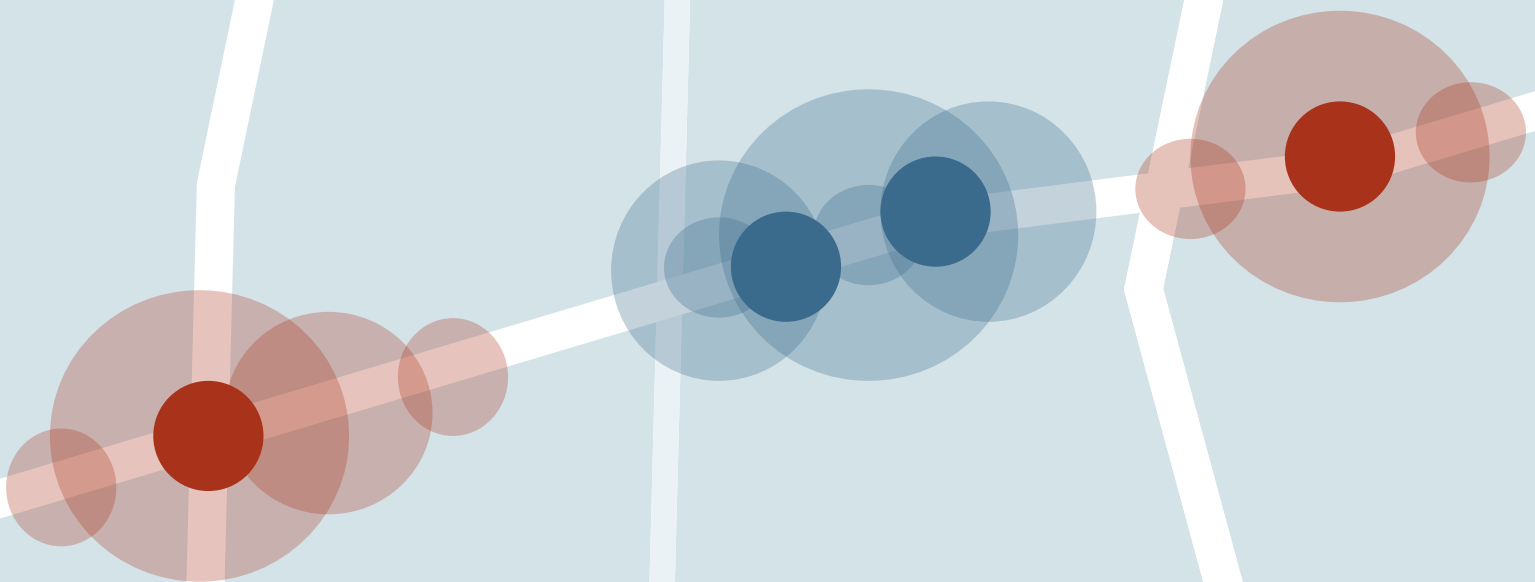


DETECTION AND RESPONSE

How Waze Data Can Improve Roadway Safety
and First Responder Situational Awareness



October 2022



I-30 WAZE AND 9-1-1 INTEGRATION PILOT

This project was funded by the Texas Department of Transportation (TxDOT) with additional support from the North Central Texas Council of Governments (NCTCOG). To investigate the efficacy of Waze data, TxDOT and NCTCOG launched the I-30 Waze and 911 Integration Pilot. The pilot, a joint effort between the University of Texas at Austin Center for Transportation Research (UT CTR) and Texas A&M Transportation Institute (TTI), complements the Texas Connected Freight Corridors (TCFC) project, which is Texas's largest deployment of connected vehicle technology and was initialized by a 2017 U.S. Department (USDOT) grant. The project team would like to thank the participating public safety answering points of Fort Worth, Arlington, and Grand Prairie, as well as the North Central Texas Emergency Communications District for contributing data and participating in the project.

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Executive Summary

Time and safety are the essential elements of incident response. The time required to detect and classify the incident, dispatch resources, and arrive on scene are critical to determining the outcomes of crashes and road hazards. Since first responders play an essential role in clearing incidents and saving lives, knowing when and where an incident occurs is crucial.

In 2021, there were nearly 60,000 crashes in the Dallas-Fort Worth (DFW) metroplex resulting in more than 400 traffic fatalities and significant region-wide delays in congestion. Road hazards also pose a safety risk. Abandoned vehicles or road debris like metal objects, shredded tires, and other litter can cause damage to a vehicle, and even prove deadly for motorists. A study by AAA found that nearly 37 percent of all deaths in road-debris crashes resulted from a driver swerving to avoid hitting the debris.

In the event of a crash or major road hazard, a witness will typically call 9-1-1 and the report will be logged by a public safety answering point (PSAP). Callers, however, do not always provide an accurate location or sufficiently detailed information. With a response time goal of just under nine minutes in the DFW region for priority one calls such as major crashes, every second counts.¹

The North Central Texas Emergency Communications District (NCT 9-1-1) began looking to crowdsourced data to supplement their situational awareness. In 2019, NCT 9-1-1 partnered with Waze, a navigation application that enables users to report and receive traffic alerts in real-time.

Waze users identify crashes, road hazards, adverse weather conditions, traffic jams, and road closures. By tapping into Waze data, PSAPs can improve incident detection and response.

Project Scope and Objectives

Conducted through a joint effort by the University of Texas at Austin Center for Transportation Research (CTR) and Texas A&M Transportation Institute (TTI), the I-30 Waze and 911 Integration Pilot aims to improve incident response and situational awareness along a 23-mile stretch of I-30 in the DFW metroplex (Figure i).

The pilot included three tasks. Beginning with a needs assessment, the project team identified and selected the simplest option for integrating Waze data into the PSAP computer-aided dispatch systems. The project team then developed a basic web browser-based prototype tool that enabled PSAP operators to visualize Waze incidents and filter by incident and roadway type. Finally, the project team conducted an evaluation of seven months of data (September 2021 to March 2022) for the Fort Worth, Arlington, and Grand Prairie PSAPs.

The evaluation focuses on three key criteria in order to assess the value of Waze data:

1. **Timing:** How are traffic incidents first reported—through Waze or PSAP—and how quickly?
2. **Location:** How far apart are Waze and PSAP events?
3. **Incident Type:** How do the characteristics of crashes and road hazards differ?

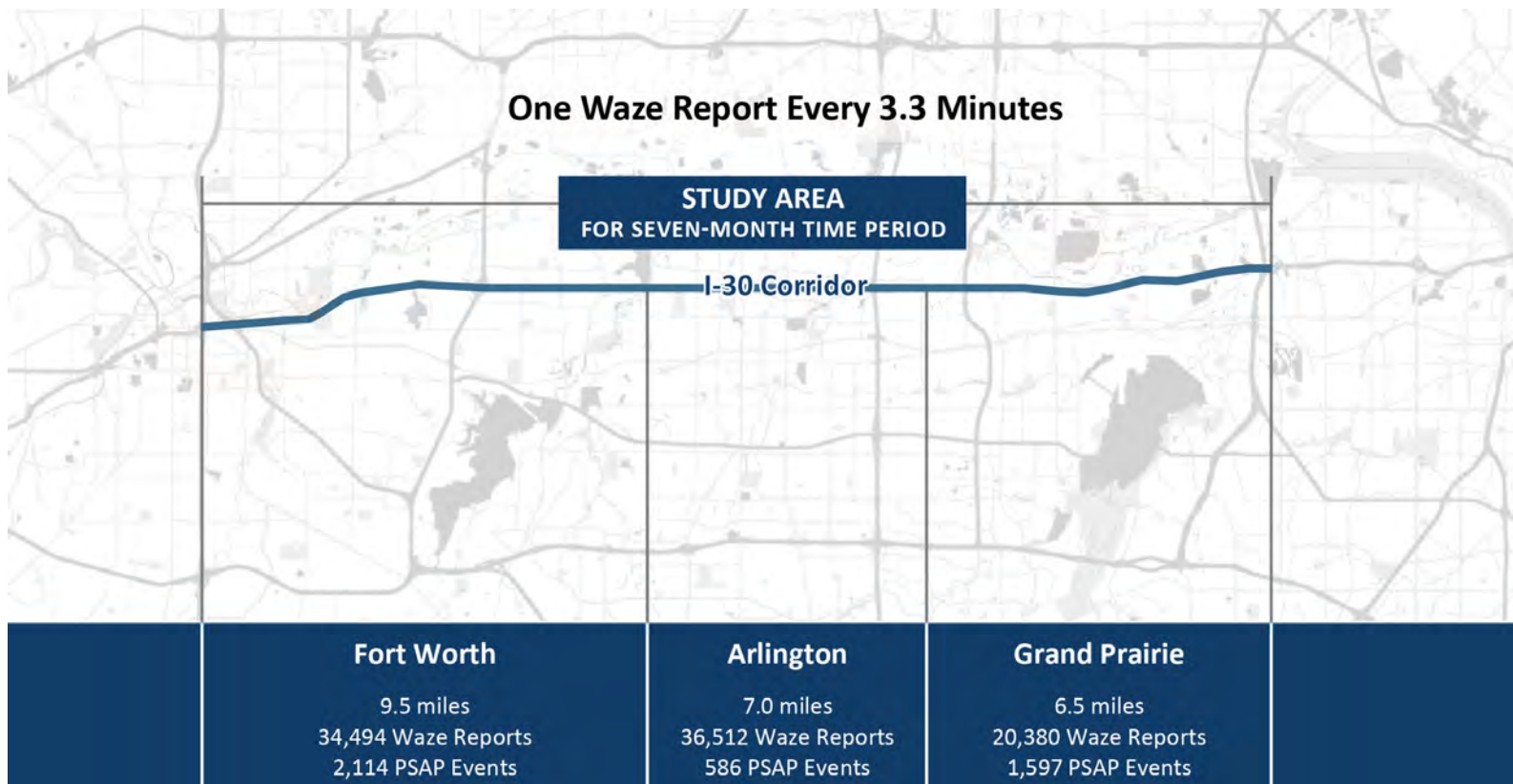


Figure i. Study Area and Data Collected During Seven-Month Evaluation Period

Waze Data: An Untapped Resource

The seven-month analysis period generated a significant volume of data and demonstrated that Waze data is a valuable tool that can enable PSAPs to optimize limited resources. The study included 91,386 individual Waze reports, an average of one Waze report every 3.3 minutes, and includes information that can be crucial for first responders—report time, location, and type of incident. The incident type is of particular interest because it determines the type of response. For example, crashes warrant the immediate dispatch of fire and emergency medical services (EMS); whereas, a car stopped on the shoulder may require roadside assistance or a tow. Figure ii shows that the majority of Waze reports were road hazards (63 percent), traffic jams (33 percent), or crashes (4 percent).

Often, several Waze reports were associated with a single incident. The project team therefore clustered Waze reports of the same type that occurred within the same geographic area (2,500-meter radius) and timeframe (60-minute window) into a single Waze event. The spatial and temporal parameters were determined through a sensitivity analysis, and the clustering process resulted in 29,493 unique Waze events.

PSAP Data: An Emergency Lifeline

Within the same seven-month analysis period, 4,297 PSAP events occurred—less than five percent of the Waze data volume. Figure iii shows that the majority of PSAP events were either crashes (45 percent) or road hazards (41 percent), with a smaller portion for other incidents including welfare checks and medical emergencies. Of the crashes that occurred, roughly 60 percent of them were major crashes, including one that required an airlift.

Of the road hazards that were reported, a large number of abandoned vehicles (41 percent) and stranded motorists (23 percent) were identified. These issues are important to detect quickly as they can put motorists at risk and may even cause crashes. PSAPs can use this information to coordinate with TxDOT's courtesy patrol program, which can provide roadside assistance and clear the roadway quickly.

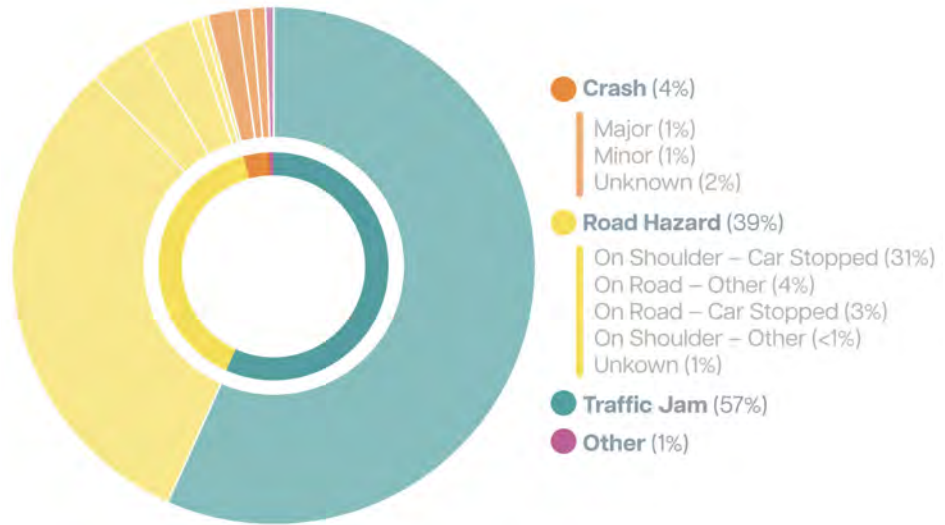


Figure ii. Waze Reports by Type and Subtype

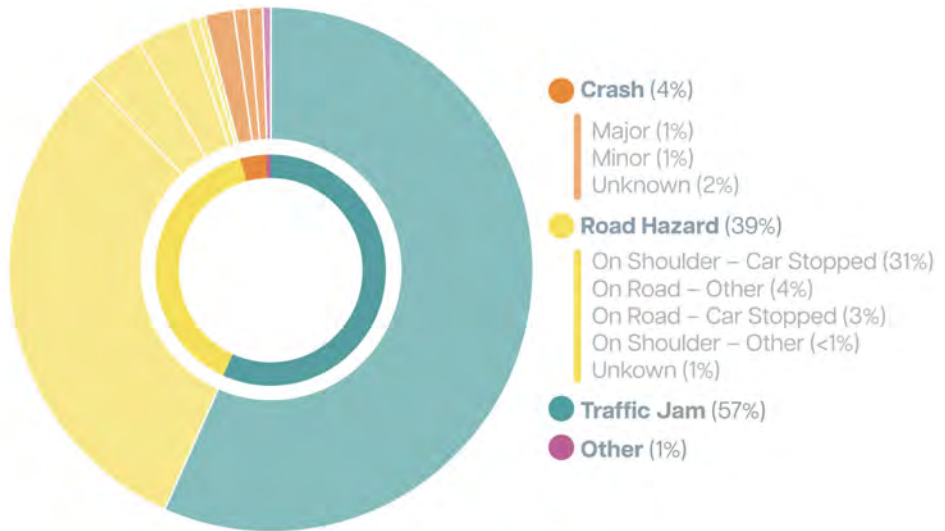


Figure iii. PSAP Events by Type and Subtype

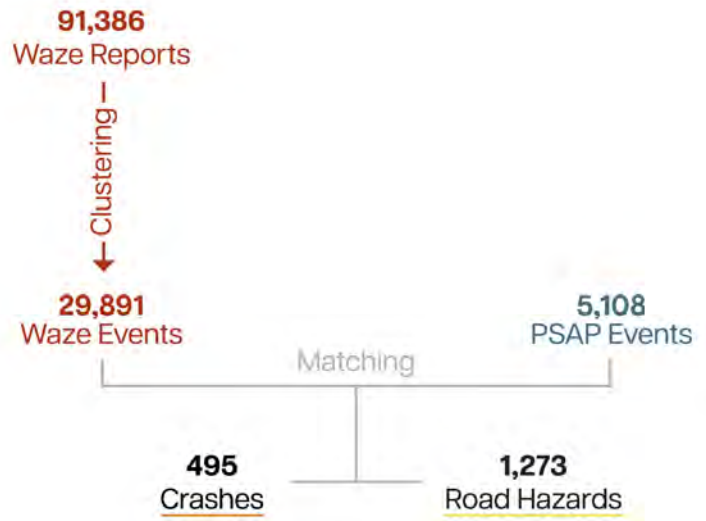
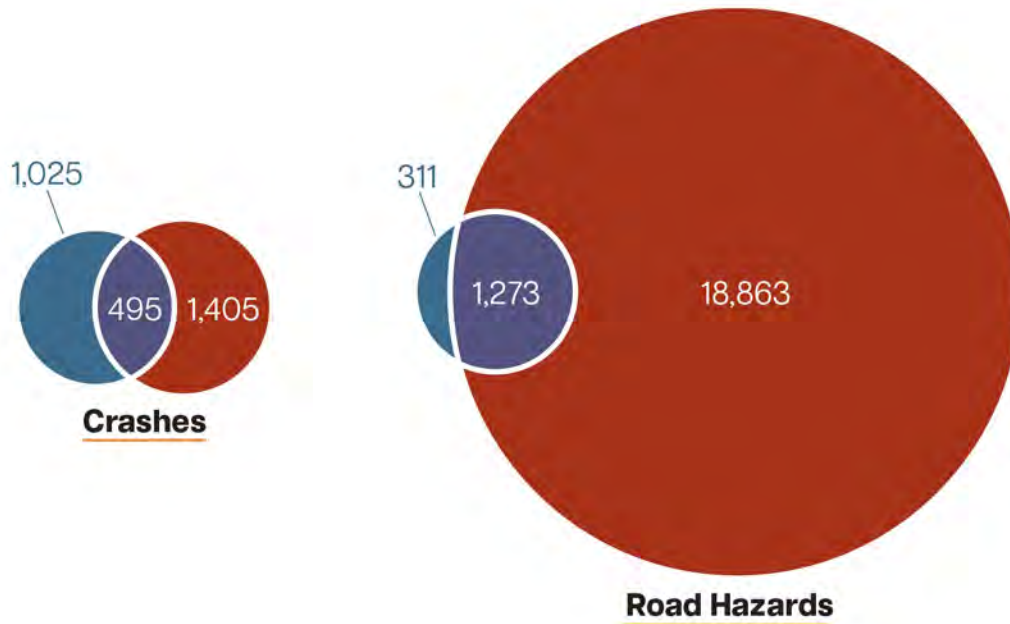


Figure iv. Data Analysis Workflow

How Do Waze and PSAP Data Compare?

In order to compare Waze and PSAP data, the project team developed a matching model to link Waze and PSAP events with one another (Figure iv). The project team conducted a sensitivity analysis to determine the appropriate spatial and temporal parameters for the matching process. Crashes were matched within 2,500 meters and 30 minutes, while road hazards were matched within 2,500 meters and 60 minutes. The process resulted in 495 matched crashes and 1,273 matched road hazards, as shown in Figure v. Figure v further illustrates that PSAPs are particularly keen in detecting major crashes; whereas, Waze detects a significant number of cars stopped on the shoulder that go undetected by PSAPs.



Crash Reports by Subtype

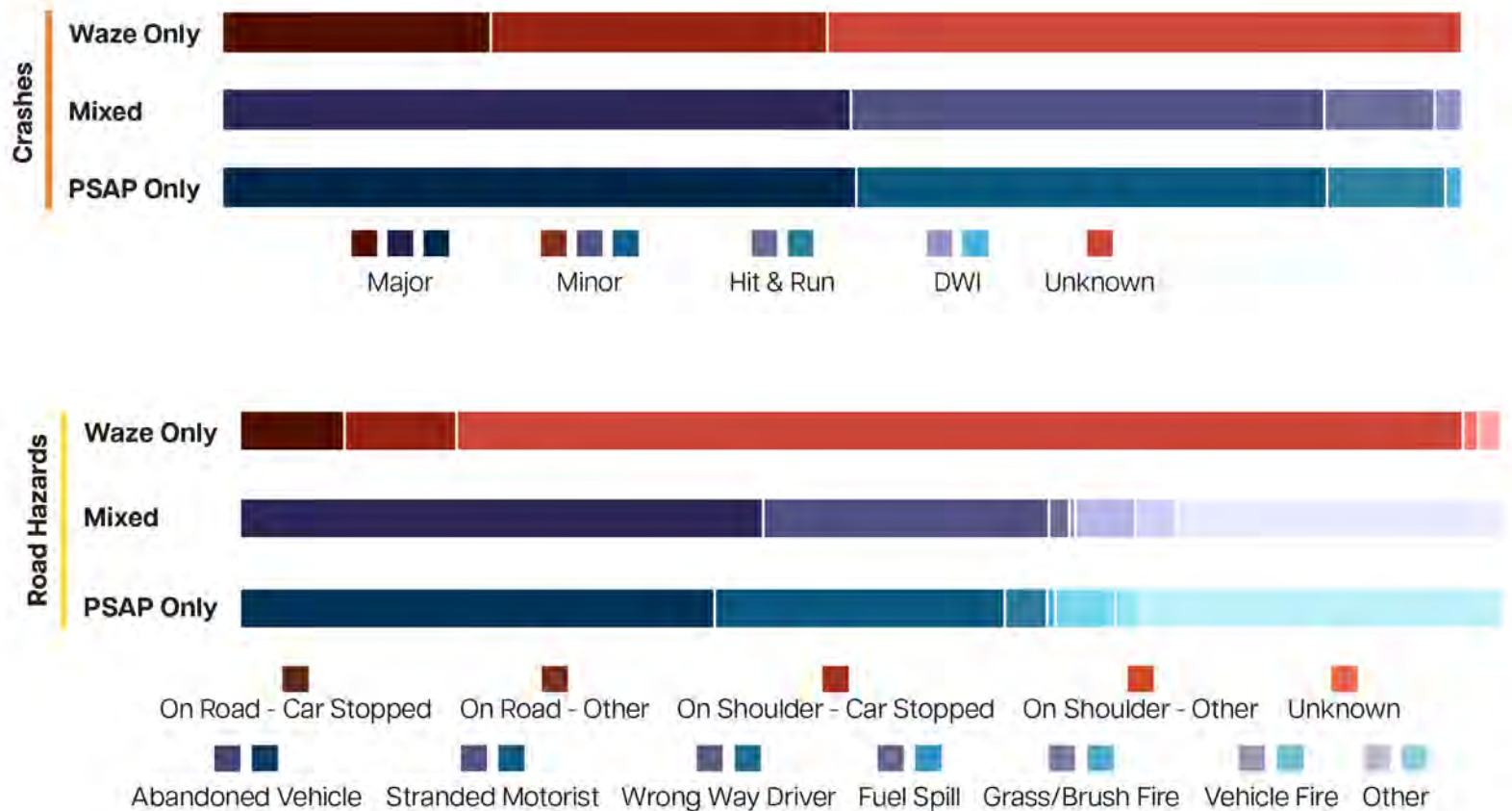


Figure v. Comparison of Matched and Unmatched Waze and PSAP Events

First Report

Response time translates into saving lives. The analysis revealed that crashes were first reported to PSAPs at an average of 10 minutes earlier than Waze 80 percent of the time. While this is a significant portion, PSAPs will still benefit from focusing on the remaining 20 percent of incidents that are reported first to Waze an average of nine minutes before their corresponding PSAP report (Figure vi). In particular, Waze was quicker to detect minor crashes, as shown in Figure 7. The ability to improve response times using Waze data has several immediate health implications for persons injured in roadway incidents, including faster treatment, reduction in secondary crashes, and lower fatality rates.

