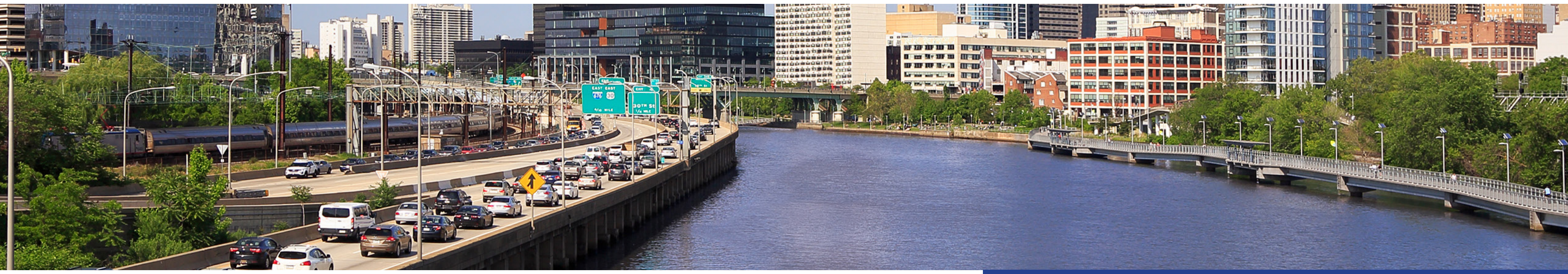


Pennsylvania DOT Using Crowd Sourced Data to Assess and Improve Statewide Traffic Incident Management (TIM)

Pennsylvania Department of Transportation (PennDOT) is responsible for nearly 40,000 miles of roadways, roughly a third of one of the largest statewide road networks in the US. To monitor and manage its network, PennDOT operates four Regional Traffic Management Centers (RTMC) located across the state. The RTMCs focus on the 'core network' of roughly 4,000 miles of Interstates and other key arterials.[1]

PennDOT has been one of the national leaders in applying TSMO (Transportation Systems Management and Operations) approaches statewide, with urban and rural areas with varied ITS infrastructure [CCTV cameras, dynamic message signs (DMS), etc.]. Traditional tools can monitor conditions where ITS equipment is deployed, with data from police/911 dispatch centers often filling in the gaps for crash detection outside of that ITS network. Generally, this leads to a two-tier level of service across a statewide network, with many incidents having severely delayed detection or no detection at all.

PennDOT realized these gaps in their incident detection, and decided to analyze the potential of crowdsourced data to improve incident timelines. PennDOT has access to two sources of crowdsourced data statewide: INRIX real-time traffic data licensed under the I-95 Corridor Coalition's Vehicle Probe Project and WAZE data via the Connected Citizens Program. In late 2017, PennDOT began to assess the value of monitoring real-time crowdsourced data in the RTMCs to improve traffic incident management operations. At that time INRIX data was being used

Key Points

- PennDOT conducted yearlong statewide study of incident detection/response on core road network
- Compared INRIX data, Waze user reporting, and traditional agency-based detection/monitoring
- INRIX detected more reportable crashes first and typically faster than Waze or traditional methods
- INRIX and Waze combined yields huge incident detection improvements over traditional methods
- INRIX data aided in understanding crash locations and patterns, allowing PennDOT to adapt procedures and develop a new crowd-sourced incident application to improve TIM
- Other state DOTs can replicate these methods to improve their statewide TIM

extensively by PennDOT for 511PA services, performance measures and planning purposes. The Waze data was just becoming available. PennDOT's goal was to maximize the benefit of crowdsourced data to improve TMC operations, particularly around TIM and set about to understand the data more deeply to determine if it can help, and how best to update systems and processes to maximize the benefits.

This case study highlights the results of the study, as well as initial improvements PennDOT has made based on the findings. In short, crowdsourced data can be a game changer – particularly INRIX data – if utilized properly, and can help facilitate true statewide TSMO/TIM strategies. The analysis confirms crowdsourcing detects more crashes than traditional methods, provides more detailed congestion and queue data during incidents allowing RTMCs to make better traffic management decisions, and identifies congestion and crash location patterns.

Analysis

PennDOT analyzed data across the full calendar year 2017 on its core roadway network. Four data sources were used to conduct the analysis:

PennDOT Crash Reporting System (CRS) Data: CRS allows police agencies in PA to have a means to electronically file, store and retrieve crash investigation data. Data for all reportable crashes[2] on the core network served as the 'ground truth' for crash data for this analysis, including when, where, cause, and severity. 15,237 reportable crashes were identified across the core network in 2017.

