance personnel and the TMCs. Additionally, as with secondary crashes, over 85% of work zone-related crashes had a DMS in proximity to the crash that may have been used to alert motorists that they were approaching the work zone congestion. As with secondary crashes, future analysis will focus on the extent to which DMS messaging can prevent work zone-related crashes.

Table 7. Distance of Work Zone Congestion-Related Crashes from the Work Zone

Distance (Miles)	Work Zone Crashes	DMS? [13]	%	Fatalities	Total Injured
<.5	778	655	84%	10	521
.5 to 2	122	103	84%	1	96
2 to 5	150	128	85%	1	99
> 5	131	123	87%	0	100
Total	**1181**	**1009**	**85%**	**12**	**816**

Table 7 breaks down work zone-related crashes by their distance from the work zone. The majority, 65%, of these crashes occurred within half a mile of the work zone. This highlights the fact that that areas approaching a work zone are at higher risk for crashes, as well as the importance of having

[12] A DMS was present within 5 miles upstream of the site of the crash

[13] A DMS was present within 5 miles upstream of the site of the crash

situational awareness of planned work zones and an operational response in place for when congestion begins to build in the work zone.

Crashes in Congestion from Unidentified Sources

A considerable number of crashes associated with non-recurring congestion do not have an identifiable congestion type. Almost half of all congestion-related crashes took place in congestion with an unidentified source. Examples of potential causes of congestion that this analysis cannot currently capture include: inclement weather, local special events (outside of RCRS), a non-reportable crash, other minor traffic incidents, police activity, and others. We have already started to bring in some of those examples into our databases, and hope to have those correlations ready for analysis later in 2019.

The totals in Table 8 further highlight the need for improving our situational awareness regarding congestion on the roadways. Crashes that occurred in congestion of unknown cause led to 12 fatalities and nearly 1600 injuries in 2017. It is noteworthy that while most of these crashes were associated to congestion classified as major or worse, there were still as sizeable number of crashes in less severe congestion.

Table 8. Severity of Unidentified Congestion that Contributed to a Crash

Congestion Level[14]	Crashes Caused
Critical	26
Severe	526
Major	939
Moderate	566
Minor	339
Total	**2396**

[14] Congestion level is classified by severity score, which = (Duration of Incident) * (Historical Avg Speed – Avg Speed during Incident). Critical >=10000, Severe 3000-9999, Major 1000-2999, Moderate 300-999, Minor 100-299.