Road hazards, on the other hand, were reported first through Waze 66 percent of the time at an average of 32 minutes before a 9-1-1 call was placed. Abandoned vehicles and stranded motorists represented the highest portion (64 percent) of matched road hazards. Although a flat tire or a sputtering engine can force a driver to pull over on the shoulder, occasionally a vehicle comes to an unexpected halt in the travel lane. The research team cross-referenced the Waze data with crashes reported in the media and found an October 2021 incident in which a nineteen-year-old man who was experiencing car trouble was struck and killed in a chain-reaction crash. The collision resulted in three other hospitalizations and more than four hours of delay. Of note are six reports submitted to Waze prior to the

fateful crash. While it is unclear if the early reports were associated with the vehicle that was ultimately involved in the crash, this example demonstrates that Waze can be a valuable resource to improve PSAP response time and reduce the risk of road hazards from becoming crashes.

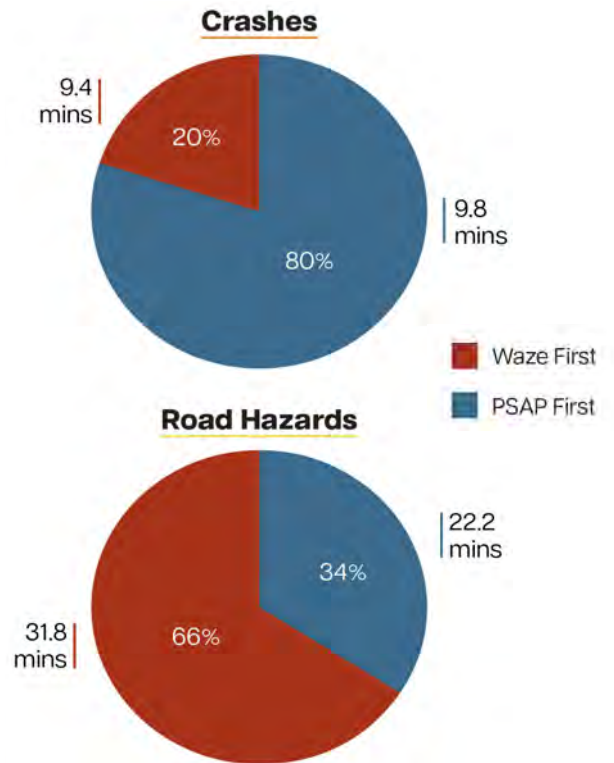


Figure vi. Percent and Average Time of First Report by Type

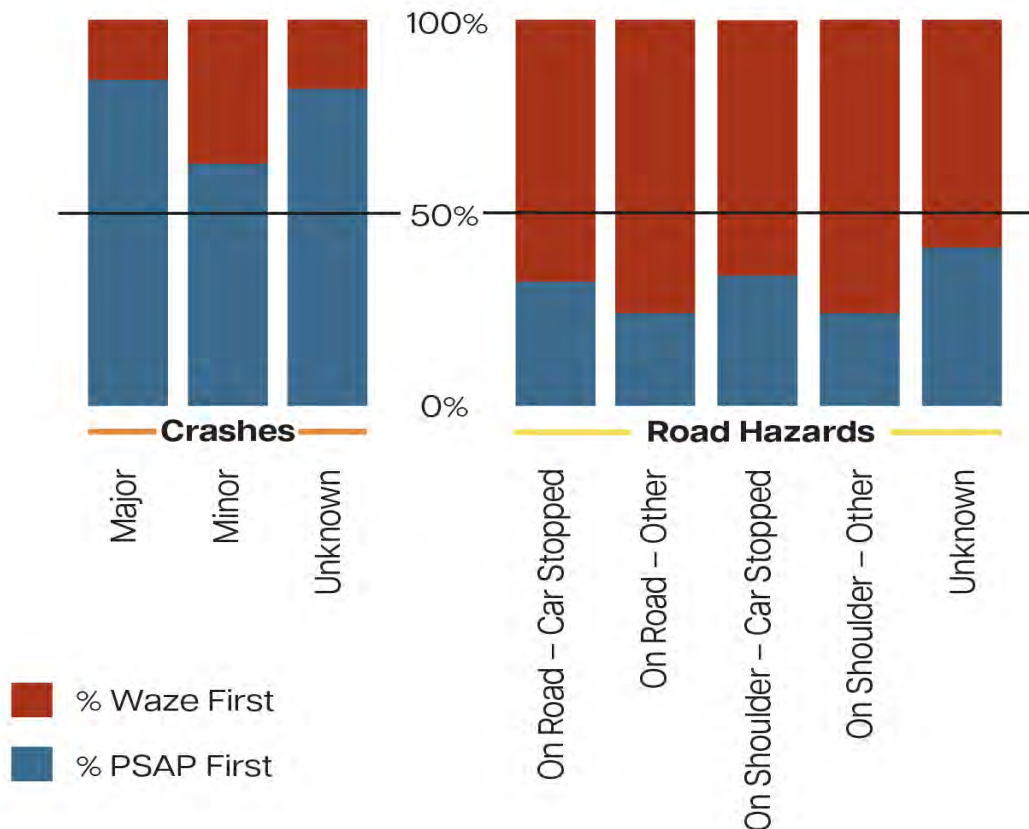


Figure vii. First Report by Subtype

Timing and Location

Waze data can also assist first responders with homing in on the precise location of the incident. Incident responses for crashes are concentrated more closely together (a mean distance of roughly 500 meters) than road hazard reports (more dispersed, at a mean distance of just over 1,000 meters), as shown in Figure viii. This pattern is most likely the result of people who were involved in the crash calling 9-1-1 or the human tendency to report an emergency involving people with greater immediacy than the observation of road debris.

Furthermore, Waze users typically report information while continuing to travel; as a result, the incident location can be several hundred meters behind the reported location. PSAPs can, therefore leverage Waze reports to guide first responders to the scene as well as confer with traffic management center (TMC) operators who have access to live camera feeds of the corridor. Crashes are concentrated more closely together in time and space, whereas road hazards are further dispersed.

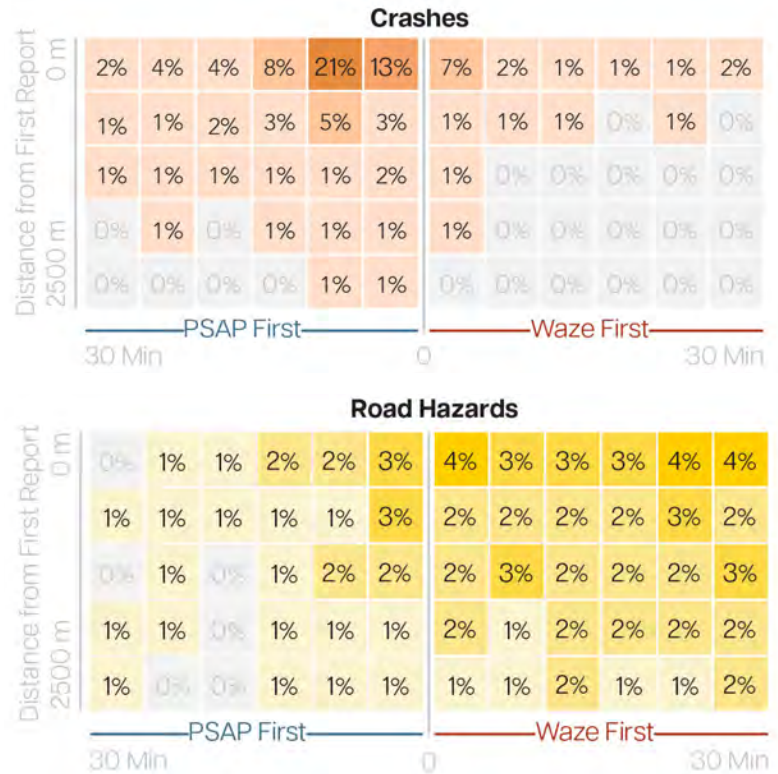


Figure viii. Time and Distance Distribution by Type

KEY FINDINGS

This is the first report to develop a robust methodological framework to evaluate Waze and PSAP data, finding that Waze data can prove most useful in early detection of major road hazards and minor crashes. Time savings for first responders can reduce the risk of primary and secondary crashes.

PSAP beats Waze in detecting a crash 80 percent of the time.

A crash witness will call 9-1-1, on average, 10 minutes before Waze users are reporting. This may be due to the large traffic volume on the I-30 corridor and human instinct to call 9-1-1 for medical attention in the event of a major crash. For the 20 percent of crashes that are first reported to Waze, first responders can be dispatched an average of nine minutes sooner. While there may not be serious injuries, clearing the crash can reduce the risk of secondary crashes and ensure proper medical attention is provided. Additionally, Waze offers the potential benefit to identify crashes that go unreported to PSAPs.

Response times for minor crashes can be improved by nine minutes.

For the 20 percent of crashes that are first reported to Waze, first responders can be dispatched an average of nine minutes sooner. While there may not be serious injuries, clearing the crash can reduce the risk of secondary crashes and ensure proper medical attention is provided.

Waze has a 32-minute advantage in detecting road hazards.

Of the hazards that are called into 911, 66 percent of the time they are first reported through Waze an average of 32 minutes earlier. Road hazards increase the safety risk to travelers. Using Waze data, PSAPs can improve roadside assistance, debris removal, and towing services.

Responding to road hazards can lower crash risk.

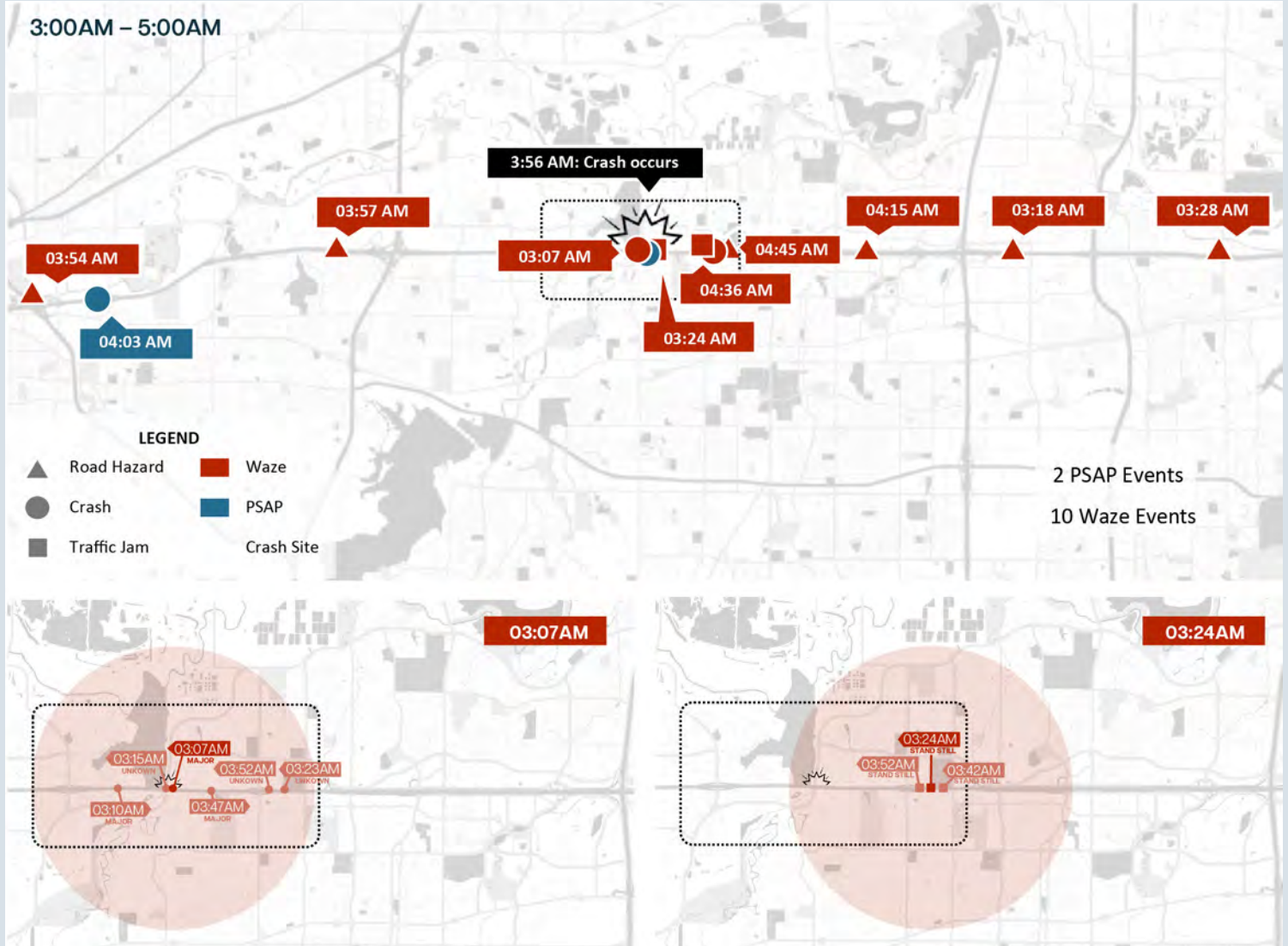
There are more than 12 times more road hazard events reported through Waze, with 94 percent of them never being reported to a PSAP. While many people may feel that a car stopped on the shoulder does not warrant a 9-1-1 call, they consider it significant enough to report to their fellow drivers through the Waze platform. As seen by the chain-reaction crash, addressing road hazards in a timely manner, particularly those in the travel lanes, can reduce the likelihood of crashes.

Further Research

Additional data sources can reveal further safety insights. This research may be supplemented by other public and private data sources to improve the situational awareness of PSAPs. In particular, probe and connected vehicle data can be used to better quantify safety risks such as hard braking and adverse weather conditions. Furthermore, TMC traffic cameras are an excellent source of ground truth. Private data sources may include basic safety messages from connected vehicles, images captured by automated trucks, and near-miss information from artificial intelligence solutions. This research serves as a strong foundation that may be leveraged to develop predictive models and early indicators of crash risk.

Case Study

The research team cross-referenced the Waze data with crashes reported in the media and analyzed the following case study as an example of how Waze reports may be used as an early safety risk indicator.



An Unexpected Breakdown Sets Off a Chain-Reaction

October 28, 2021 | Arlington, Texas

At 3:56 a.m. on October 28, 2021, a nineteen-year-old driver experiencing car trouble stopped his vehicle in the center westbound lane of I-30 near the Green Oaks Boulevard overpass. His vehicle was struck from behind by an SUV, which was in turn hit by a motorcycle. As the disabled-vehicle driver stepped out of his vehicle, a pickup truck collided with the other vehicles and the nineteen-year-old driver, killing him upon impact.

The three passengers who were inside the disabled vehicle were hospitalized with injuries that were not considered life-threatening. The drivers of the other vehicles suffered minor injuries but were not hospitalized.

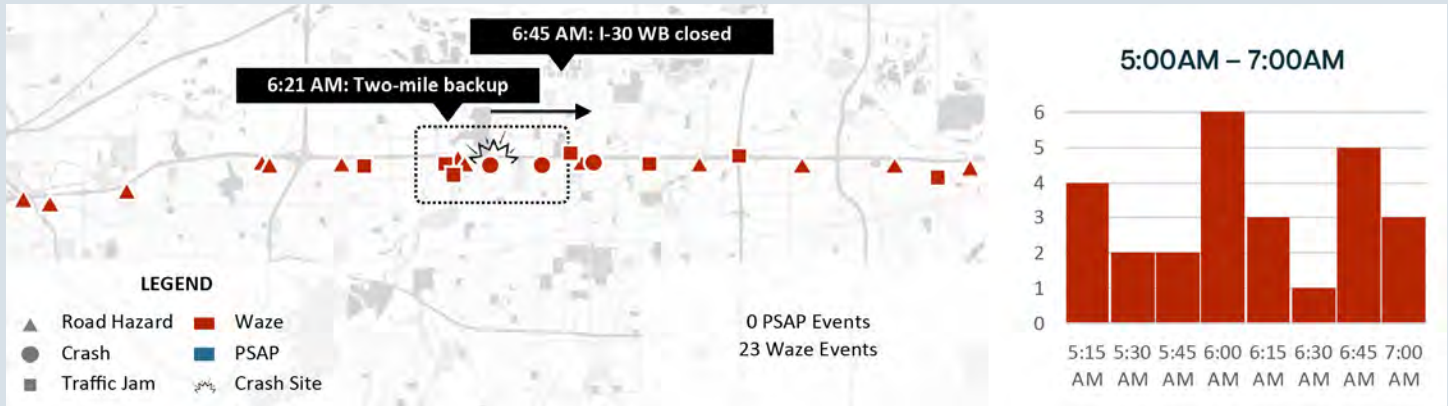
News outlets reported a two-mile backup at 6:21 a.m. Shortly after, the Arlington Police Department tweeted that the I-30 westbound lanes were closed. I-30 westbound was reopened just after 10:30 a.m. once crews worked to investigate and clear the scene.

Early Warning Signs

Preceding the crash, five Waze event clusters occurred along the I-30 corridor: one crash, three road hazards, and one traffic jam. Focusing on the crash and traffic jam cluster that occurred in closest proximity to the crash site, a total of nine individual Waze reports were made—six crash and three traffic jam reports. Although it is unclear that these Waze reports are in direct reference to the vehicle that would later be involved in the crash, this example shows that Waze alerts pose a safety risk and should be taken seriously.

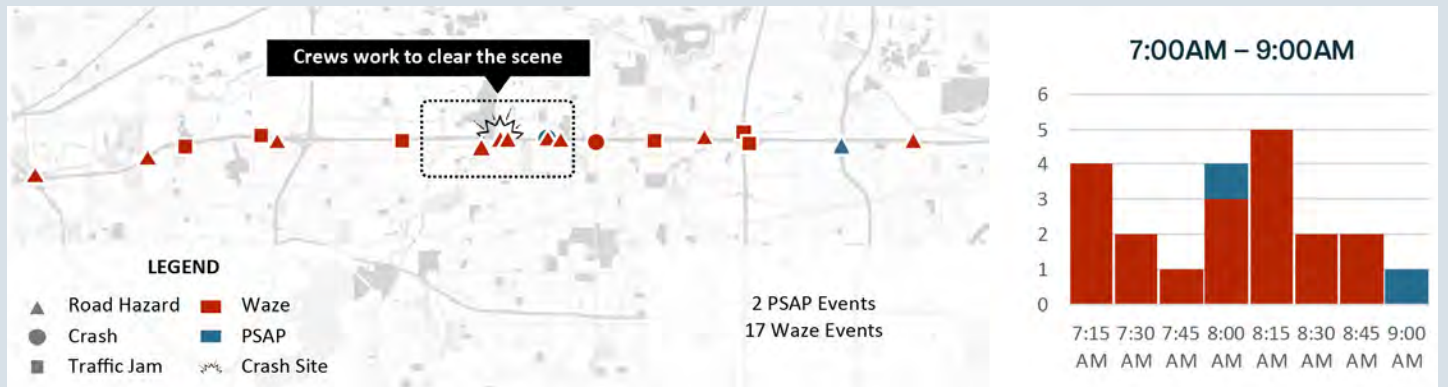
Crash Response

Within 10 minutes following the crash, two 9-1-1 calls were placed and one Waze road hazard report was made. Three additional Waze clusters formed before 5:00 am that included four crash reports, six traffic jams, and one road hazard.



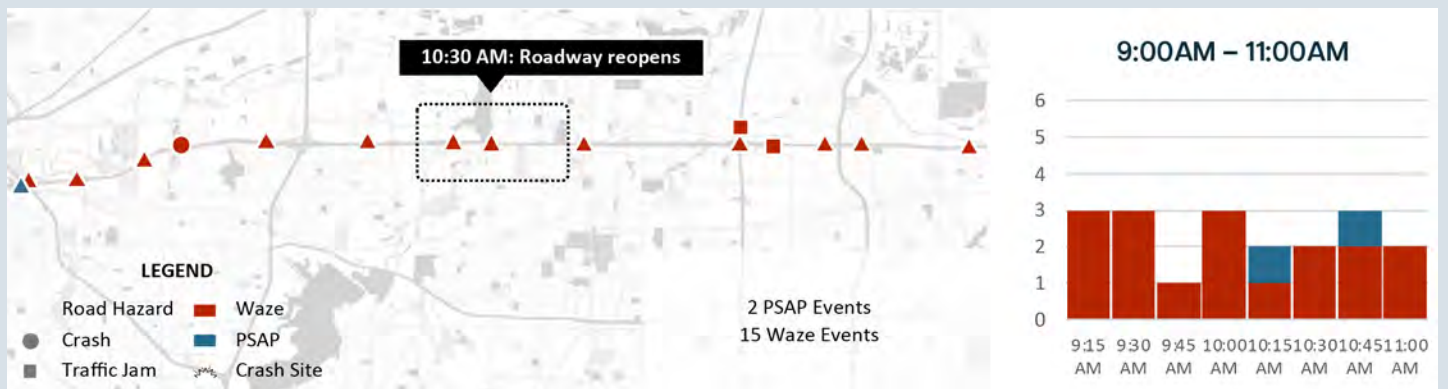
Traffic Impacts Due to Road Closure

During the next five-and-a-half hours, there were severe traffic delays while I-30 westbound lanes were closed. Two additional 9-1-1 calls and 17 Waze events were made.



Roadway Repopens

The roadway reopened at 10:30 am. Waze users continued to report road hazards and traffic jams. Waze report levels returned to normal later that afternoon.



Lessons Learned

- Waze road hazard reports can be used as an early indicator of safety risks; further research is needed to evaluate the correlation between road hazards and crashes.
- The reports made within 10 minutes of the crash were very accurate in location and became more dispersed over time.
- After the initial crash, significantly more reports were made through Waze denoting either road hazards or traffic jams.

BACKGROUND

Time and safety are the essential elements of incident response. The time required to detect and classify the incident, dispatch resources, and arrive on scene are critical to determining the outcomes of crashes and road hazards. Since first responders play an essential role in clearing incidents and saving lives, knowing when and where an incident occurs is crucial.