PennDOT Road Condition and Reporting System (RCRS): Statewide system of real-time geo-located incidents, restrictions, work zones, etc. served as the 'real-time' view of anomalous conditions on the core network as understood by PennDOT personnel.

Waze Connected Citizen Incidents: Incidents as reported by Waze via its Connected Citizens program that PennDOT is part of were archived in real-time.

INRIX Congestion Events: When correlating INRIX data to crashes, PennDOT developed logic that looked at proximity segments that were experiencing INRIX reported congestion in real time, and also linked congestion events available to PennDOT via API. These geo-located messages summarize queues detected by INRIX and are updated throughout the life of each slowdown event. Figure 1 illustrates congestion event examples.

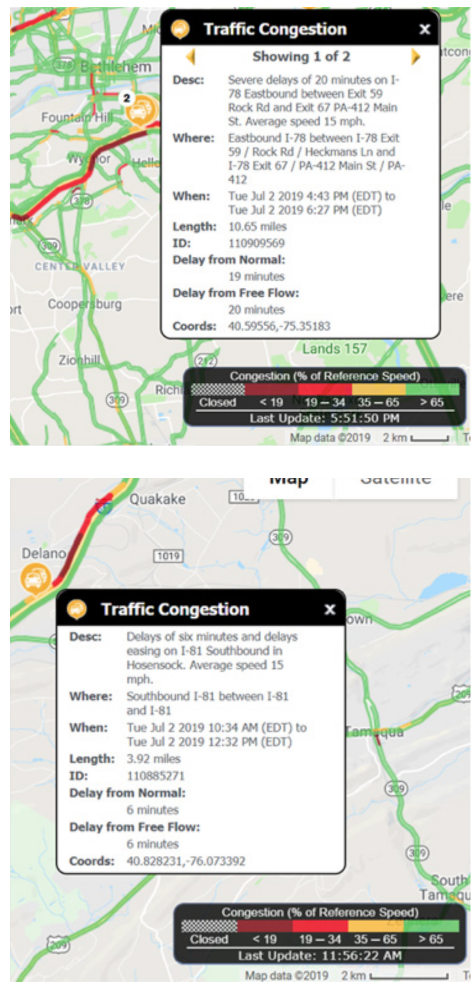


Figure 1 - INRIX Congestion Event Examples

Data from these four sources was integrated and normalized in PennDOT's Traffic Operations Analysis (TOA) tool.[3] PennDOT developed and applied rules linking crashes to RCRS data (traditional method), Waze and INRIX data to determine, if and when the data source 'detected' the crash as compared to the time reported in the CRS. Additionally, 'high congestion'[4] conditions were also defined to distinguish performance in cases where significant traffic flow impact occurred (3,147 crashes were classified high congestion in total, more than 8 every day statewide). Additionally, the TOA tool enabled analysis of detection by each method and overall statistics by crash type, region, district, day, time, etc.

Results

The Analysis lead to a myriad of conclusions related to incident detection/monitoring and uncovered significant findings with respect to the scale and nature of crashes and congestion across the state. Key overall findings relevant to peer states are included in this case study. PennDOT also generated a significant number of detailed findings at the region/district level that are helping them identify specific incremental improvements for TIM across Pennsylvania.

Incident Detection

The more quickly a crash is identified, the faster it can be managed and cleared, reducing its impact on mobility, reducing the risk of secondary incidents, and saving lives. Detecting incidents quickly and reliably is the first step in a quality TIM program. The analysis showed crowdsourced data is essential to improve incident detection.

1. How good is each method at detecting incidents? Of all reportable crashes, INRIX detected 81.2%, Waze data 61.2%, and 32.8% were reported in RCRS. INRIX/Waze combined to detect 86.7% of reportable crashes statewide.

2. Which method detected incidents first? Figure 2 summarizes results. INRIX detected more reportable crashes first (47%) and detected roughly half of High Congestion crashes first (49%).

3. How quickly did each method detect incidents? Figure 3 highlights median time to detect by method. INRIX was faster to detect a crash versus Waze and nearly twice as fast as traditional methods.