In 2021, there were nearly 60,000 crashes in the cities of Dallas, Grand Prairie, Arlington, and Fort Worth—resulting in more than 400 traffic fatalities and significant region-wide delays in congestion.¹ Road hazards also pose a safety risk. Abandoned vehicles or road debris like metal objects, shredded tires, and other litter can cause damage to a vehicle, and even prove deadly for motorists. A study by AAA found that nearly 37 percent of all deaths in road debris crashes resulted from the driver swerving to avoid hitting the object.² Consequently, first responders are turning to new data sources in order to increase their situational awareness of crashes and road hazards. This study evaluates the efficacy of Waze data—a real-time, crowdsourced platform of traffic alerts—in order to determine its value to first responders.

Challenge: Limited Data for First Responders

In the event of a crash or major road hazard, someone will typically call 9-1-1 and the report will be logged by a public safety answering point (PSAP). Callers, however, do not always provide an accurate location. The majority of calls that come into a PSAP today are placed through cellphones, which are routed through the nearest cellphone tower and do not allow for PSAP operators to quickly pinpoint the caller's location. PSAP operators will determine the caller's approximate location using a combination of triangulation and trilateration, narrowing the location down to within 300 meters of the nearest cell tower—about three football fields, a distance that can still take first responders a significant time to search. With a response time goal of just under nine minutes in the DFW region, every second counts.

Additionally, callers often fail to provide sufficient detail about the incident, particularly if it is on the road or the shoulder. While PSAPs can coordinate with local traffic management centers (TMCs) to tap into closed-circuit television (CCTV) cameras, these systems are not automated and require a TMC operator to manually inspect the incident. Finally, PSAPs have blind spots in their data. For example, callers may not report minor crashes or road hazards that are not perceived as an emergency. This type of information is especially useful to track the impact of fender-benders or to identify stopped vehicles that pose a safety risk, as seen in the chain-reaction case study. Crowdsourced data can prove to be a useful resource of information, homing in on an incident's location, providing additional detail, and filling in data gaps.

Opportunity: Crowdsourced Data Expands Situational Awareness

The proliferation of real-time data collected from road users, connected vehicles, and sensor-based infrastructure is revolutionizing incident response. The North Central Texas Emergency Communications District (NCT 9-1-1) is expanding the situational awareness of its PSAP operators with crowdsourced data. In 2019, NCT 9-1-1 partnered with Waze, a navigation application that enables users to report and receive traffic alerts in real-time. Waze users identify crashes, road hazards, adverse weather conditions, traffic jams, and road closures. Due to its simple user interface, large market share, and robust partnership network, there have been several studies that have shown Waze users to be faster in reporting incidents. A study by UCLA and UC Irvine found that crash-related reports from Waze users came an average of two minutes and 41 seconds earlier than reports received by California Highway Patrol emergency personnel.³ Looking at these time savings, NCT 9-1-1 recognizes the opportunity to improve response times, increase safety, and reduce congestion.

The Need for Data Evaluation

Although Waze data has proven valuable for incident management operations throughout the country, the specific benefits are dependent on several factors: traffic volume, incident type, and actionability. First, the time difference between a Waze and PSAP first report is dependent on the traffic volume. Freeways in urban areas have a higher traffic volume than suburban arterials, for example, and therefore have a higher number of people traveling who can report an incident either through Waze or by calling 9-1-1. Consequently, an evaluation of a specific corridor will reveal greater insights than an analysis of a broad geographic area that includes a variety of transportation facility types. Second, time savings vary greatly for different types of incidents. Crashes, in particular, have greater immediacy, and travelers will report the incident through Waze and/or 9-1-1 with a higher sense of urgency. On the other hand, road hazards, especially ones perceived as minor, may be reported with less urgency or not at all. Due to these differences in human behavior, it is important to investigate crashes and road hazards separately. Finally, a data evaluation should be designed to identify actionable insights. When a Waze user reports an incident, there is up to a two-minute delay until that information is transmitted to the PSAP. Therefore, time savings should be calculated based on when the Waze report is received by the PSAP. Based on these considerations, the project team crafted a methodology appropriate for the I-30 corridor in DFW.

PROJECT SCOPE, OBJECTIVES, AND DATA COLLECTION

To investigate the efficacy of Waze data, the Texas Department of Transportation (TxDOT) and North Central Texas Council of Governments (NCTCOG) launched the I-30 Waze and 911 Integration Pilot. The pilot complements the Texas Connected Freight Corridors (TCFC) project, which is Texas’s largest deployment of connected vehicle technology and was initialized by a 2017 U.S. Department (USDOT) grant. Conducted through a joint effort by the University of Texas at Austin Center for Transportation Research (CTR) and Texas A&M Transportation Institute (TTI), the I-30 Waze and 911 Integration Pilot aims to improve incident response and situational awareness along a twenty-three-mile stretch of I-30 in the Dallas-Fort Worth metroplex.

The pilot included three tasks. Beginning with a needs assessment, the project team identified and selected the simplest option for integrating Waze data into the PSAP computer-aided dispatch systems. The project team then developed a basic web brows-

er-based prototype tool that enabled PSAP operators to visualize Waze incidents and filter by incident and roadway type. Finally, the project team conducted an evaluation of seven months of data (September 2021 to March 2022) for the Fort Worth, Arlington, and Grand Prairie PSAPs. The evaluation focuses on three key criteria in order to assess the value of Waze data:

1. **Timing:** How are traffic incidents first reported—through Waze or PSAP—and how quickly?
2. **Location:** How far apart in distance and time are Waze and PSAP events?
3. **Incident Type:** How do the characteristics of crashes and road hazards differ?

Study Area

The pilot centered around the Interstate 30 (I-30) corridor in the Dallas-Fort Worth Metroplex. In particular, the analysis concentrated on a twenty-three-mile segment that extended through the Cities of Fort Worth, Arlington, and Grand Prairie, as shown in Figure 1.

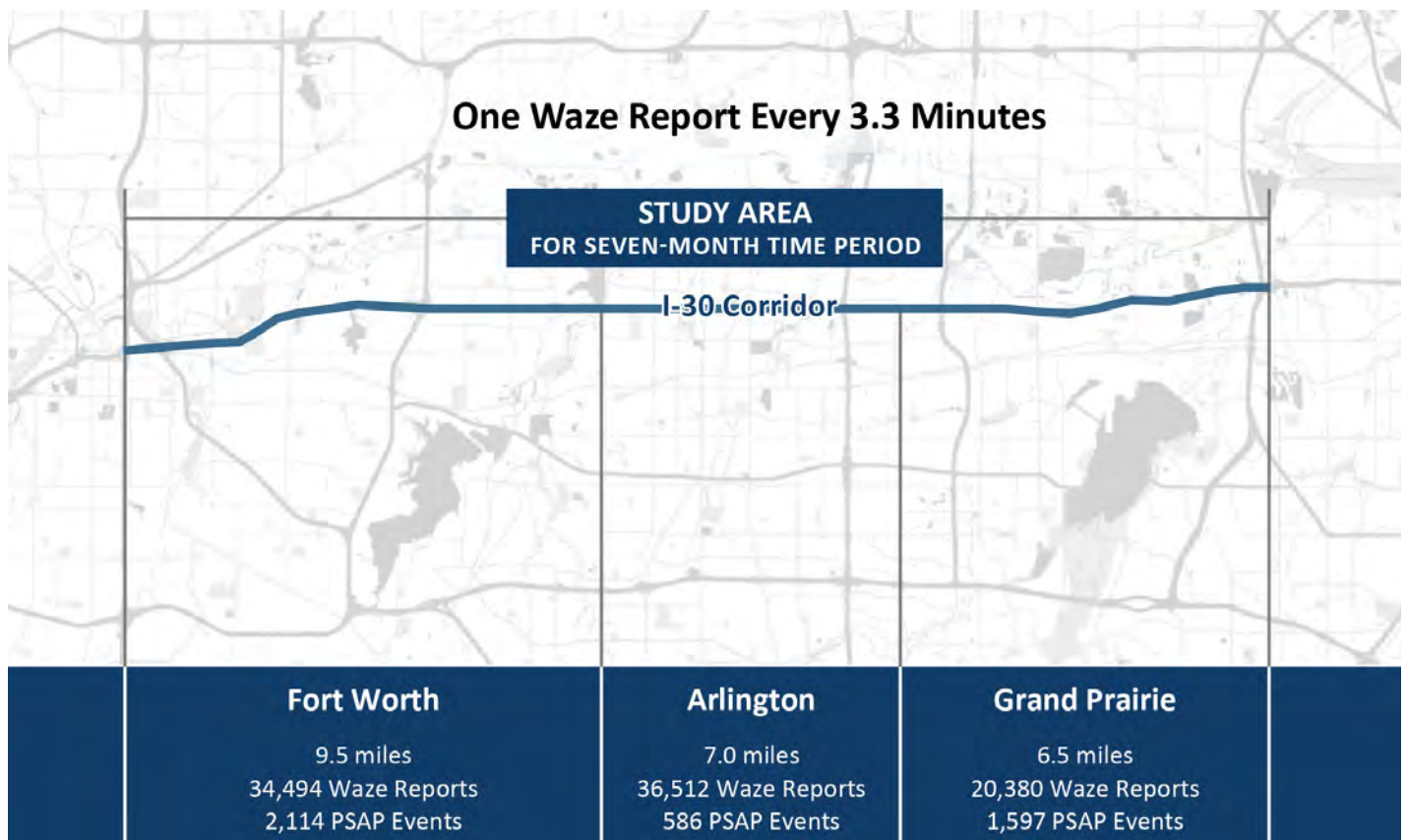


Figure 1. Study Area

Data Collection

The two primary data sources are Waze and PSAP event data that was collected over a period of seven months, from September 2021 to March 2022. A brief overview of the data sources is provided.

Waze Data Collection

Initially commercialized in 2008, Waze is the largest community-based, free traffic and navigation application that uses crowdsourced data to provide real-time traveler information.⁴ Waze users—known as “Wazers”—report and/or confirm existing reports of traffic incidents, ranging from crashes and stopped vehicles to roadside debris and nearby speed traps.

Waze launched the Connected Citizens Program (CCP) in June 2014 and was later updated to Waze for Cities (W4C). The program provides agencies with data on roadway incidents and disseminates information on road conditions to drivers. Waze data is accessible to its agency partners using eXtensible Markup Language (XML) or JavaScript Object Notation (JSON) formats.⁵

To collect data for this evaluation, the research team created a geofence around the I-30 corridor to collect Waze reports. All alert types and their available fields are archived at two-minute intervals in a data repository and can be accessed using Microsoft Azure and Storage Explorer. The research team filtered out a number of road types, such as trails, ferry crossings, and parking lot roads, that are not relevant to this study to minimize storage requirements. The Waze reports contain the type of incident, location, reporting time, confidence score, and reliability score. The confidence score is based on other Wazers reaction such as

‘thumbs up/down’ to the event (0-10) and reliability is based on other user’s reaction such as ‘thumbs up/down’ and the level of the Waze reporter (0-10).

PSAP Data Collection

A public safety answering point, or PSAP, is a call center to which 9-1-1 calls are routed. Dispatchers transfer calls to the appropriate agency to allocate emergency personnel and resources based on the type of event.⁶

The North Central Texas Emergency Communications District is responsible for overseeing more than forty PSAPs in the Dallas-Fort Worth Metroplex through which the study corridor runs. To provide effective service, PSAPs in the Dallas-Fort Worth Metroplex can handle multiple call types including those from land lines, wireless phones, and call from multi-line telephone switches. This pilot focuses on the wireless calls because they are the most comparable to the Waze events, which are likely to be reported by wireless devices.

The cities of Fort Worth, Arlington, and Grand Prairie contributed data to the pilot. The Fort Worth PSAP implemented an XML to provide data in real-time, while the cities of Arlington and Grand Prairie provided their data in a single data transfer. To maintain spatial consistency, the geographic fencing used to collect the Waze data along the I-30 corridor was applied to extract the PSAP data. The PSAP data feed provides event-based data, including: event ID, service type (law, fire, medical etc.), created time, updated time, name of the location, event coordinates, event description, and city. The data feed from Grand Prairie includes an additional field with the caller’s coordinates.



Table 1. Waze Data Fields and Formats		
Waze Field	Format	Description
Eventuuid	Text	Unique ID of the alert.
Eventtimestamp	Timestamp	Timestamp when the incident was reported.
Location_X	Double Precision	Longitude of user.
Location_Y	Double Precision	Latitude of user.
City	Text	City of the report (values are Grand Prairie, Fort Worth, and Arlington).
Roadtype	Numeric	Road type of the incident (values are 1 = Streets, 2 = Primary Street, 3 = Freeways, 4 = Ramps, 6 = Primary, 7 = Secondary, 17 = Private road, 20 = Parking lot road).
Magvar	Numeric	Heading of the user at the time of reporting. Value between 0-359. North is 0.
Street	Text	Street description of the incident.
Eventtype	Text	Type of the event (values are Accident, Jam, Road Closed, Weather Hazard).
Subtype	Text	Subtype of the event.
Reportdescription	Text	User description of the incident (optional).
Reportrating	Numeric	Rank of the user who reported the incident. Waze ranks its users based on how experienced and trustworthy they are. Value between 0 and 5, with 5 being most trustworthy.
Confidence	Numeric	Indicates feedback from other users based on reactions. Value between 0 and 5, with 5 being highest confidence.
Reliability	Numeric	Indicates how reliable the alert is based on other users' reactions and the rank of the reporter. Value between 5 and 10, with 10 being most reliable.
Nthumbsup	Numeric	Number of thumbs up given by users.

Table 2. PSAP Data Fields and Formats		
PSAP Field	Format	Description
Eventid	Text	Unique ID of the report.
Service	Text	Assigned service for the report (values are Fire, Police, Medical, Rescue)
Createdtime	Timestamp	Timestamp of when the incident was created.
Location	Text	Street description of the incident.
Latitude	Double Precision	Latitude of the incident as assigned by PSAP operator.
Longitude	Double Precision	Longitude of the incident as assigned by PSAP operator.
Description	Text	Type description of the incident.
City	Text	City of the report (Grand Prairie, Forth Worth, and Arlington).
Caller Latitude	Double Precision	Latitude of the caller (available only for Grand Prairie).
Caller Longitude	Double Precision	Longitude of the caller (available only for Grand Prairie).

METHODOLOGY

This study evaluated the potential benefits of incorporating Waze data to gain an enhanced situational awareness of real-time traffic conditions. All data feeds were stored in a PostgreSQL database with PostGIS extension. The incidents were visualized and analyzed in PostgreSQL, R and PowerBI. The project team developed a robust methodological framework for data processing, which consisted of four steps as illustrated in Figure 2.

1. **Pre-Processing.** Duplicate reports are removed and the remaining reports are reclassified.
2. **Clustering Waze Data.** Multiple Waze reports are clustered into a single event.
3. **Matching Waze and PSAP Data.** Waze and PSAP events that are related to the same incident are matched to one another.
4. **Evaluating: First Report, Time and Location, Incident Type.** Multiple analyses are performed to assess the value of Waze and PSAP data.

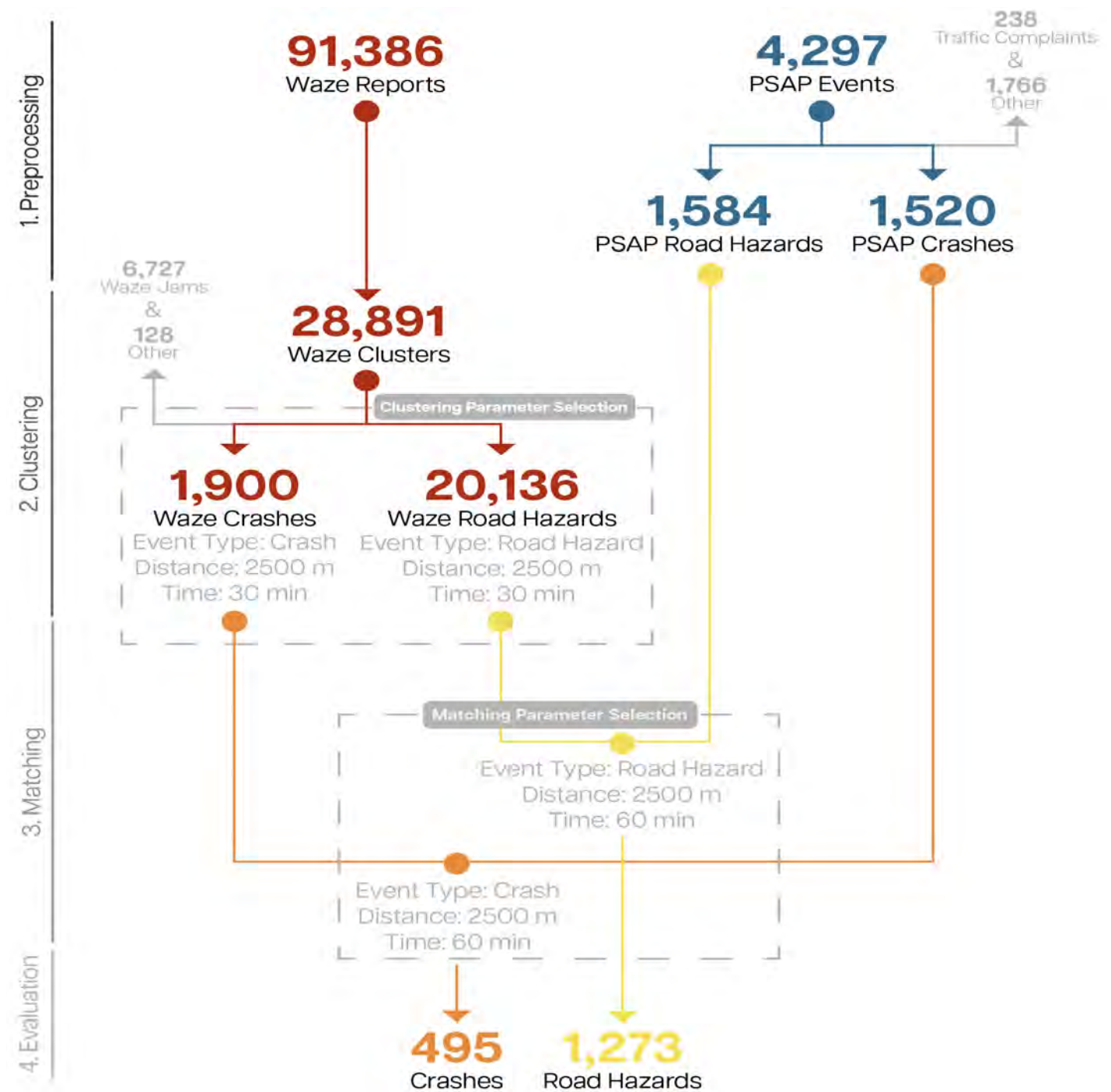


Figure 2. Evaluation Framework

1. Pre-Processing

Once the project team collected the raw PSAP and Waze data, the project team performed a series of preprocessing steps to transform it into cleaner information that is more suitable for further analysis and interpretation.

Reclassification

To align Waze and PSAP reports, the research team developed the reclassification system shown in Table 3. First,

the project team corrected a Waze misnomer by relabeling roadway and shoulder incidents (e.g., hazard on road - car stopped) from “Weather Hazards” to “Road Hazards.” Second, the project team grouped similar PSAP incidents that used different naming conventions (e.g., “Drive Wrong Way” and “Wrong Way Driver”) into a single set of subtypes. The reclassification system serves as the foundation for the clustering and matching processes and enables more direct comparisons.

Reclassified Type	Reclassified Subtype	Data Source	Raw Data Subtype
Crash	DWI	PSAP	Accident DWI
	Hit & Run	PSAP	Hit & Run: Commercial Vehicle
			Hit & Run Accident
			Hit & Run Accident: Auto/Pedestrian
			Hit & Run Report
			Hit & Run Accident
	Major	PSAP	Accident Commercial Vehicle
			Accident Involving Roll-over
			Accident Major
			Accident with Injury
			Accident with Trapped Person
			Fatality Accident
			Major Accident
			Major Accident: Commercial Vehicle
			Major Accident: Auto/Pedestrian
			Major Accident: Extrication
			Major Accident: Extrication with Helicopter
			Major Accident on Freeway
			Waze
	Minor	PSAP	Accident Minor
Accident Minor/Delayed			
Minor Accident: Commercial Vehicle			
Minor Accident: Auto/Pedestrian			
Minor Accident: Blocking			
Minor Accident: Not Blocking			
		Waze	Accident Minor
Unknown	Waze	Accident	
Traffic Complaint	Traffic Complaint	PSAP	Traffic Complaint
Road Hazard	Abandoned Vehicle	PSAP	Abandoned Vehicle
			Abandoned Vehicle: Priority
			Abandoned Vehicle: Routine
			Stranded Vehicle
	Fuel Spill	PSAP	Fuel Spill
Fuel Spill: Freeway			

Table 3. Reclassification System (cont.)

Reclassified Type	Reclassified Subtype	Data Source	Raw Data Subtype
Road Hazard, cont.	Grass/Brush Fire	PSAP	Grass Fire
			Grass/Brush
			Grass/Brush: Freeway
	Other	PSAP	Other: Traffic Hazard
	Stranded Motorist	PSAP	Other: Stranded Motorist
	Vehicle Fire	PSAP	Vehicle Fire
	Wrong-way Driver	PSAP	Drive Wrong Way
			Wrong-Way Driver
	On Road: Car Stopped	Waze	Hazard On Road: Car Stopped
	On Road: Other	Waze	Hazard On Road
			Hazard On Road: Construction
			Hazard On Road: Ice
			Hazard On Road: Object
			Hazard On Road: Pot Hole
			Hazard On Road: Road Kill
On Road: Traffic Light Fault			
On Shoulder: Car Stopped	Waze	Hazard On Shoulder: Car Stopped	
On Shoulder: Other	Waze	Hazard On Shoulder	
		Hazard On Shoulder: Animals	
		Hazard On Shoulder: Missing Sign	
Unknown	Waze	Hazard On Shoulder: Road Hazard	
Traffic Jam	Waze	Jam: Heavy Traffic	
		Jam: Moderate Traffic	
		Jam: Stand-still Traffic	
		Jam: Unknown	
Other	Other	PSAP	Ambulance Emergency
			Check Welfare
			Deceased Person
			Medical Emergency
			Psychiatric/Attempt Suicide
			Shooting
	Weather Hazard	Waze	Hazard Weather: Unknown
			Hazard Weather: Flood
			Hazard Weather: Fog
			Hazard Weather: Hail
	Hazard Weather: Heavy Snow		
	Road Closed	Waze	Road Closed: Construction
			Road Closed: Event
Road Closed: Hazard			

Pre-Processing Waze Data

The seven-month analysis period generated a significant volume of data and demonstrated that Waze data is a valuable tool that can enable PSAPs to optimize limited resources.

The first step in pre-processing the Waze data was to remove duplicate reports. Waze incidents that remain in the system for longer than the two-minute collection interval result in multiple reports from the same user. To reduce the number of reports down to one per user per event, the Unique User ID created by Waze was utilized, with information such as the first report time and last report time along with other pertinent information kept.

Once duplicate reports were removed, the study included 91,386 individual Waze reports—an average of one Waze report every 3.3 minutes. Each Waze report includes information that can be crucial for first responders—report time, location, and type of incident.

The incident type is of particular interest because it determines the type of response. For example, crashes warrant the immediate dispatch of fire and emergency medical services (EMS); whereas, a car stopped on the shoulder may require roadside assistance or a tow. Figure 3 shows that the majority of Waze reports were road hazards (39 percent), traffic jams (57 percent), or crashes (4 percent).

Waze report volumes varied by time of day. Figure 4 shows the contribution of different event types for each hour of the day during the seven months of the study period. As shown in the figure, traffic jam events were dominant during the morning and evening peak hours. Overall, the number of events (of all types) was higher during the afternoon peak hours.

Pre-Processing PSAP Data

Within the same seven-month analysis period, 4,371 PSAP reports were made. Many of the reports, however, belonged to the same caller and event because a PSAP operator will generate multiple reports depending on the types of law enforcement, medical, and/or fire resources that need to be dispatched. After removing duplicate reports, there were 4,297 unique PSAP events.

Figure 5 shows that the majority of PSAP events were either crashes (41 percent) or road hazards (43 percent), with a smaller portion for other incidents including welfare checks and medical emergencies. Of the crashes that occurred, over half of them were major crashes, including one that required an airlift.

PSAP report volumes also vary by time of day, as shown in Figure 6. The number of crashes and road hazards were the highest during the evening peak and morning peak respectively. Similar to Waze, PSAPs also experienced the highest number of events during the evening peak hours compared to other parts of the day.

The framework addresses some of the limitations of previous work in this field through three key features:

New Classification System. The raw data from Waze and PSAPs prevented an intelligible comparison. In particular, Waze does not include an explicit “Road Hazard” type; rather incidents such as potholes, objects, and construction are confusingly considered “Weather Hazards.” The project team therefore created a new “Road Hazard” type and classified the incidents based on placement: on road, on shoulder, or unknown. Secondly, the three PSAPs who contributed data to the study use different naming conventions for the same incidents. For example, Arlington uses the label “Drive Wrong Way” while Fort Worth uses “Wrong Way Driver.” The project team grouped similar incidents together in order to create a single set of subtypes. Using the new classification system, the project team was able to match and more directly compare Waze and PSAP reports.

Consideration of Event Type. Previous work either considers a singular event type (i.e., crashes) or ignores the event type entirely. However, the characteristics of the events and the incident response vary greatly by type and subtype. Major crashes, for example, warrant immediate response and the dispatch of medical services; whereas a road hazard, such as a shredded tire on the shoulder, is less urgent and requires a debris removal crew. Using the new classification system, the project team used the event type in order to cluster multiple Waze reports into a single event as well as to match Waze and PSAP events with one another. By separating the incidents by event type, the project team was able to provide more granular insights.

Data-based Approach to Select Clustering and Matching Parameters. Most studies use arbitrary time and distance parameters for the clustering and matching processes, ranging from 20-90 minutes and 70-40,000 meters. For this study, the project team conducted a robust sensitivity analysis in order to select appropriate time and distance parameters for both the clustering and matching processes. Additionally, the event was used in the sensitivity analysis which resulted in parameters being selected for crashes and road hazards separately. Consequently, the project team was able to detect differences between the spatial and temporal distribution of crashes and road hazards.

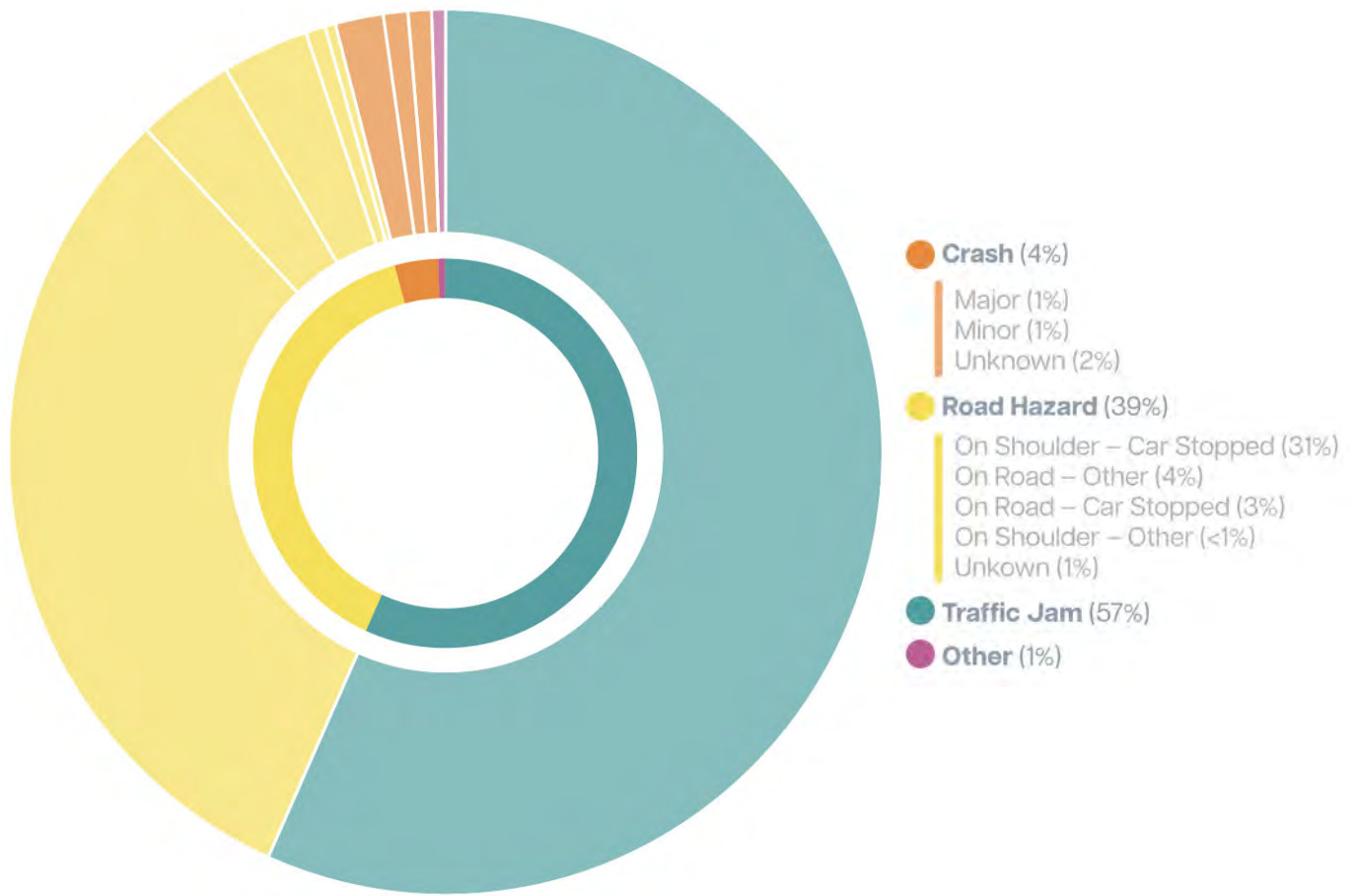


Figure 3. Waze Reports by Type and Subtype for the Seven-Month Time Period

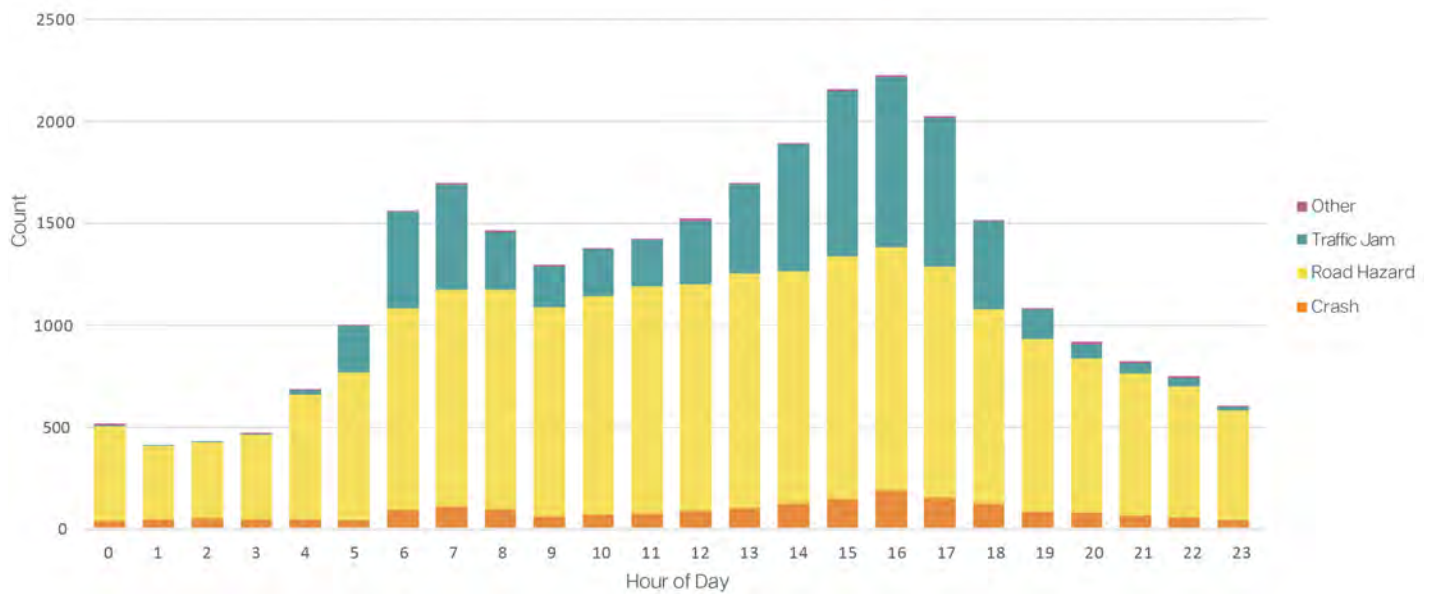


Figure 4. Waze Reports by Hour (and Event Type) for the Seven-Month Time Period

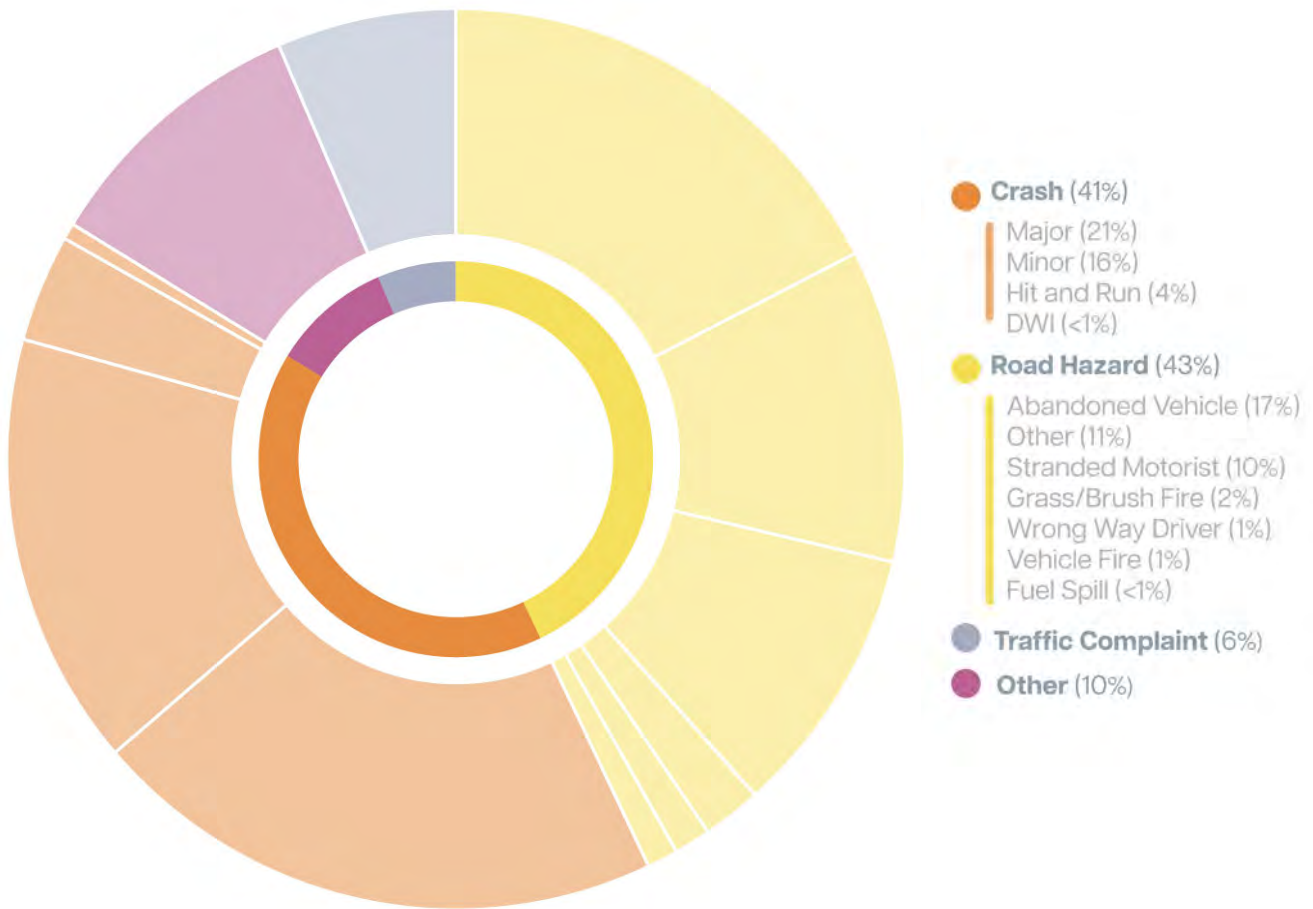


Figure 5. PSAP Events by Type and Subtype for the Seven-Month Time Period

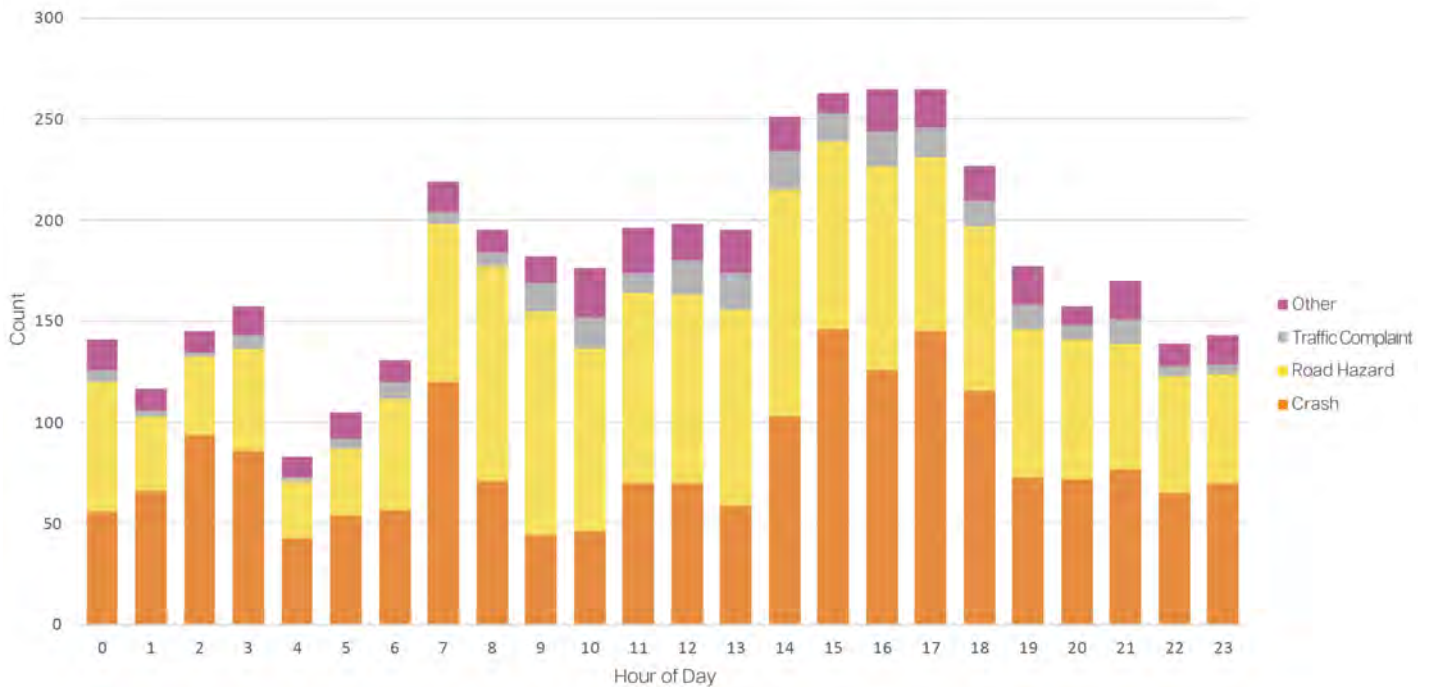


Figure 6. PSAP Reports by Hour of Day (and Event Type) for the Seven-Month Time Period

2. Clustering Waze Data

Often, several Waze reports were associated with a single incident. The project team therefore clustered Waze reports based on their event type as well as proximity in both time and space. Figure 7 illustrates the clustering process.

Sensitivity Analysis. To determine the criteria for clustering, a robust sensitivity analysis was performed for both crashes and road hazards. The project team performed 24 iterations by testing different combinations of time and distance thresholds. Three time intervals were tested—30 minutes, 60 minutes, and 90 minutes—and eight distance thresholds were tested, ranging from 500 meters to 3,500 meters at 500-meter increments. The final parameters selected for the evaluation of both crashes and road hazards were 60 minutes and 2,500 meters. The full sensitivity analysis may be found in Appendix B.

Results of the Clustering Process. The clustering process resulted in 29,493 unique Waze events. Since the cluster was formed around the first Waze report, the location and timestamp of the cluster were taken to be that of the first Waze report in the cluster.

3. Matching Waze and PSAP Data

Next, the Waze clusters and PSAP events were matched to one another in order to characterize a single incident. Figure 8 illustrates the matching process.

Sensitivity Analysis. Similar to the clustering process, the project team performed a sensitivity analysis for both crashes and road hazards in order to determine the appropriate matching criteria. The project team per-

formed 12 iterations by testing different combinations of time and distance thresholds. Two time intervals were tested—30 minutes and 60 minutes—and six distance thresholds were tested, ranging from 1,000 meters to 3,500 meters at 500-meter increments. The final parameters selected for the evaluation differed for crashes and road hazards. The crash parameters were 30 minutes and 2,500 meters, while road hazards were matched at 60 minutes and 2,500 meters. The longer time parameter for road hazards can be attributed to the fact that incidents such as abandoned vehicles may remain for an extended period of time, whereas crashes typically occur and are cleared within a half-hour. The full sensitivity analysis may be found in Appendix B.

Results of the Matching Process. Waze and PSAP events were matched using their respective parameters by creating a spatial and temporal buffer around each PSAP event. As shown in Figure 8, a PSAP crash was matched with a Waze crash that was reported within 30 minutes and 2,500 meter of the PSAP report. Table 4 reports the success rate of matching Waze and PSAP events by type and subtype. For crash events, approximately 26 percent of Waze crashes and 33 percent of PSAP crashes were matched. Of note, are the 78 percent of unmatched Waze minor crashes which represent incidents that are going unreported to PSAPs. For road hazards, only 6 percent of Waze road hazards are being matched whereas 80 percent of PSAP road hazards are being matched. This drastic difference indicates that road hazards reported to PSAPs are highly likely to be confirmed and validated by Waze reports.

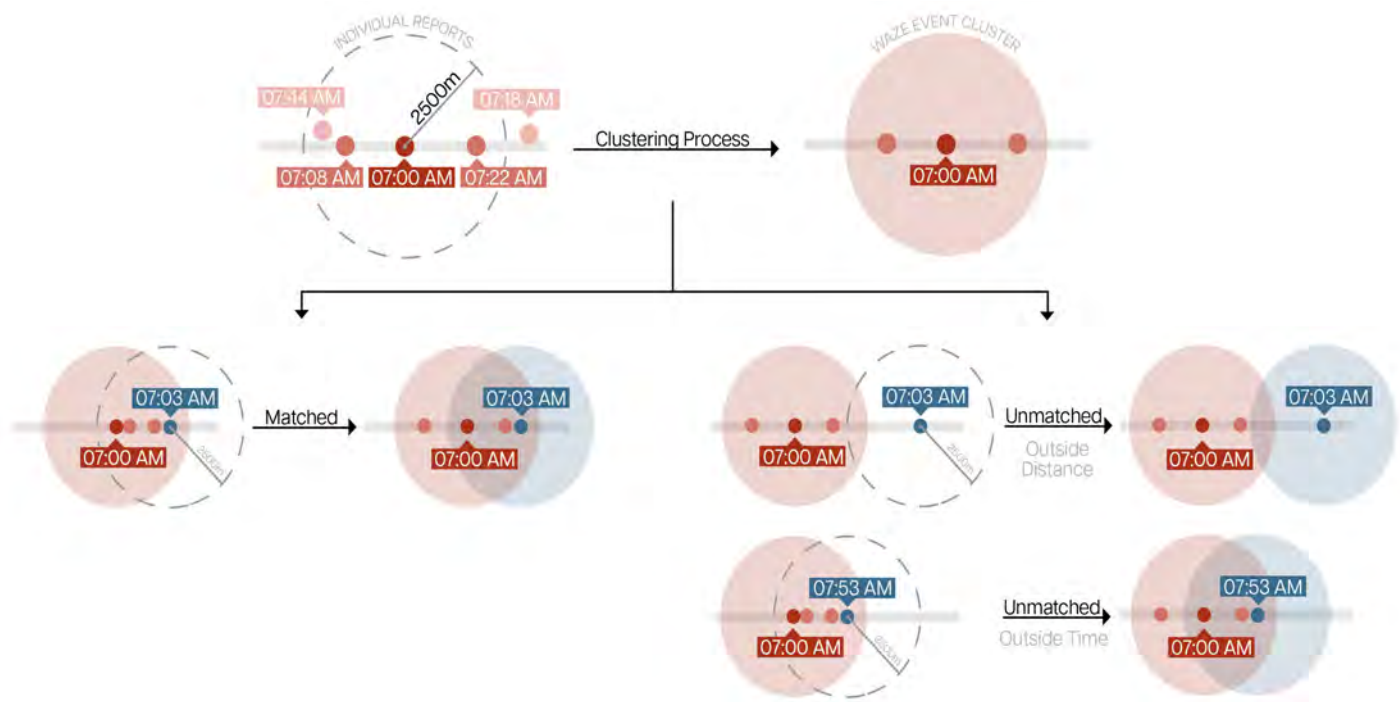


Figure 7. Clustering Process

Table 4. Count of Matched and Unmatched PSAP Events by Type and Subtype

Event Type	Subtype	Waze Matched	Waze Unmatched	PSAP Matched	PSAP Unmatched
Crash	Major	149	304	252	525
	Minor	110	384	189	390
	DWI	—	—	10	12
	Hit & Run	—	—	44	98
	Unknown	236	717	—	—
	Road Hazard: Unknown	495	1,405	495	1,025
Road Hazard	On Road: Car Stopped	128	1,552	—	—
	On Road: Other	123	1,709	—	—
	On Shoulder: Car Stopped	991	15,097	—	—
	On Shoulder: Other	12	181	—	—
	Road Hazard: Unknown	19	324	—	—
	Abandoned Vehicle	—	—	530	117
	Stranded Motorist	—	—	290	72
	Fuel Spill	—	—	3	1
	Grass/Brush Fire	—	—	63	15
	Vehicle Fire	—	—	42	6
	Wrong-way Driver	—	—	19	11
	Other	—	—	326	89
	TOTAL ROAD HAZARDS		1,273	18,863	1,273

4. Evaluation

The project team conducted a comprehensive analysis of the matched Waze and PSAP. In particular, a series of core analyses were performed to focus on key research questions of interest to first responders. Additionally, the project team performed three supplemental analyses to offer insights to traffic operators and the academic community. The findings of the core analyses are presented in the Results and Discussion section and the results of the supplemental analyses can be found in Appendix C.