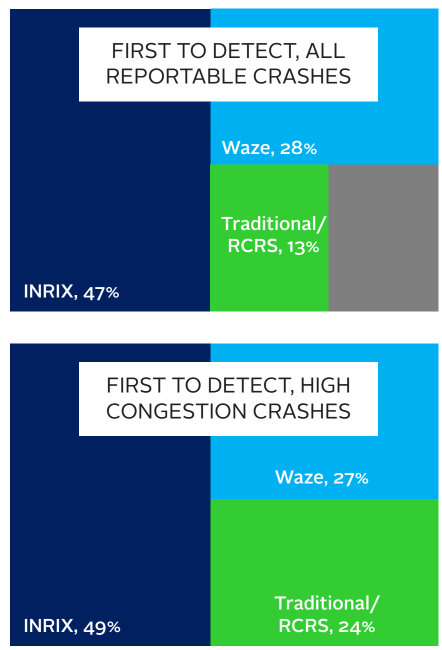


Figure 2 - First to Detect a Reportable Crash, by Method

*Crashes that did not cause detectible congestion or were reported by Waze or RCRS.

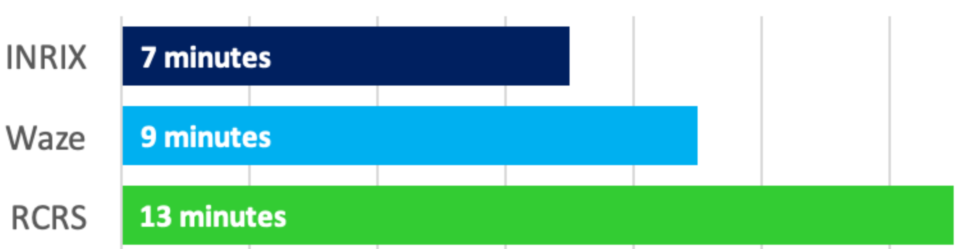


Figure 3- Median Detection Time by Method, All Reportable Crashes

Crash/Congestion Stats and Facts

There are few studies that have focused on crash and congestion correlation over long time periods across a full statewide limited access highways network.[5] In addition to assessing different incident detection methods, the analysis also generated information that can aid all states regarding the scale and causes of congestion, and areas where TSMO can have positive impacts of safety and traffic flow.

Secondary Crashes

Congestion from a primary crash[6] contributed to 986 secondary crashes on the core network in 2017, meaning about 7% of all reportable crashes contributed to a secondary crash, with seven total fatalities and 679 total injuries.

Other key findings:

- 65% of secondary crashes occurred with no RTMC staff situational awareness of the primary crash
- 75% of the time queues were present 15 minutes or more before the secondary crash; 40% for an hour+
- 87% of secondary crashes had a permanent DMS within 5 miles upstream of the primary crash
- 22% of secondary crashes happen 5 miles or more upstream of the primary crash (see Figure 4)

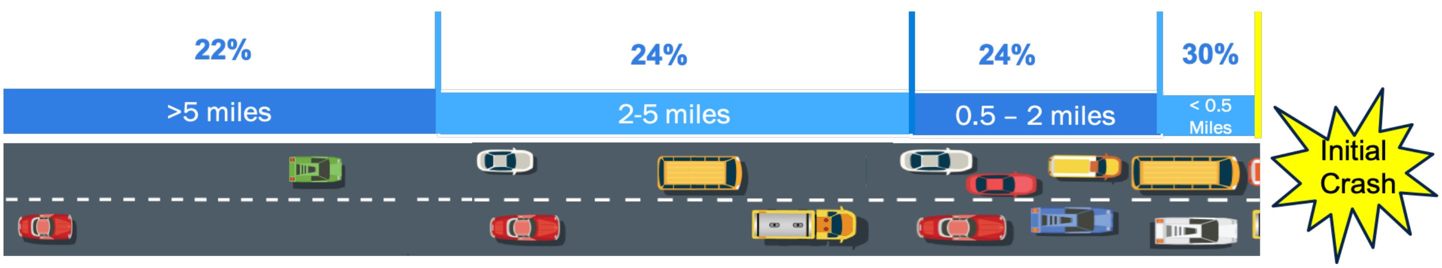


Figure 4 – Percentage of Secondary Crash from Primary/Initial Crash by Distance

Work Zone Related Crashes

There were 1,181 reportable crashes[7] on the core network in 2017 that occurred in congestion originating from a work zone, 9% of all reportable crashes, with 12 total fatalities and 816 total injuries.

Other key findings:

- 11% of work zone-related crashes occurred with no RTMC staff awareness of work zone
- 85% of work zone-related crashes had a permanent DMS within 5 miles upstream of work zone
- 24% of the crashes were 2 miles or more from start of work zone (see Figure 5)

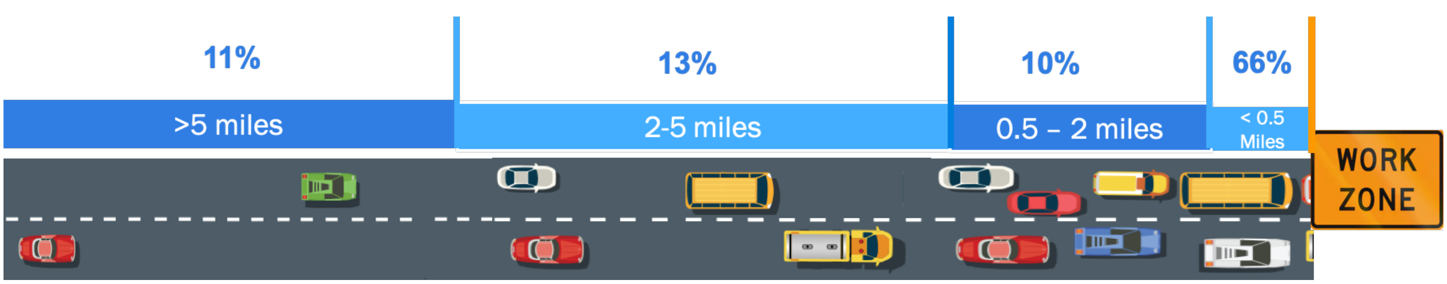


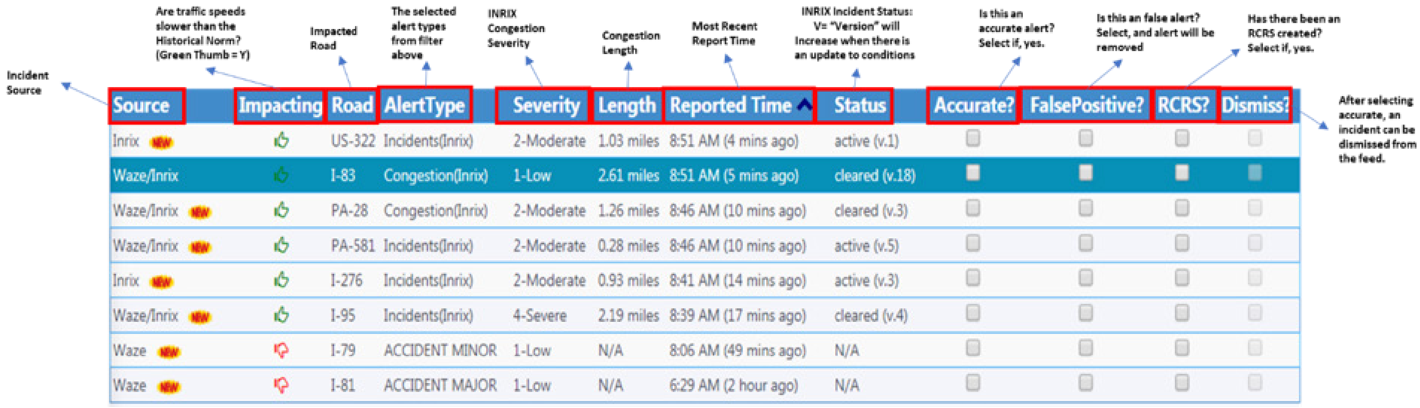
Figure 5 – Percentage of Work-Zone Related Crashes by Distance Upstream of Work Zone

Changes Based on Analysis

Leveraging the results of the analysis, PennDOT has made several modifications to their RTMC operating procedures and supporting tools. Highlights include:

Traffic Alerts Dashboard for RTMCs

PennDOT has established a new tool that integrates INRIX Congestion Event and Waze Traffic Alerts in a single map/menu tailored for the TMC operators use.[8] Figure 6 illustrates a summary menu of events an operator may see, just one of many views in the tool.