Core Analyses

Volume, Type, and Subtype Comparison. A side-by-side comparison of the volume, type, and subtype features across PSAP and Waze events to understand the strengths of each data source.

First Report. An analysis to determine if an incident is first reported to Waze or a PSAP and how quickly.

Time and Distance. A spatiotemporal distribution for matched crashes and road hazards that describes how closely in time and space Waze and PSAP reports are made to one another.

Case Study. A deep-dive into a single incident using Waze data that was cross-referenced with crash reports in the media.

Supplemental Analyses

Grand Prairie Caller Location Analysis. Examines the 9-1-1 caller’s location relative to the PSAP reported location for Grand Prairie events only.

False Report Analysis. Ascertain whether the large volume of unmatched Waze road hazards are false alarms using INRIX speed data as a supplemental data source.

Mixed Matching Analysis. Performs a second iteration of the matching process without first sorting the events by type. In other words, PSAP crashes are allowed to match with Waze crashes, road hazards, or traffic jams. This analysis was conducted to enable comparison with other research efforts who use a mixed matching methodology as well as to demonstrate the benefit of including the event type as one of the criteria in the matching process.

RESULTS AND DISCUSSION

The project team determined the potential benefits of integrating Waze data with PSAP data using the methodology outlined in the previous section. This chapter interprets and illuminates the key findings for first responders.

How do Waze and PSAP Data Compare?

In order to compare Waze and PSAP events side-by-side, the project team used the matching process described in Section 3.3 to link Waze and PSAP events with one another. Figure 9 illustrates the number of matched and unmatched events, including a breakdown by subtype. The matching process resulted in 495 matched crashes and 1,273 matched road hazards. Several observations are made regarding the volume, type, and subtype of the events.

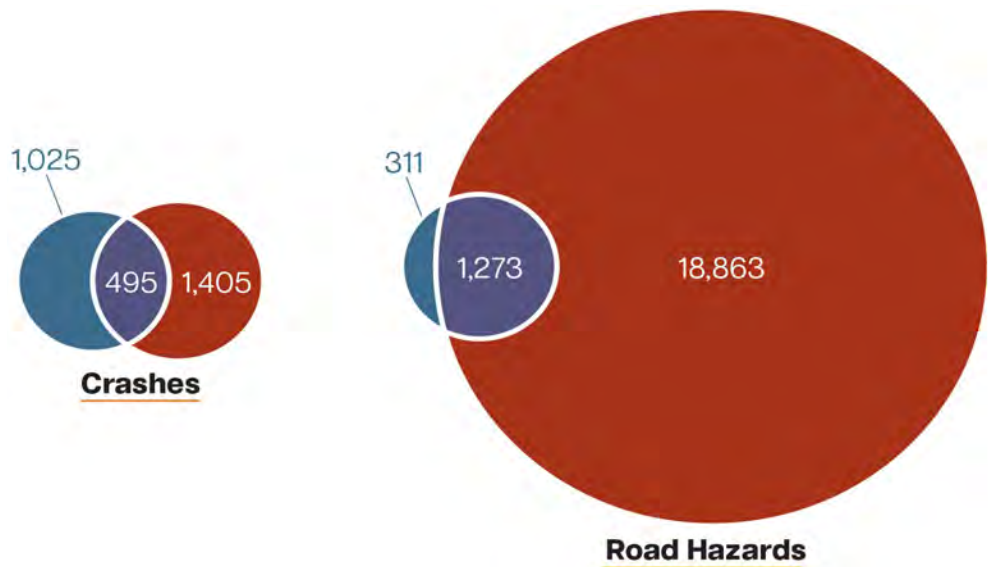


Figure 8. Matched and Unmatched Waze and PSAP Events by Type

KEY FINDING

There were significantly more road hazard events than crashes, nearly 12 times.

First, the sheer number of road hazards outweighed the number of crashes 12 to one. The majority of the events, 94 percent, went unreported to PSAPs—demonstrating that Waze can be a valuable resource to address a PSAP data gap. Taking a closer look at the subtype, 80 percent of the unreported Waze road hazards were cars stopped on the shoulder. As shown by the chain-reaction crash, detecting road hazards early can significantly lower the crash risk for motorists.

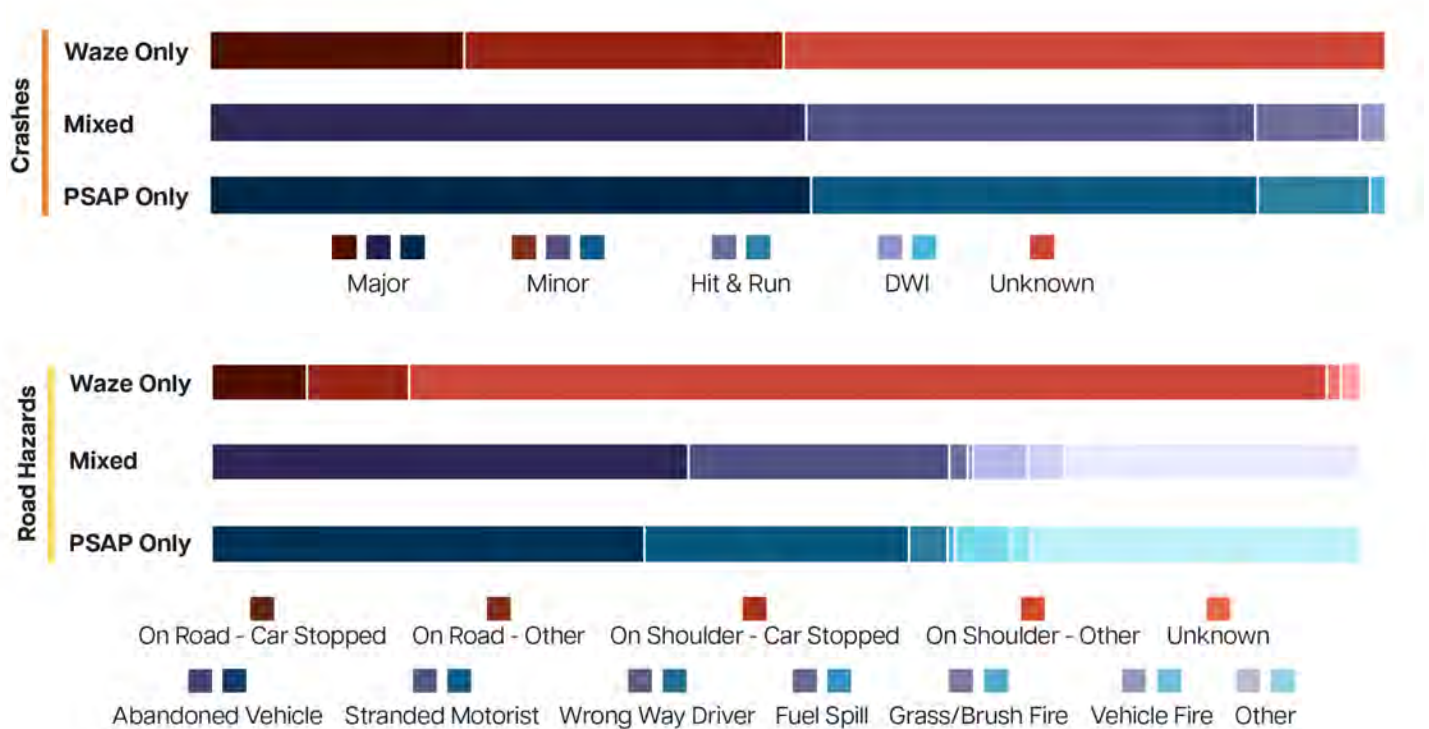


Figure 9. Matched and Unmatched Waze and PSAP Events by Subtype

Who Reports It First and How Quickly?

When it comes to incident response, time has critical safety and mobility implications. The project team conducted a first report analysis to determine how events are being first reported and how quickly. Figures 10 and 11 show the results by type and subtype, respectively.

KEY FINDING Crashes were first reported to PSAPs an average of 10 minutes earlier than Waze 80 percent of the time.

A vast majority of the time, travelers are reporting crashes to a PSAP before Waze. This result shows that for safety emergencies (crashes or incidents that potentially involve injury) drivers are more likely to call 9-1-1 than to report to Waze. This finding is confirmed by previous reports that indicate public agencies generally detect major crashes on interstates earlier than Waze.⁷

KEY FINDING PSAPs should focus on the 20 percent of crashes first reported to Waze an average of nine minutes sooner.

PSAPs can use Waze data to improve response times for one out of every five crashes. This opportunity has several immediate health implications for persons injured in roadway incidents, including faster treatment, reduction in secondary crashes, and lower fatality rates. Hence, Waze crash reports are still likely to have major safety impacts. The findings also indicate that Waze is more adept at detecting minor crashes earlier compared to major ones. PSAPs can benefit from the head start gained from the Waze first reports to tailor incident responses and minimize traffic disruption.

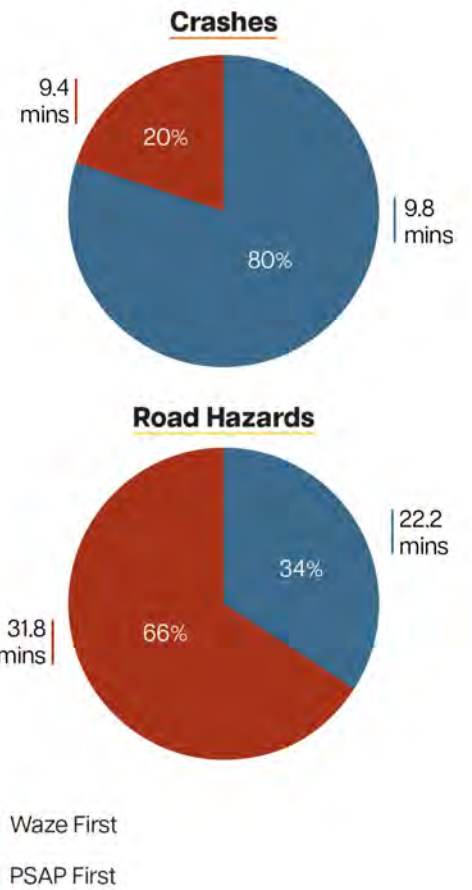


Figure 10. First Report by Type

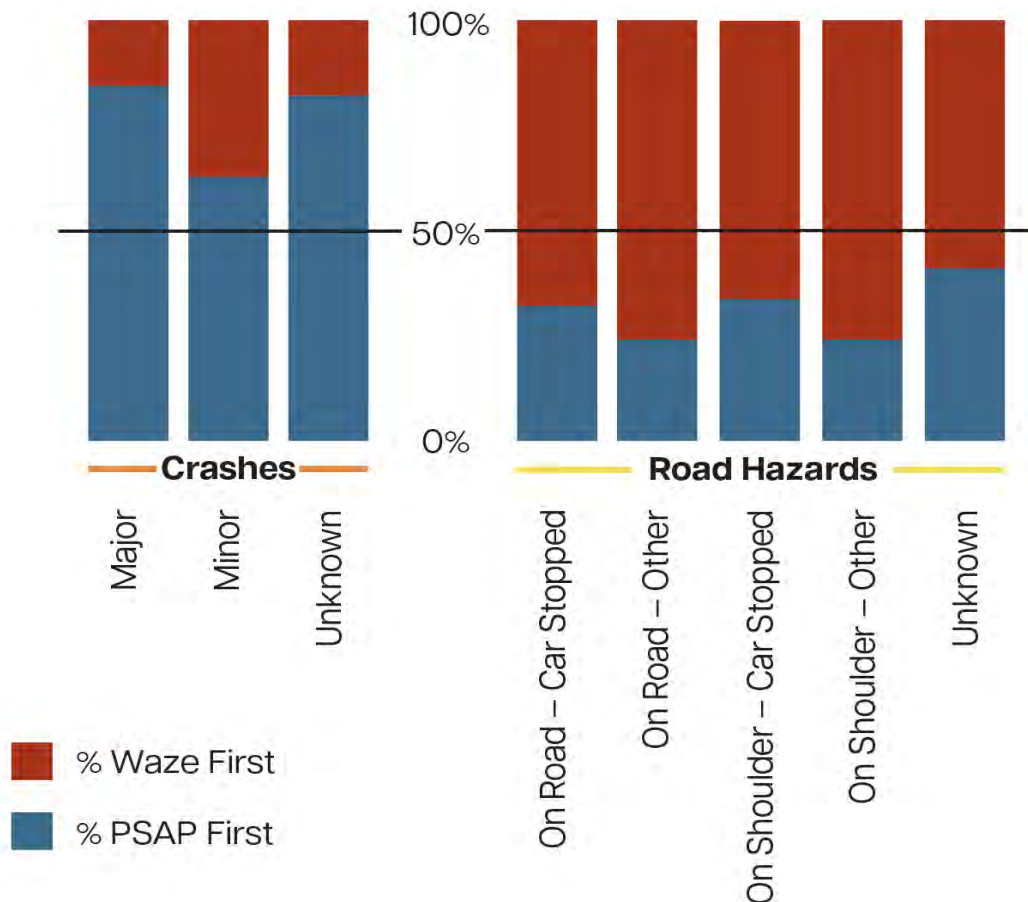


Figure 11. First Report by Subtype

KEY FINDING

Road hazards, on the other hand, were reported first through Waze 66 percent of the time at an average of 32 minutes before a 9-1-1 call was placed.

Road hazards are typically considered non-emergency events, which is reflected in the frequency of road hazards being reported through Waze first and often unreported to PSAPs. Yet, road hazards—even minor ones—should be addressed in a timely manner. Given that road hazards often disrupt traffic or cause crashes, Waze data can be leveraged by PSAPs to increase situational awareness and improve incident response times. The findings suggest that Waze is indeed quite efficient in detecting road hazard events early, providing PSAP operators with ample time to act accordingly. Moreover the case study presented in this report, where several road hazard reports were made during the half-hour preceding the fatal crash, underlines the fact that road hazards pose a safety risk and should be taken seriously.

KEY FINDING

Waze data is dependent on the number of active users, making it particularly effective during peak hours.

Figure 12 shows a comparison of the first report for crash events by time of day. The number of crash reports, first reported by Waze, was the highest during the evening peak hours. Therefore, PSAPs can anticipate more first reports being detected by Waze when the traffic is heavy.

SUPPLEMENTAL ANALYSIS

The following summarizes the key findings from each of the supplemental analyses:

Grand Prairie Caller Location Analysis. The caller locations obtained from Grand Prairie were found to be in close proximity to the PSAP-reported location. Therefore, the Grand Prairie PSAP can continue to rely upon their system for obtaining coordinates through cell phone carriers.

False Report Analysis. Upon examination of the unmatched Waze events, the project team found that up to 50 percent of crashes and 20 percent of road hazards were valid. The project team used INRIX data to cross-reference the unmatched events and was able to confirm atypical traffic conditions for several events. This type of analysis could be scaled in order to provide PSAPs with a real-time reliability score that would increase their trust of Waze data.

Mixed Matching Analysis. When the project team performed a second iteration of the matching process without first sorting the events by type, it was found that 55 percent of the time Waze received the first report an average of 16 minutes sooner than the PSAP was notified. This process, however, is biased towards the large volume of road hazards which are typically received by Waze an average of 32 minutes before a PSAP road hazard report. This analysis allows the project team to compare its findings with other studies who used a mixed matching process and validates the importance of first sorting the events by type.

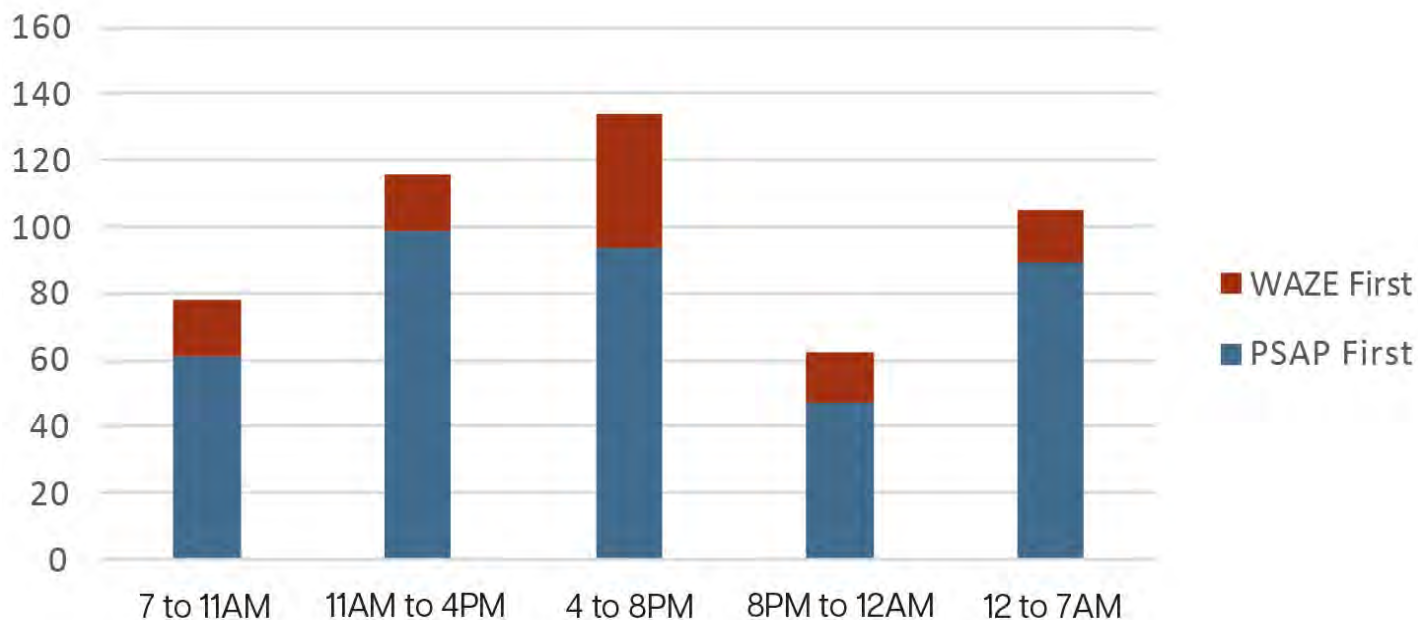


Figure 12. Comparison of Waze and PSAP Crash First Reports by Time of Day

How Accurate Is Waze Data?

In addition to early reporting, Waze can provide location information to the PSAP operators. Callers often fail to provide an accurate position of the incident and information provided by wireless cell phone carriers can vary widely. Waze data can be used to supplement and home in on the incident's position. Even when a traveler may call 9-1-1 first, a PSAP operator may review the incoming Waze reports to dispatch resources to the appropriate coordinates. To assess how accurate Waze reports are in both space and time, the project team developed a spatio-temporal distribution, shown in Figure 13, for both crashes and road hazards.

KEY FINDING Crashes are concentrated more closely together in time and space, whereas road hazards are further dispersed.

Approximately 60 percent of the matched crashes reported by Waze and PSAP were closely spaced (within 500 meters), which is comparable to other studies.⁸ Furthermore, around 60 percent of the matched crashes were closely spaced (within ten minutes) in time. This finding suggests that the Waze reported coordinates for crashes are reasonably accu-

rate and agencies can take a cue from Waze data to ascertain a crash location when needed. This pattern is most likely the result of people who were involved in the crash calling 9-1-1 or the human tendency to report an emergency involving people with greater immediacy than the observation of road debris.

Matched road hazards, however, were farther from their reported location. Around 15 percent of road hazard incidents were located more than 2,000 meters apart. As a result, incident responders may need to search up to 2,500 meters beyond the reported location when using location coordinates for road hazards from Waze. This finding may be a result of Waze users reporting information while continuing to travel; as a result, the incident location can be several hundred meters behind the reported location. PSAPs can use Waze reports to guide first responders to the scene as well as confer with traffic management center (TMC) operators who have access to live camera feeds of the corridor. Additionally, the time difference for matched road hazards was comparatively longer—taking PSAPs 30 to 60 minutes to detect around 40 percent of the Waze first reported events. This finding may reflect a lower sense of urgency and therefore willingness to call 9-1-1 for minor road hazards or hazards on the shoulder

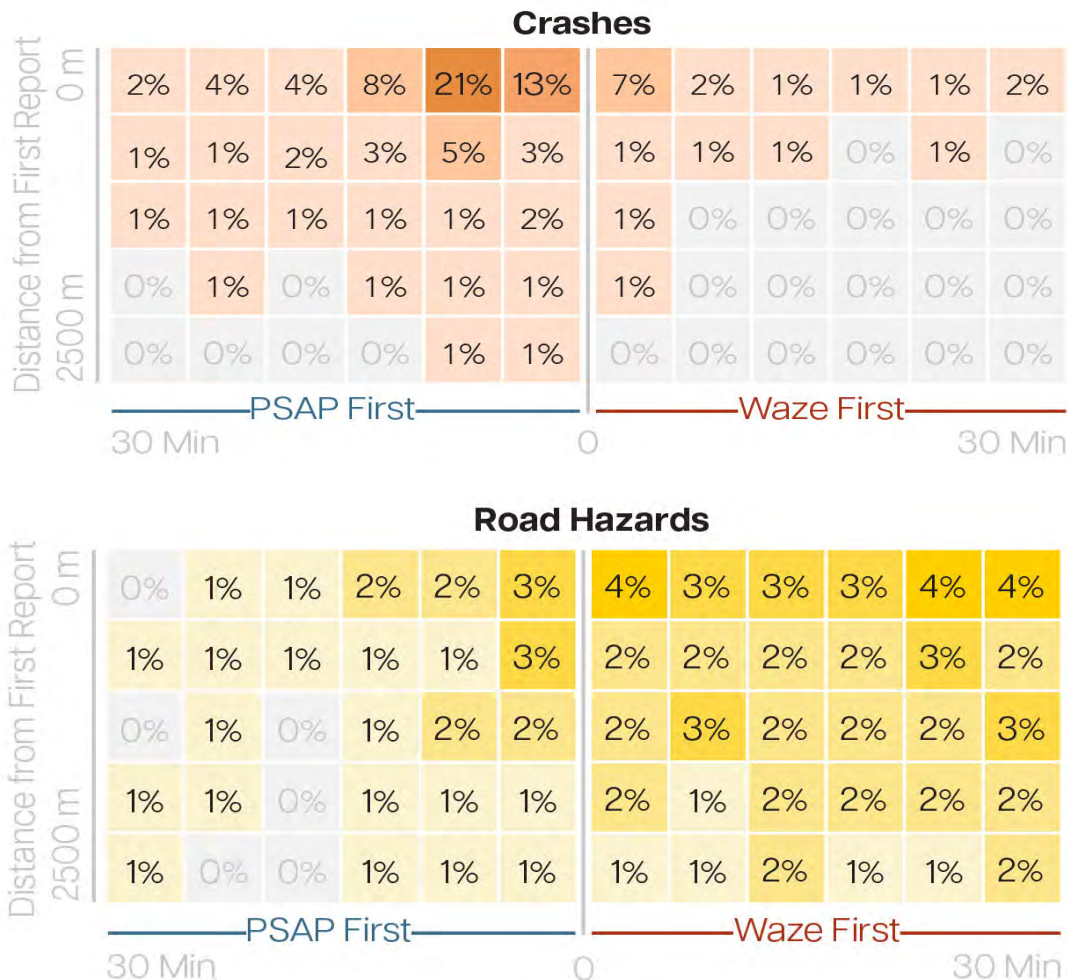


Figure 13. Timing and Location for Crashes and Road Hazards

RECOMMENDATIONS AND FUTURE RESEARCH

Based on the comprehensive evaluation, the project team has formulated several recommendations for PSAPs. Additionally, the project team has proposed a few avenues for future research to increase the effectiveness of the Waze-PSAP integration and to minimize the impact of traffic-disrupting events.

Recommendations

This study is the first to lay out a robust methodological framework to assess and evaluate Waze and PSAP data. It found that Waze data can prove most useful in early detection of road hazards and minor crashes. Time savings for first responders can further reduce the risk of primary and secondary crashes. Key findings of the report include:

Continue to rely on 9-1-1 calls as the primary reporting mechanism when crashes occur. PSAP beats Waze in detecting a crash 80 percent of the time. A crash witness will call 9-1-1, on average, 10 minutes before Waze users are report in the app. This may be due to the large traffic volume on the I-30 corridor and human tendency to call 9-1-1 in the event of a major crash.

Look to Waze data to improve response times for minor crashes. For the 20 percent of crashes that are first reported to Waze, first responders can be dispatched an average of nine minutes earlier. While there may not be serious injuries, clearing the crash can reduce the risk of secondary crashes and ensure proper medical attention is provided. In case of a Waze-reported major crash alert, even if a 9-1-1 call has not been received, PSAPs should take the report seriously and can coordinate with the TMC to verify the incident.

Leverage Waze data to pinpoint crash locations. Waze data was found to be reasonably accurate in locating crashes, which can assist first responders as they search for the scene of an incident. Most Waze reports were near the PSAP crash locations, indicating higher reliability and accuracy. First responders can review Waze-reported coordinates to home in on the location of a crash when needed.

Use Waze data to identify, prioritize, and address road hazards early. Waze has a 32-minute advantage in detecting road hazards. Of the hazards that are called into 9-1-1, 66 percent of the time they are first reported through Waze. Using Waze data, PSAPs can improve roadside assistance, debris removal, and towing services thus mitigating the road hazard safety risk to travelers.

Expand search radius for road hazards. Road hazard reports were found to be more dispersed, requiring first responders to search up to 2,500 meters beyond the reported location. Often, Waze reported coordinates were further downstream from the actual road hazard due to continued travel. To manage a Waze-reported road hazard event, first responders may need to expand their search upstream.

Respond to road hazards to lower crash risk. Twelve times more road hazard events are reported to Waze, with 94 percent of them never being reported to a PSAP. While many people may decide that a car stopped on the shoulder does not warrant a 9-1-1 call, they consider it significant enough to report to their fellow drivers through the Waze platform. As seen by the chain-reaction crash, addressing road hazards in a timely manner, particularly those in the travel lanes, can reduce the likelihood of crashes.

Future Research

Building off this study, the project team has identified three areas of future research:

Develop a credibility score to assess Waze false reports. The study revealed two inherent issues related to Waze: 1) a substantial number of Waze alerts were not detected by a PSAP and 2) several PSAP alerts were not detected by Waze. The significant volume of the Waze alerts that were unmatched by the PSAPs highlights the challenge faced by the dispatching agencies with limited resources. It is not practical for PSAPs to dispatch resources to respond to every Waze alert without having additional information. Therefore, there is a need to develop an automated process to filter incoming Waze alerts before transmitting them to TMC operators. In the pursuit to understand when an independent Waze alert is reliable enough to dispatch resources, a methodology is needed to determine which of the unmatched Waze alerts are credible and which are false reports. Determining if the unmatched alerts are a false alarm or an actual event not reported to the PSAP could be addressed by conducting further validation from an independent data source such as INRIX. Preliminary results from the false report supplemental analysis in this study have already suggested that INRIX was able to capture an additional 50 percent of the unmatched crashes and an additional 20 percent of the unmatched road hazards. Future research can extend quantitative insights into those reports incorporating multiple criteria including weather (NOAA data), location type (Rhino data), reliability (Waze report), and vehicle speeds (INRIX data). The automated filtering process would enable TMC operators to take prompt decisions to dispatch resources with confidence based on incoming Waze alerts.

Study the Relationship between Road Hazards and Crashes. The current study had already indicated that Waze offers an average 32-minute advantage in detecting road hazards. Moreover, a significant number of road hazard events were not reported in PSAP, many of which were serious enough to disrupt the regular traffic flow. Road hazards of any kind can be responsible for a crash, safety risk, or traffic congestion—all of which can be avoided if a roadside incident is handled promptly. Past studies as well as the case study presented in this report have suggested a possible relationship between roadside hazards and crashes.⁹ For instance, a study examining crashes from 2011 to 2014 revealed that road debris was a factor in a

total of more than 200,000 police-reported crashes resulting in approximately 500 deaths. Hence, to reduce these hazard-related crashes, a deeper understanding of the relationship between road hazards and crashes is warranted. Future research can build on the current study and leverage additional data such as crash contributing factors (using CRIS), hard-braking and acceleration events (using connected vehicle data), speed profiles (using vehicle probe data), and video footage to detect near-misses (using dashcams and other sensors) to understand the safety risk posed by the roadside incidents. The research outcome is expected to help incident management operators know when and how a Waze-reported road hazard event needs to be addressed to reduce safety risks and traffic disruption.

Establish a predictive safety model to alert TMCs in real-time of high-risk conditions. Finally, Waze data can be utilized to develop a real-time crash model to inform traffic management centers of and dispatch resources during high-risk safety conditions. Generally, these crash models monitor real-time traffic conditions, such as speed, traffic flow, congestion,

weather, and driver behavior to forecast the crash risk within a short time period. In recent years, considerable research has been invested in the development of real-time crash models which heavily relied on loop detector and roadside radar sensor data. Undoubtedly, the recent proliferation of crowdsourced and vehicle-probe-based traffic data are paving the way to a more profound and extensive analysis of traffic dynamics than ever before.

Crowdsourced data has an important implication for the real-time crash models. For example, a roadside hazard alert, repeatedly reported in Waze, may represent a high crash risk. Additionally, some driving behavior such as hard braking may significantly increase the risk of vehicles-to-vehicle interactions. 3-1-1 data may also be a valuable resource to identify debris and other object reports. Finally, historical crash trends may also inform the predictive safety model, identifying safety hotspots at specific locations or times of day. Future research can develop a machine-learning model that fuses multiple real-time data sources and historic data to assess safety risks and enable PSAPs and TMCs to take proactive steps.





APPENDIX A: PREVIOUS STUDIES AND EFFORTS

Among the sources that have been leveraged for crowd-sourced data, Waze has emerged as a potential data source for cities. Waze is a social navigation application in which people can report on traffic information. Waze has partnered with cities through their Waze for Cities program (formerly the Connected Citizens Program (CCP)).^{A1} Through this program, Waze provides real-time, anonymous incident and slow-down information to cities that is collected from drivers.^{A2} Data from Waze comes in two forms, passively collected traffic speed data and actively reported user reports such as incident and traffic jam reports.^{A3}

Waze Clustering Methodologies

Because of the nature of the data collection and with multiple Waze users being able to report on the same incident, there is the possibility of having redundant and related alerts for the same traffic incidents. As noted by Ali et al. the clustering of related alerts and matching those alerts with data from other sources is one of the main challenges to using Waze data.^{A4} One factor affecting the effectiveness of matching Waze data to other sources is the highly variable nature of Waze alert reporting, which is correlated with drivers' routines.^{A5} To cluster multiple Waze reports to a single incident, and to other sources of incident detection data, researchers have relied on various parameter matching, segmentation, and clustering techniques. Others have utilized semantic information found in the incident reports such as road name, direction of travel, and type of incident to further match incidents and check that clustering techniques do not match unrelated reported together.^{A6}

One of the first studies to include crowdsourced data, Ali et al. used geohashing to map and link multiple events together based solely the distance between two locations.^{A7} Accounting for spatial and temporal proximity of Waze alerts, Dos Santos et al. related two or more records together if the published time was within an hour, and the reports were within 50 meters of each, or 150 meters if the reports are on the same road.^{A8} Lenkei and Eriksson built on the work of Dos Santos et al. but relaxed the parameters used to 70 meters, and 500 meters if on the same road.^{A9} It was noted that these criteria values were not calibrated and are based on assumptions of reporting delays and inaccuracies of location information. Along with the use of spatial and temporal matching, Density Based Spatial Clustering of Application with Noise (DBSCAN) has also been used to cluster-related alerts.^{A10} Utilizing this clustering technique, Amin-Naseri recommended the use of incident clustering thresholds of 2.5-mile radius, and two hours of lag time.^{A11} Senarath et al. used DBSCAN to cluster related alerts before conducting Bayesian Information fusion, used tighter parameters of 25-minute period and 100-meter distance.^{A12}

Waze and PSAP Matching Methodologies

Building off these recommendations and focusing on matching Waze to advanced traffic management system (ATMS) reports, Li et al. used a t-test to determine the optimal threshold for matching of incidents, which were found to be 1.4-mile radius and a 90-minute window, 20 minutes before incident reaches ATMS systems to 70 minutes after initial report.^{A13} Like previous studies, Goodall and Lee matched incidents to VDOT reports using a 0.5-mile radius and a start time within 30 minutes.^{A14} Studies analyzed the detection time of Waze and conventional sources to understand the benefits of Waze alerts. When Waze detected events first, previous studies found an average time difference ranging from 2.5 up to 10 minutes sooner than conventional sources. Looking specifically at emergency 911 calls, Young et al. found that Waze reports were created on average 2:57 minutes before California Highway patrol reports, with little improvement to precision when waiting for additional reports to be created.^{A15} Senarath et al. along with Dicembre and Pecheux found that crowdsourced data (including Waze) detected crashes approximately five minutes sooner than conventional data.^{A16} Finding that Waze detected events on average 9.8 minutes sooner, Amin-Naseri found that around 34 percent of Waze crash and congestion reports were not covered in current ATMS data stream, with 12 percent of the reports being crashes not previously covered.^{A17} Measuring Waze latency to Iowa ATMS information, Khalilzadeh found that Waze most resembled ATMS detection time distributions with majority of events detected within +/- 20 minutes of ATMS events with the average latency centered around 0 minutes.^{A18}

First Report

While Waze has shown that it has the potential to detect events sooner than traditional sources, other studies have found minimal additional benefits. DosSantos et al. noted that the classification used by Waze is not completely reliable and subject to user discretion with users often not having direct access to an incident site.^{A19} Like this current study and previous projects, Dos Santos et al. go on to note that a low number of events are matched between sources and that the lack of an API creates barriers for the integration of Waze into emergency response dispatch centers. In contrast to the studies in the above paragraph, Goodall and Lee found that the Virginia Department of Transportation-Transportation Operations Centers (TOC) were often aware of crashes and disabled vehicles before they were reported to Waze.^{A20} They found that only around 4 percent of events were detected by Waze first with 17 percent detected simultaneously. As with the location used for our study, Goodall and Lee noted that the quick detection from TOC operators may be due to the study area being an urban freeway with dense camera coverage, whereas rural freeway with spares video and minimal TOC coverage would see a higher benefit of additional data.

APPENDIX B: SENSITIVITY ANALYSIS DETAIL

Clustering Parameters

The Waze App logs an incident when a user submits a report specifying the event type. Other users passing through an ongoing incident are allowed to verify the already reported incident or create their own reports. Hence, the Waze data feed is expected to have multiple reports of the same event. In order to handle the data redundancy and gain a full understanding of the matched and unmatched events, it was necessary to cluster the multiple reports into a single event. Generally, events are clustered based on their proximity in both time and space.

Selecting Time and Distance Parameters. Reviewing the literature, many different time and distance parameters have been used to cluster similar Waze events. This study performed a sensitivity analysis to evaluate the parameters suitable for the study area. In addition to creating a spatial and temporal buffer, this study also sorted the events by type as part of the clustering process. Therefore, a road hazard event was only grouped with other road hazard reports if they are within the specified spatial and temporal parameters.

The project team performed 24 iterations by testing different combinations of time and distance parameters. Three time intervals were tested—30 minutes, 60 minutes, and 90 minutes—and eight distance thresholds were tested, ranging from 500 meters to 3,500 meters at 500-meter increments. The final parameters selected for the evaluation of both crashes and road hazards were 60 minutes and 2,500 meters based on the number of clusters for each time-distance combination.

Figure B1 presents the result of the 24 iterations. Intuitively, the number of clusters decreases as the parameters chosen are relaxed and allowed to span larger temporal and spatial ranges. The project team made an observation that the graphs for crashes and road hazards begin flattening around 2,500-meters. Moreover, the distance between the 30- and 60-minute graph is smaller than the distance between the 60- and 90-minute graph, which may be due to groupings of secondary events that are not related to one another.

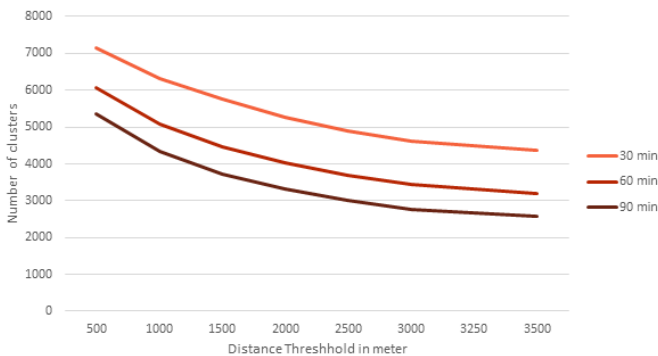


Figure B1. Number of Clusters by Time-Distance Parameter Combinations

Further analysis was conducted to observe the distribution of events within a cluster for crashes and road hazards, as shown in Figure B2. The figures clearly indicate that the number of clusters with only one event become relatively steady after 2,500 meters. From these observations, the decision was made to select 2,500 meters as the spatial parameter with the temporal parameter set at 60 minutes.

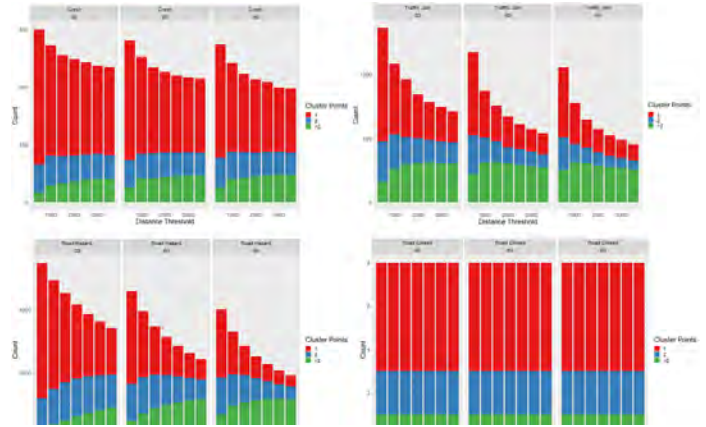


Figure B2. Distribution of Reports per Cluster by Event Type and Parameter Combination

Evaluating the quality of cluster. Given that the identification of clusters is likely to affect any subsequent data exploration and interpretation, a step was taken to evaluate the quality of the formed clusters with the chosen spatial and temporal parameters. Table B1 illustrates the distribution of the clusters by cluster

Number of Events in Cluster	Count
1	8372
2	6956
3	4880
4	3321
5	2107
6+	3857
Total Clusters	29,493

size. The table shows that majority of the clusters had only one event. However, over 30 percent of the unique clusters were formed with more than three reports.

Further analysis was conducted to observe the distribution of cluster size by event type, as shown in Figure B3. The graph also provides valuable insights into the varying clustering pattern among the event type. As Waze is a popular tool to provide directions for drivers, road hazards had the highest percentage of clusters with multiple reports. With many organizations interested in

using Waze to supplement existing data feeds and seeking effective filters, it should be noted that approximately 60 percent of crash events only contained one report. This high number of single report clusters suggested that the majority of drivers either report directly to the PSAP or thumbs up a previously reported crash. Collectively, the findings clearly underlined the characteristic difference between crash and road hazard reports.

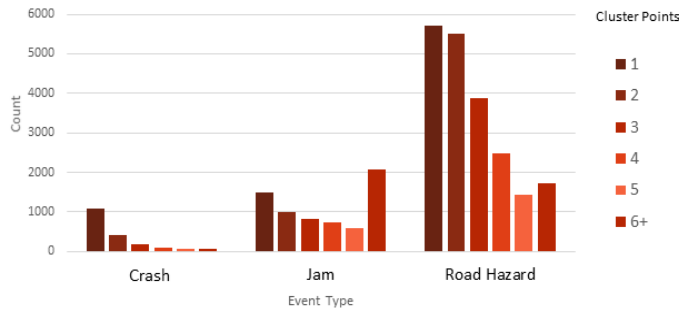


Figure B3. Number of Waze Clusters with Multiple Reports by Event Type

Matching Parameters

Similar to the above clustering process, the task of matching Waze and PSAP events also requires the selection of time and distance parameters. Previous studies have indicated that Waze can report crashes several minutes earlier to hours later than the police-reported crashes.^{A21} Drawing insights from the findings of the clustering analysis, this study performed a sensitivity analysis for each event type. Two time intervals were tested—30 minutes and 60 minutes—and six distance thresholds were tested, ranging from 1,000 meters to 3,500 meters at 500-meter increments. The final parameters selected for the evaluation differed for crashes and road hazards. The crash parameters were 30 minutes and 2,500 meters, while road hazards were matched at 60 minutes and 2,500 meters.

The evaluation criteria was the number of matched Waze and PSAP events. It was hypothesized that the trend in the number of matched events would indicate suitable temporal and spatial parameters. Figure B4 shows that the number of matched road hazard events increased more as the distance and time parameters increased, with approximately 50 more matched events with an increase in time from 30 to 60 minutes. Opposite of this trend, the number of matched

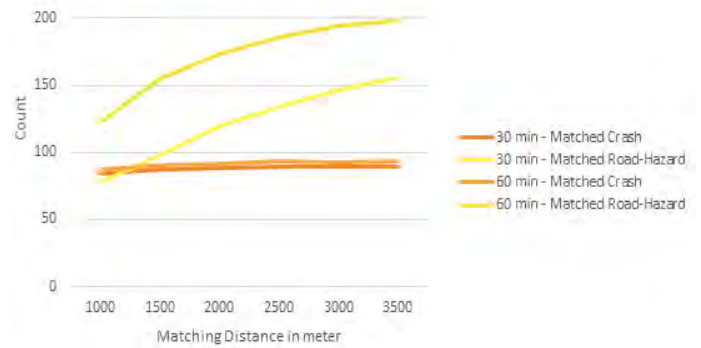


Figure B4. Number of Matched Events by Time-Distance Parameter Combinations

crash events was relatively steady between 30 and 60 minutes. Moreover, for both crash and road hazard, the trend relatively flattened when approaching the 2,500-meter threshold.

Along with the number of matched events, the average time difference and difference in distance between the PSAP and the first Waze report (first report within a Waze cluster) of the matched Waze cluster were studied as shown in Figure B5. Figure B5(a) shows that regardless of time, the distance between matched PSAP and Waze rises more steeply after 2,500 meters. This indicates that a spatial buffer of greater than 2,500 meters is probably matching unrelated events that are located far from one other.

Furthermore, the graph evaluating the average time difference between matched PSAP and Waze events revealed differences in crashes and road hazards. For the crash events, the average time difference was approximately one minute between the 30- and 60-minute matching parameters. However, for the road hazards, larger differences were observed averaging approximately a 13-minute difference between the 30- and 60-minute matching parameters. This finding reflects that crash events, when matched, are reported by both Waze and PSAP sources within a short period of time. On the other hand, it may take some time before a road hazard event detected by Waze is reported in the PSAP and vice versa. Based on the graphs presented in Figure B5, it was determined to match crashes using a 30-minute and 2,500-meter threshold with road hazards being matched using a 60-minute and 2,500-meter threshold.