Source	Impacting	Road	AlertType	Severity	Length	Reported Time	Status	Accurate?	FalsePositive?	RCRS?	Dismiss?
Inrix NEW		US-322	Incidents(Inrix)	2-Moderate	1.03 miles	8:51 AM (4 mins ago)	active (v.1)				
Waze/Inrix		I-83	Congestion(Inrix)	1-Low	2.61 miles	8:51 AM (5 mins ago)	cleared (v.18)				
Waze/Inrix NEW		PA-28	Congestion(Inrix)	2-Moderate	1.26 miles	8:46 AM (10 mins ago)	cleared (v.3)				
Waze/Inrix NEW		PA-581	Incidents(Inrix)	2-Moderate	0.28 miles	8:46 AM (10 mins ago)	active (v.5)				
Inrix NEW		I-276	Incidents(Inrix)	2-Moderate	0.93 miles	8:41 AM (14 mins ago)	active (v.3)				
Waze/Inrix NEW		I-95	Incidents(Inrix)	4-Severe	2.19 miles	8:39 AM (17 mins ago)	cleared (v.4)				
Waze NEW		I-79	ACCIDENT MINOR	1-Low	N/A	8:06 AM (49 mins ago)	N/A				
Waze NEW		I-81	ACCIDENT MAJOR	1-Low	N/A	6:29 AM (2 hour ago)	N/A				

Figure 6 – Screen shot of Live Incident Details in PennDOT's Traffic Alerts Dashboard

RTMC Procedural Changes

The data from the analysis uncovered several opportunities to improve the impact of the RTMCs on an overall basis. A couple notable highlights were:

Detection Gaps: The high congestion crashes were evaluated in detail to further understand the crash patterns and causes, and determine what types of improvements, TSMO or otherwise, could help reduce crashes and fatalities going forward. One element of the analysis focused on patterns of when and where high congestion crashes were occurring that were not reported in RCRS.

> **Where?** Heat Maps of each PennDOT district highlighted where crashes were missed, to raise RTMC awareness to increase focus on these locations going forward and provide insight into potential new locations for ITS infrastructure installations
>
> **When?** The analysis also uncovered that on weekdays from 1 PM to 4 PM, about 1 in 3 high congestion crashes were not captured in RCRS statewide, identifying an area improvement. One district expanded its TMC's operating hours 3 hours each weekday (3pm to 6pm) as data showed a large number of high congestion crashes in those hours.

Operator Focus: Analyzing the results led to some findings that in turn led to revisions in operator instructions to help reduce secondary crashes:

Enter queue protection messaging on the DMS in more accurate locations/times and contact service patrols as first actions, then enter data into incident management system

Deactivate DMS messages only when the queue is cleared instead of deactivating the message when the incident is cleared, and monitor queues as they progress after incident clears and continue to light queue protection messaging upstream as needed

Automated DMS Messaging to Improve Driver Alerting

A virtual queue detection/smart work zone capability is in development for inclusion into PennDOT's Advanced Transportation Management System (ATMS) that will provide automated DMS messaging to protect stopped traffic ahead and relieve RTMC operator workload. Based off the INRIX data, the system will automatically calculate the distance ahead for slow or stopped traffic continuously, and post to DMS as the queues grow or lessen. With accompanying DOT policy for connectivity of work zone portable DMS, this functionality will be deployed during the 2020 construction/maintenance season.

Statewide Traffic Operations Performance Management Program

Furthermore, the basis of correlating crowd-sourced congestion and incident data to existing PennDOT databases has helped the Department formally establish a Traffic Operations Performance Management Unit. They are actively working to get Operations strategies integrated into core DOT performance measures that will consistently assess any impacts to roadway performance (construction or operational).

1. For a map of the core network: https://www.511pa.com/pdfs/PA511IncidentandFlowNetwork.pdf
2. A reportable crash is one in which an injury or a fatality occurs, or if at least one of the vehicles involved required towing from the scene.
3. For details on the TOA tool, see: https://www.tesc.psu.edu/assets/Session%20PDFS/Room206/3B-McNary.pdf
4. High congestion is when the product of congestion duration and nonrecurring delay severity exceed a threshold defined in http://vpp.ritis.org
5. The only comparable analysis we are aware of was conducted in Indiana by Purdue University and Indiana DOT: Abstract, Characterizing Interstate Crash Rates Based on Traffic Congestion Using Probe Vehicle Data. http://docs.trb.org/prp/16-1194.pdf
6. 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.
7. 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.
8. https://trafficalerts.penndot.gov/#/home