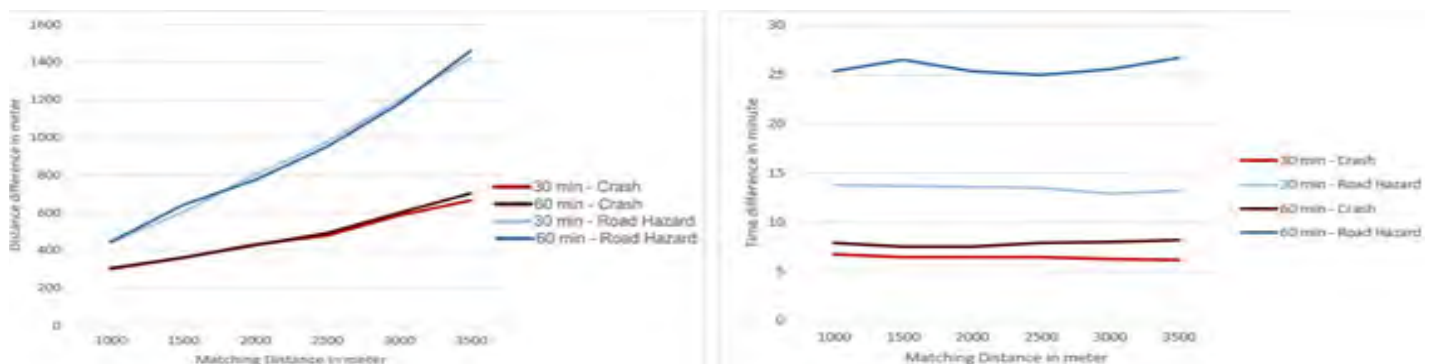


Figure B5. (a) Mean distance difference between matched PSAP and Waze Events
(b) Mean Time Difference Between Matched PSAP and Waze Events

APPENDIX C: SUPPLEMENTAL ANALYSES

The following describes each of the supplemental analyses in greater detail.

Grand Prairie Caller Location Analysis

An additional analysis was conducted using Grand Prairie PSAP caller locations to determine how close callers are from the PSAP reported location. This information was only available for 511 Grand Prairie PSAP events. Figure C1 illustrates the distribution of the distance between the caller's location and the reported PSAP location. It was observed that the caller's locations are mostly near the PSAP-reported location, indicating that the system that Grand Prairie PSAP uses to ascertain the caller's location is reasonably accurate.

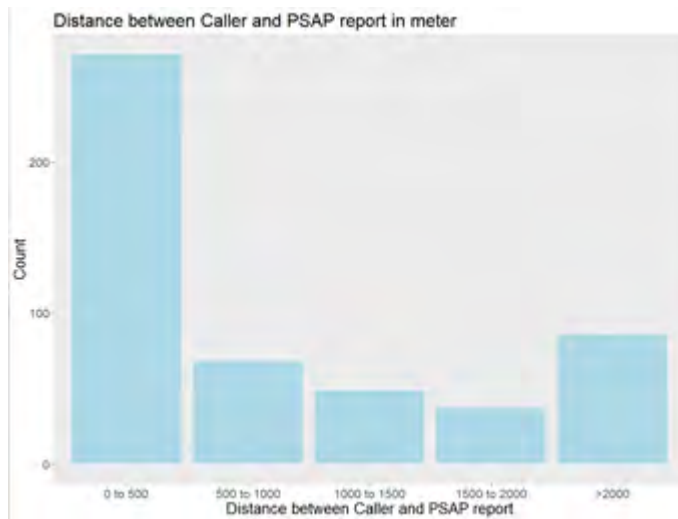


Figure C1. Distance between Caller's Location and Grand Prairie PSAP Reported Location

False Alarm Analysis

With the substantial number of unmatched Waze alerts, the project team sought to determine whether the unmatched events were false reports or if they were incidents that were not captured by the PSAP. Using INRIX data, the project team created a process that could detect disruptions in traffic flow. To identify potential incidents in the INRIX data, two flags for atypical conditions were developed. The first flag was if speeds fell below 35 mph, and the second flag was for speeds being two or more standard deviations below the typical speed for the I-30 corridor. Using these flags, Figure C2 shows that INRIX detected reductions in traffic speeds for approximately 100 unmatched crashes and approximately 800 unmatched road hazards. Looking specifically at the crashes, the matched crashes remain stable up to 20 minutes before decreasing in number, unlike road hazards which decrease by about 40 percent for delays that are present for 10 minutes or more. Further evaluation is needed to better understand if the delays that are detected are due to recurring congestion or represent incidents that are not captured by Waze or PSAPs.

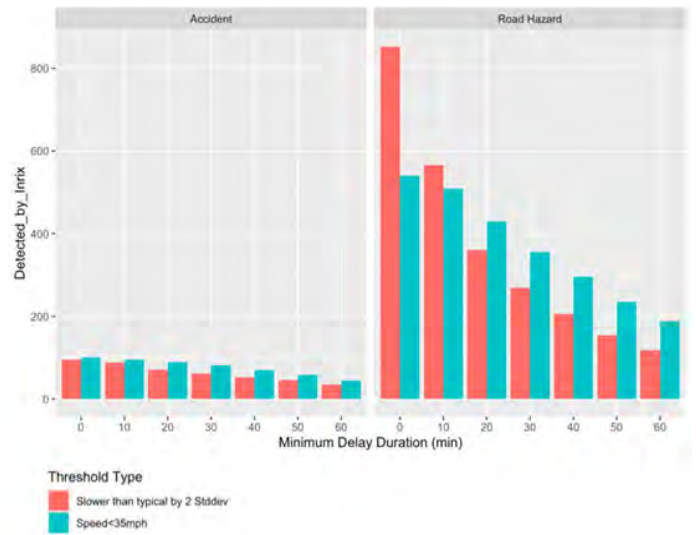


Figure C2. Potential Matches by Event Type

To further assess the impacts of the delays detected by INRIX data, the project team plotted the delays at five-minute intervals for 30 minutes before and after the incident was detected. Figure C3 shows that some of the incidents flagged affect less than one mile while others have slowdowns of up to three miles. In this instance, clusters with a low number of affected miles and/or short-lasting delays are more likely to be characteristic of recurring traffic conditions. One area of further research is to develop a reliability score for Waze reports using information from INRIX and other TMC data sources to validate Waze reports as they come into the PSAP.

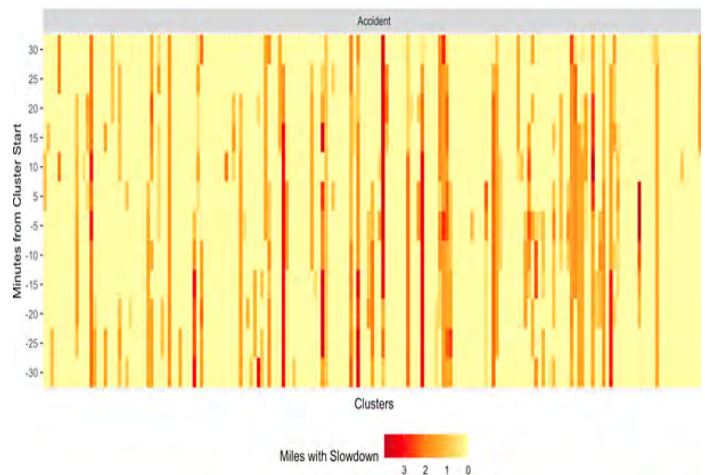


Figure C3. INRIX Captured Delays by Cluster

Mixed Matching Analysis

While this study used a matching analysis where events were sorted by type, the project team found it worthwhile to perform a second iteration of the matching analysis without using the event type restriction. The mixed matching analysis allowed PSAP crashes to be watched with any Waze event type—crashes, road hazards, traffic jams, or other events. The parameters used for the mixed matching analysis were 30 minutes and 2,500 meters.

Table C1 compares the matched volume of PSAP events by matching mechanism. The project team observed that when the event type was not considered, that the number of matched events increased due to the linking of unrelated events. Without including the event type, Waze detected the majority of first reports—55 percent—an average of 16 minutes sooner than the PSAP was notified. The main reason for the change in first report percentage is that this process is skewed towards the significant number of road hazard events reported through Waze, which can be reported 30 minutes or sooner than to the PSAP.

From the analysis of events matched with PSAP crashes, road hazards form the highest percentage of the PSAP crashes. Around 20 percent of the PSAP crashes were matched with three Waze clusters (traffic jam, crash, and road hazard). Those that are primarily traffic jam events represent smaller percentages of events matched with PSAP crashes. This suggests that through this mixed matching process, unrelated events are likely being matched. Additionally, there is also a possibility that road hazard events are either leading to crashes or Waze users are only seeing the road hazard and not the crash that has been cleared or happens after they travel through the location.

Table C1. Comparison of Matched Events by Matching Mechanism and Event Type		
Matching Mechanism	Crash	Road Hazard
Sorted (Event Type Included)	495	923*
Mixed (Event Type Excluded)	986	1017
*Volume for 2500 m ± 30 min matching parameter		

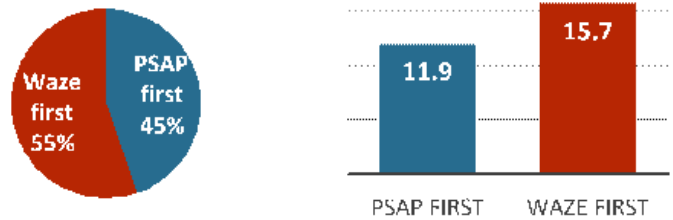


Figure C4. Mixed Matching Methodology Results: (a) First Report and (b) Average Time Difference of First Report (mins)

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Texas Connected Freight Corridors



I-30 Waze and 911 Integration Pilot – Task 1

Version 1.0

July 9, 2021

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REVISION HISTORY

Version	Date	Author(s)	Comment
1.0	9 July 2021	TTI	Initial Draft
1.1	30 July 2021	TTI	Final Report
1.2	20 August 2021	TTI	Revised Final Report

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1 INTRODUCTION

Texas was one of the ten recipients selected for the 2017 U.S. Department of Transportation's (USDOT) Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grants for projects that develop model deployment sites for large scale installation and operation of advanced transportation technologies. Technologies such as connected vehicle (CV) applications can improve the safety of travelers, increase the efficiency of the roadways, and provide a larger return on infrastructure investment from their deployment.

The Texas Connected Freight Corridors (TCFC) project will be Texas' largest deployment of CV technology aimed at significantly reducing the number and severity of crashes, reducing congestion on major interstates that serve the nation, and reducing fuel consumption of freight trucks. The TCFC project will apply advanced safety and congestion management technologies to improve traveler information, asset condition assessment, and system performance. A USDOT ATCMTD award launched this initiative in Texas to be a national model deployment for addressing freight mobility and safety needs and creates the foundation for a full-scale, sustainable connected and automated vehicle deployment for the state. The I-30 Waze and 911 Integration Pilot (Project) complements the TCFC project by improving traffic incident response and data along the I-30 corridor. If successful, the Pilot will be a scalable model for deployment throughout Texas and beyond.

1.1 PURPOSE OF THE DOCUMENT

This document provides a description and findings of the Project.

1.2 PROJECT SCOPE

The TCFC vision is to create a sustainable, CV deployment in Texas using I-35, I-10, I-30, and I-45 to showcase CV applications applicable to TxDOT and its partners throughout the "Texas Triangle" as shown in Figure 1.

The project covers the 865-mile Texas Triangle using I-35 (including an extension to Laredo), I-10, I-30, and I-45 linking Austin, Dallas-Fort Worth, Houston, and San Antonio to showcase CV applications relevant to TxDOT and its partners throughout the Texas Triangle.

The Project is located at the top of the Texas Triangle in the Dallas-Fort Worth region (Figure 2). It was funded to complement the TCFC project by improving incident response and incident data in the corridor. This project is also consistent with the region's goal of making the I-30 corridor the leading technology testing corridor in North Texas.

The pilot project is along 30 miles of the I-30 corridor between Fort Worth and City of Dallas. It consists of three main tasks:

Task 1: Assess Needs & Explore Integration Options

Task 2: Develop Prototype and Provide Assistance

Task 3: Evaluation

This document describes the work and findings for Task 1. Tasks 2 and 3 will be reported separately.

I-30 Waze/911 Integration Pilot for Texas Connected Freight Corridors



Figure 1: Map of the Texas Triangle.

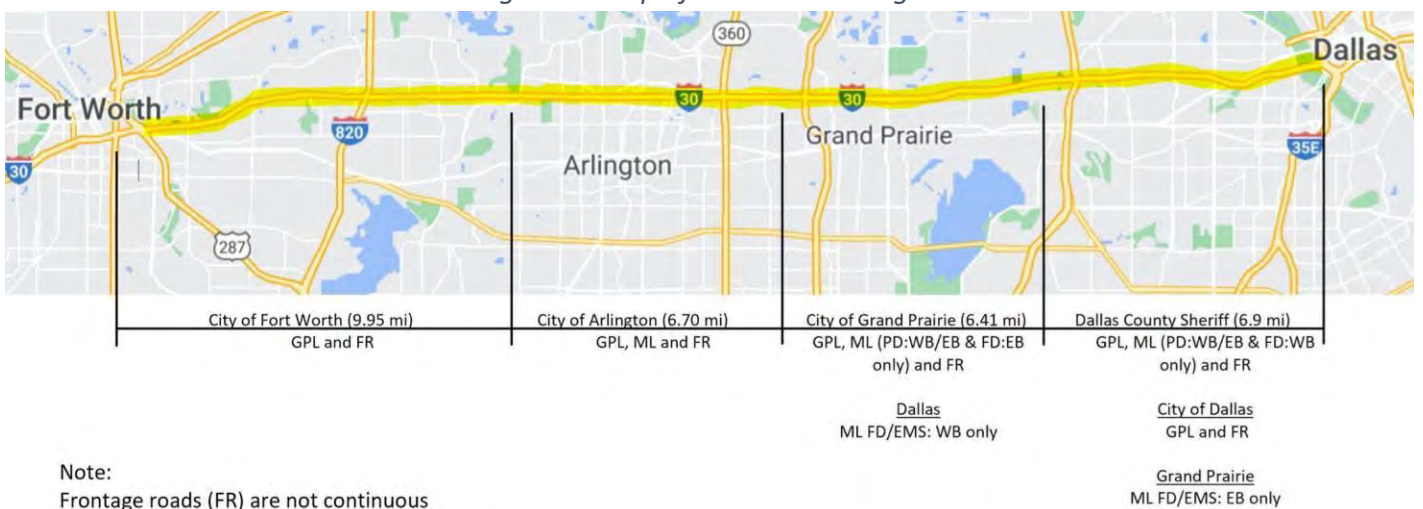


Figure 2. Map of the I-30 Corridor.

1.3 PROJECT GOALS

The Project's overall goals are:

1. Integrate Waze data into the I-30 911 Centers as shown in Figure 2 (Cities of Arlington, Fort Worth, Grand Prairie, Dallas, and Dallas County Sheriff)
2. Improve situational awareness of roadway incidents and reduce both emergency response times for roadway incidents and secondary crashes

The intent of the Project is to try to answer these research questions:

- Are Waze traffic incidents detected sooner than 911 Public Safety Answering Points (PSAPs)?
- Are Waze traffic incidents more accurate positionally than 911 PSAPs?

1.4 APPROACH

The first task, Assess Needs & Explore Integration Options, will involve researchers meeting with I-30 stakeholders, and documenting their existing systems as well as their hardware/software needs for a successful integration. The general approach included:

- Review of existing Waze/911 integrations in DFW.
- Define the different levels of integration, hardware and software needed, and develop cost estimates.
- Conduct meetings with interested I-30 corridor stakeholders such as PSAP centers from Arlington, Fort Worth, Grand Prairie, Dallas, and Dallas County Sheriff.
- Determine existing computer aided dispatch (CAD) package/vendor and desired integration solution.

2 REVIEW OF EXISTING WAZE/911 INTEGRATIONS IN DFW

2.1 WAZE OVERVIEW

Initially commercialized in 2008, Waze is a free software application (app) that uses crowdsourced data by collecting map data, travel times, and traffic information from its users, “Wazers”. Wazers can report accidents, traffic jams, speed and police traps, and can even edit/update roadways with an online map editor. Wazers sends anonymous information, including users' speed and location, back to its server database to improve the service as a whole.

Based on the information collected, Waze provides routing and real-time traffic updates. Waze offers turn-by-turn voice navigation, real-time traffic, and other location-specific alerts. Waze encourages its users to report traffic or road hazards by offering points. Waze has the ability to direct users based on crowdsourced information. Waze users can report a multitude of traffic-related incidents from accidents to police traps as shown in Figure 3. This data is used by Waze to help other users either by alerting them of the condition ahead or rerouting the user to avoid the area entirely. In addition to user input, Waze relies on information from state agencies or local municipalities for traffic events such as road construction and closures. The ‘crowdsourced’ concept is that the more people that provide data the more accurate it will be.

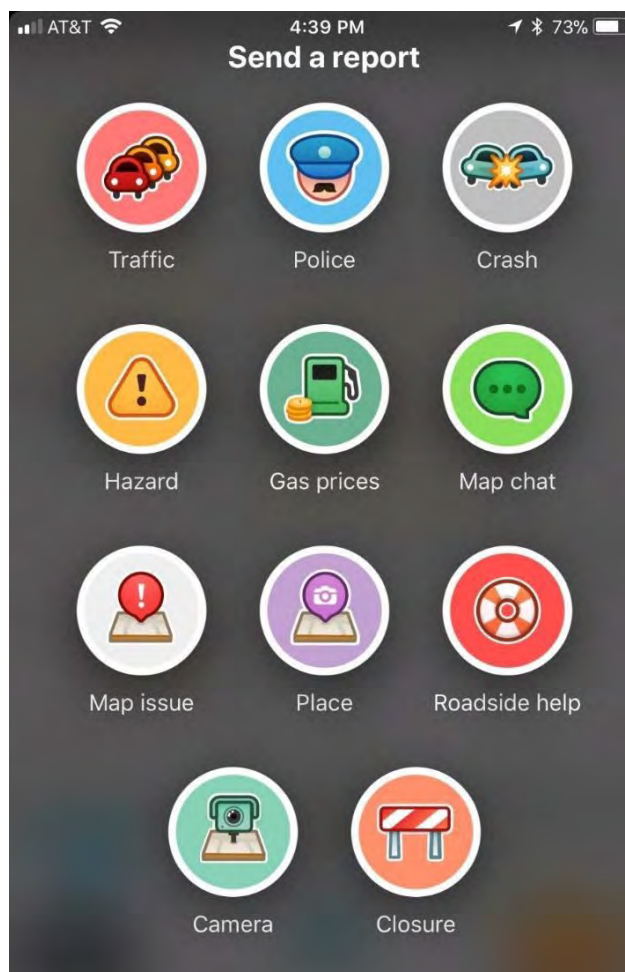


Figure 3. Waze Report Types.

Google acquired Waze in June 2013. At the time of Google's acquisition, there were nearly 50 million Waze users¹. There were 130 million monthly active users as of February 2020², with about 30 million in the United States as of October 2018.

Waze launched the Connected Citizens Program (CCP) in June 2014 which was later changed to Waze for Cities ([W4C](#)). This program is a free, two-way data exchange program between Waze and its partners such as governments, departments of transportation, and municipalities for traffic analysis, road planning, and emergency workforce dispatching.

2.2 WAZE/911 INTEGRATIONS IN DFW

TTI researchers met with three entities that have integrated Waze data into their operations (at various levels) within DFW. The goal was to gain a better understanding of the different integration methods and practices as well as any lessons learned. The major findings are reported below, and the meeting notes are provided in Appendix A.

2.2.1 TxDOT Dallas Traffic Management Center: Daltrans

TxDOT Dallas District started a Waze pilot project in early 2021. Operators log into a Waze test version of Lonestar, where the Waze data is displayed on a map. The goal of the pilot is to see if incidents can be detected sooner than existing methods, refine the Waze feature based on feedback, and eventually implement it statewide (although no timeframe has been set).

Originally, the Waze feature showed events on all roadways (i.e., freeways plus arterials) and on shoulders. However, to minimize clutter on the map the Waze data stream is currently filtered for just freeways and "on road" events (i.e., main lanes) such as accidents (or collisions), hazards like debris, construction, and closures as shown in Figure 4. It also includes events for all confidence and reliability index scores. The confidence score is based on other Wazer's reaction such as 'thumbs up/down' to the event (0-10) and reliability is based on other user's reaction such as 'thumbs up/down' and the level of the Waze reporter (0-10). The Wazer gains levels by contributing to the map starting at level 1 and reaching up to level 6. There is no two-way exchange of data with Waze at this time.

¹ <https://en.wikipedia.org/wiki/Waze>

² <https://expandedramblings.com/index.php/waze-statistics-facts/>

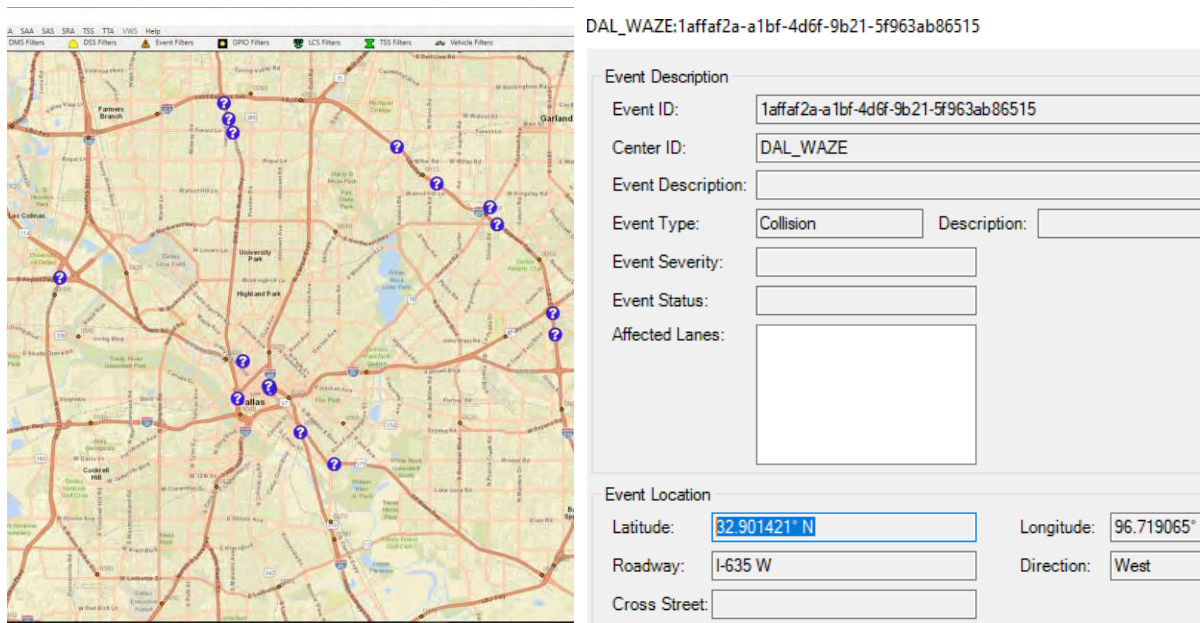


Figure 4. TxDOT Waze Feature Example.

The District is informally evaluating the Waze feature, but initial feedback from TMC operators indicates that they generally do not find it too useful. Some reasons reported include:

- Location is wrong or wrong information.
- Some events are created at the same time as Waze events appear, but so far, no Waze events were detected before the TMC operator-generated events.
- Arterials cannot be filtered or turned off.
- Operators are frustrated by seeing multiple events for the same incident.

The Waze feature is a pilot, and as such, bugs and enhancements are a normal part of development. As the application evolves, maybe the TMC operators' opinions will evolve as well.

Some of the Waze enhancements discussed included adding reporting capabilities, filtering, and ultimately having Lonestar automatically generate new TMC events that operators just have to verify and accept.

2.2.2 City of Frisco

Starting in 2018, the City of Frisco used an [ESRI geoevent server](#) to integrate the Waze data into an in-house application known as Situational Awareness For Emergency Response (SAFER). It is used by 911 CAD operators, Police, Fire, and Traffic to have a better situational awareness and a common operating picture of incidents. However, it is used as a separate app and there are no plans to integrate it with the current CAD system.

The Waze data shown through SAFER includes accidents, construction, objects in the road, stopped vehicles, traffic jams, construction lanes - including Frisco's Public Work construction projects with partially closed roadways. It was noted that although all operators are encouraged to use the Waze feature in SAFER, it is not mandatory and thus, not everyone uses it. The City is using all the confidence and reliability index scores.

The City has a two-way feed with Waze. They are reporting incidents and roadway closures to Waze, as mentioned above. A latency issue was reported as it appears that Waze takes several minutes to ingest the data sent by Frisco.

The City started to evaluate the Waze data and potential benefits in 2019 but did not update it due to the 2020 COVID-19 pandemic. This was done by utilizing the reporting capabilities from the Waze dashboard in the City's emergency operations center, which also houses the transportation operations department. This dashboard is separate from the Waze feature in SAFER. However, managers and operators generally feel that the Waze data helps them to be proactive in identifying and verifying incidents. A key lesson learned was that having good communication to end-users and responders (such as patrol cars) is important so that they know what is coming with the new tool or datastream.

2.2.3 NCT911

The North Central Texas Emergency Communications District (NCT911) is responsible for the planning, implementation, and maintenance of an emergency 911 system for 42 PSAPs in 13 counties surrounding the Dallas/Fort Worth Metroplex. Previously NCT911 used an ESRI geoevent server to integrate the Waze data into an in-house map. This map was replaced by a commercial solution called RadiusPlus, in early 2021. RadiusPlus is a product from Rapid Deploy and provides the following advantages over the former map solution:

- Waze feed is directly integrated.
- Map rendering is quicker and clearer.
- Uses the native Waze icons.
- Provides device hybrid locations by integration with Google and Apple transportation tools that provide higher-precision location updates. For example, Google updates every 5 seconds and Apple updates every 10 seconds. Traditional methods from cell towers update every 30 seconds. These tools pass the exact phone location (breadcrumb trail) instead of locations from the cell carrier's rough tower location. The higher-precision location updates are limited to cellular 911 calls (i.e., excludes landline or VOIP 911 calls). If a caller dials 911, and has a data connection, the phone can share its location to RadiusPlus.

RadiusPlus shares the Waze events such as accidents, car stopped, object on road, construction hazards, road closures, and traffic signal light fault with all 42 PSAPs but only events within each PSAP's jurisdiction. RadiusPlus is not integrated into any CAD system because each PSAP has its own CAD vendor, which varies among PSAPs. There is no two-way data exchange with Waze at this time.

NCT911 has heard some anecdotal feedback where a few of the PSAPs found it useful, but generally, PSAPs do not provide feedback unless something is not working. Generally, NCT911 thinks there is a benefit in sharing Waze events because most of the PSAPs are rural so getting Waze data is better than getting no data since they solely rely on callers to report incidents. NCT911 shared the following lessons learned: 1) provide good training, 2) get proper capacity and bandwidth (not a problem with Rapid Deploy), and 3) have enough screen real estate to fit the mapping application.

3 DEFINE THE DIFFERENT LEVELS OF INTEGRATION

3.1 LEVELS OF INTEGRATION

The Waze data can be integrated into the PSAPs 911 and CAD systems in several ways depending on the desired level of integration, needs, 911 software capabilities, and budget. The research team identified three levels of integration: low, medium, and high. This simple tiered approach allows the PSAPs to pick the level that best suits them. It also provides a logical path that enables the PSAPs to start with a lower level of integration and then transition to a higher level as their 911 telephony/CAD solution evolves or after experiencing the added value of using Waze.

3.1.1 Low

The low-level solution is a web browser-based prototype tool that TTI will develop during task 2. The prototype tool offers the advantage of being a minimum-cost solution that can be deployed right away. It does not require any integration with the PSAPs systems. The prototype tool will work on any computer with a web browser and an internet connection. The prototype will be available to the PSAPs during the duration of the project and provide an easy alternative to test the potential benefits of the Waze data. TTI will provide all related documentation, procedures, non-proprietary code to the PSAPs that would like to continue using the tool on their own after the pilot project. However, the PSAPs will be responsible to host the app.

The prototype tool includes the following features:

- No CAD or ATMS integration required: the tool will operate as a stand-alone application running on any computer with an internet connection and a web browser.
- Visualization of Waze events: The map will be interactive, allowing users to see the data and click on data points to get further information about the reported event.
- Clean interface: The telecommunicators already have multiple screens and applications to monitor. The map will minimize clutter and only display the Waze icons that are relevant to the PSAPs' operations.
- Event detailed information: the user will be able to obtain further event information by clicking on the Waze event icon.
- Filtering capabilities: the user will be able to filter the Waze data by event type, time window, and roadway.
- Data aggregation: TTI will investigate Waze data to confirm if data aggregation or grouping is possible and beneficial.
- Hotspots or other visual aids: TTI will investigate the use of hotspots where several events of similar nature exist.

3.1.2 Medium

The medium-level solution is a step up from the low-level solution. It consists of a third-party cloud-based mapping that integrates Waze and 911 calls from mobile devices with enhanced information. The research team investigated two potential providers: RapidSOS and RadiusPlus from Rapid Deploy. Both providers offer several products, some of which can be integrated into CAD and others that do not require any integration. In this section, we will focus on their products that do not require CAD integration.

The similar features in RadiusPlus and RapidSOS are:

- No CAD or ATMS integration required

- Integration with a set of transportation tools offered by Google Android and Apple that provide:
 - Higher precision location including breadcrumb path trajectory that allows the PSAPs to track devices in motion.
 - Extended data from the mobile device such as medical info, emergency contact, height, weight, and medications. The mobile device owner needs to provide consent to share this information.

The main differences between RadiusPlus and RapidSOS are:

- Cost: RapidSOS is free for the PSAPs. RadiusPlus is subscription-based.
- Waze data: both providers consume Waze data; however, only RadiusPlus displays Waze event data on the map. RapidSOS does not share the Waze event information at this time.
- RadiusPlus also integrates TomTom traffic and incidents as well as DarkSky weather data.

To date, RadiusPlus provides Waze event data and could potentially be used as a medium-level solution. RapidSOS does not appear to share Waze data currently, but it is likely that it will soon. This option is particularly attractive since all the I-30 PSAPs already use RapidSOS to some extent.

3.1.3 High

The high-level solution is fully integrated with the PSAP systems. During our interviews with the PSAPs, they indicated that this is the most desirable solution for them as they will see the Waze data directly on the PSAP 911 applications instead of on a different screen or tab. In addition to seeing the Waze events in the CAD map, the telecommunicators could also potentially manage Waze events and generate a dispatch call.

The City of Grand Prairie PSAP indicated that Axon's CAD product already offers full integration to Waze. The City of Arlington PSAP mentioned that their current CAD solution Hexagon Integraph 9.4 is WMS (web map services) capable which could potentially offer a path to consume Waze data. There might be several other CAD vendors that already integrate—or are planning to integrate—Waze data. However, the research team did not explore in detail their plans as this is beyond the scope of the study. Several of the PSAPs indicated that their CAD providers periodically survey their clients about their needs and then prioritizes new features. The City of Fort Worth PSAP already inquired their CAD vendor about adding Waze data. The City of Dallas said that they could ask their CAD vendor once they see the value of Waze.

3.2 HARDWARE AND SOFTWARE NEEDS

This section describes the hardware and software needs for each of the three levels of integration. The hardware and software needs are broken down into the front end and back end. The front end is the part of the system that the telecommunicators interact with and is physically located at the PSAP's command center. The back end refers to parts of a CAD application or a program's code that allow it to operate and that cannot be accessed by a user (i.e., telecommunicators). The back end equipment and software can reside in the cloud or in the PSAP's server room.

3.2.1 Low

The low-level solution will be provided by TTI during the duration of the pilot (12 months).

Front end: the prototype tool will be web-based. It will only require a computer with a web browser and an internet connection. It is expected that the telecommunicators will access the tool's website

from one of their existing computers. This solution does not require procuring additional hardware or software for the front end.

Back end: TTI is planning on using a cloud computing service (e.g., Azure) to host the prototype tool on the cloud. There are no hardware or upfront costs. However, there is a recurring fee for hosting the application.

3.2.2 Medium

The medium-level integration is a third-party cloud-based solution that does not require CAD integration. The research team investigated two of the most popular products with the potential to meet these criteria. The RadiusPlus product from Rapid Deploy meets these criteria. The RapidSOS product does not offer Waze integration now but may do so in the future. The PSAPs will have to procure this service by themselves depending on their individual needs and the number of seats required.

Front end: the medium-level solution front end is like the low-level solution. It is also web-based and only requires a computer with a web browser and an internet connection. Telecommunicators will access the website from one of their existing computers. This solution does not require procuring additional hardware or software for the front end. It works alongside any legacy CAD and call handling system without being integrated.

Back end: the provider—such as RapidDeploy—is responsible for handling all back end services, hardware, software, connection to the mobile switching center, maintenance, security, and updates. The cost for providing these services is included in the recurring seat fee.

3.2.3 High

Front end and back end: the high-level solution will be fully integrated into the CAD system. It is expected that the new Waze feature will share the same hardware and software platforms, so there is no additional equipment needed on both the front and back end. The CAD vendor will require upgrading their software to add the Waze functionality. This might be done as part of their routine upgrades to all their customers or as a custom upgrade for a PSAP. All the I-30 PSAPs have CAD vendors with on-premises solutions. However, this model is changing with several vendors offering more CAD cloud-based solutions. Grand Prairie is considering switching to a cloud-based CAD. Regardless of the CAD solution, on-premises or cloud-based, it is expected that no additional equipment will be needed—on the PSAP's side—to add Waze.

3.3 COST ESTIMATES

This section discusses the approximate costs for integrating Waze into the PSAPs operations. It is expected that the telecommunicators will be able to incorporate Waze as part of their standard operating procedures without increasing staff. Waze will be an additional tool in their toolkit. Training costs for the telecommunicators are estimated to be minimal as the Waze functionality is a simple concept to understand as shown in Table 1.

Table 1: Cost Estimate for the Different Levels of Waze Integration.

	Cost Item	Low	Medium	High
Initial costs	Implementation	None: TTI will provide the prototype tool.	RapidPlus: none, included with the monthly fee.	Varies from minimal (CAD/Waze already integrated) to high (custom integration).
	Training	Minimal: 1 to 2 hrs. per telecommunicator.	-RapidPlus: none, included with the monthly fee. -PSAP: minimal, 4 to 8 hr. per telecommunicator.	Unknown: depends on the pricing agreement with each PSAP, which could include other services.
Recurring Costs	Third-Party	\$75 to \$125/mo. to host the website and store data. TTI will pay for the first year.	RadiusPlus: \$450 per concurrent seat per Month ¹ .	Unknown: depends on the pricing agreement with the each PSAP, which includes other services.
	PSAP's IT Staff	Minimal: one to two days per year.	None.	None: not expected to increase the current IT staff hours for CAD.

Note 1: concurrent seat means that if a PSAP has 20 positions but only ten are regularly staffed, then they will pay for ten seats.

4 I-30 CORRIDOR PUBLIC-SAFETY ANSWERING POINT MEETINGS

The research team met with the I-30 PSAPs identified in Figure 2 in May, 2021. The objectives of the meetings were to describe the Project background and goals, describe Waze and the potential benefits, understand PSAP's current operations and CAD vendor as well as their desired level of integration (discussed in section 5), and to identify what TTI needed for the pilot. The major findings are reported below, and the meeting notes are provided in Appendix B.

4.1 911 BACKGROUND

There are three types of 911 entities: 1) emergency communication districts such as Tarrant County 911, 2) municipal emergency districts (or home rule city) such as Dallas, and 3) regional planning commissions such as NCT911. These entities serve as the 911 public switched telephone network (PSTN). The PSTN provides mapping services and routes the 911 calls to the nearest PSAPs.

For example, Tarrant County 911 (TC911) serves 50 PSAPs. There are two main functions within each PSAP: call taking and dispatching. TC911 is only involved with the call taking function as it provides the telephony infrastructure, *Vesta*, to the PSAPs. Note, the *Vesta* system is a 'closed system', meaning that there is no internet connection due to security reasons. Currently, any computer/workstation that is running this system on it cannot access the internet for other data feeds such as Waze.

There are also various ways PSAPs can receive 911 calls: 1) wireless calls, 2) landline, 3) voice over internet protocol (VoIP), 4) radioed in, and 5) called in over a 911 administrative line. This pilot focuses on the wireless calls because they are the most comparable to the Waze events, which are likely to be reported by wireless devices and thus, will be evaluated as part of Task 3.

4.2 CITY OF DALLAS & DALLAS COUNTY SHERIFF

The City of Dallas and Dallas County Sheriff currently share the same CAD system. As mentioned earlier, the City of Dallas is a municipal emergency district thus its PSAP performs both the call taking and dispatching (CAD) functions.

The City is not currently using the Waze feed in either the PSAP or TMC. But as with most other DFW municipalities, it does have access to NCTCOG's DFW511 and EcoTrafiX Waze events.

The PSAP is using RapidSOS "light" which requires telecommunicators to enter the wireless 911 caller's phone number to see its' location and information. However, the City is transitioning to the "full" version over the next six months. This version not only provides the current and historical locations but also the estimated address, source of information, and confidence level of the information. It also provides extended personal data (e.g., emergency contacts, medical information such as height, weight, and medications) from Android (version 4.0 or higher) and Apple (version iOS 12 or higher) devices if the user is willing to share the information. It will even show an Uber driver's name if the caller is using Uber when making the 911 call. Additionally, this version provides a jurisdiction view with the following features as described on RapidSOS's website³:

- Call clusters show telecommunicators at a glance if there are numerous calls coming in about the same incident. If a call comes in separate from the call cluster, telecommunicators can determine if the call is about another incident and can choose to prioritize that call.

³ <https://rapidsos.com/our-latest/introducing-jurisdiction-view/>

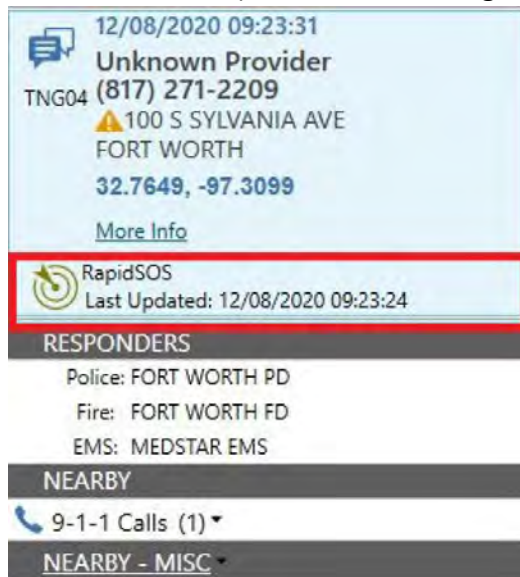
- Automatic call location plotting means that caller location data may arrive on the RapidSOS Portal screen before the call even rings at the center. For the first time, telecommunicators will have advanced knowledge of incidents separate from the 911 call — information that can be vital before a major incident or during a 911 call outage.
- Jurisdiction View simplifies the management of large volumes of emergency calls. Users can search, filter, and prioritize phone calls as they come in to the ECC.

The PSAP thinks the Waze data can help with quicker incident notifications. But the City had concerns over integration and long-term maintenance costs (discussed more in next section). Lastly, the City is open to sharing its 911 event data for the pilot.

4.3 GRAND PRAIRIE

Grand Prairie is a participant to Tarrant County 911 District. The City has been using a “limited” version of RapidSOS since March/April, 2021 which is integrated into the TC 911 telephony infrastructure, Vesta. It’s ‘limited’ by the type of information provided but does not require manual phone number entry as in the “light” version. Currently, the PSAP gets—from TC911—the following information for each wireless 911 call:

- [ANI \(Automatic Number Identification\) and ALI \(Automatic Location Identification\)](#) – provides a phone number and GPS coordinates. This information has to be refreshed manually.
- RapidSOS “limited” – only provides a phone number and GPS coordinates. The City reported that it aligns with the ANI & ALI data about 90% of the time and that it auto-refreshes every ten seconds. See sample screenshots in Figure 5.



a. RapidSOS “Limited” information



b. ANI/ALI (blue), RapidSOS (green)

Figure 5. Sample RapidSOS “Limited” Screenshots.

Grand Prairie has a memorandum of understanding agreement with Dallas Fire Rescue where the Dallas Fire Rescue (DFR) responds to all Fire/EMS calls for service in the westbound TEXpress lanes from Beckley Ave. to 161 and Grand Prairie FD responds to all Fire/EMS calls for service in the eastbound TEXpress lanes from 161 to Beckley Ave. Note, Grand Prairie PD responds to all PD incidents in TEXpress lanes, within Grand Prairie limits. This is also shown in Figure 2.

The City’s traffic management center (TMC) monitors Waze events via North Central Council of Government’s (NCTCOG) DFW511/EcoTrafiX, and online at Waze.com. The TMC also provides

roadway closure information to Waze via EcoTrafIX but not to the PSAP. The PSAP relies on the City’s water and street departments to inform them of street closures, but they aren’t always told when the closures are removed thus, affecting their ability to effectively route emergency responders. The PSAP could monitor the Waze feed for roadway closures in another app/window, but it was noted that it would be less likely to be used, particularly during spikes in calls or mass emergency situations.

The PSAP also has no way of verifying incidents, so they dispatch resources based on the information provided by callers. However, the TMC has access to TxDOT’s closed-circuit camera video feeds (CCTV) and listens to police channels. Lastly, the City is open to sharing its 911 event data for the pilot.

4.4 FORT WORTH

Fort Worth is a participant to Tarrant County 911 District and has access to the RapidSOS “limited” offered through TC 911’s Vesta. However, the City began using the “full” version of RapidSOS via the online customer portal. This is separate from the RapidSOS “limited” offered through TC 911’s Vesta. A sample RapidSOS “full” screenshot—provided by Fort Worth—showing some of the extended data is shown in Figure 6. Note, the user does not have Apple Enhanced Emergency data turned on.

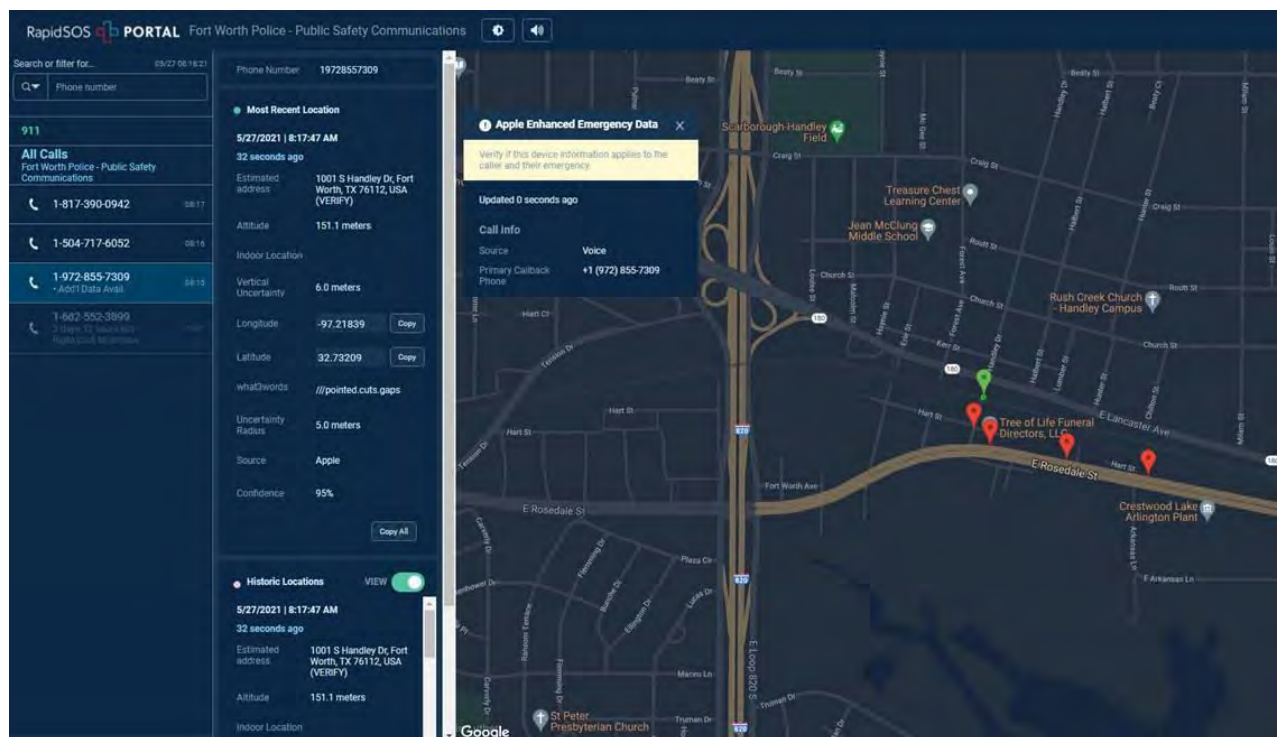


Figure 6. Sample RapidSOS “Full” Version Screenshot.

Although the PSAP is not currently using Waze, Fort Worth (IT department) has been consuming and archiving Waze data for a couple of years. In fact, it has a two-way feed and reports accidents (with severity information) and lane closures to Waze every two to five minutes. The City IT department attempted to integrate Waze information into the previous CAD system, but there were issues with importing the traffic jam data. They have not tried yet with their new CAD system deployed in May 2021. The City’s TMC also enters this information into NCTCOG’s EcoTrafIX, which sends the information to Waze.

The PSAP uses the [Waze dashboard](#) from Tarrant County Sheriff’s office, as needed. However, telecommunicators are not required to use it because they already have too many screens/apps

opened simultaneously. They are evaluating a Carrousel app to help them manage multiple screens by rotating through them at preset intervals. The PSAP is testing three licenses currently but plan to expand it to the telecommunicators so they can display apps like the Tarrant County's dashboard, weather app, and others.

The PSAP is currently working with TTI to provide samples of the 911 event data. It will continue to work with the research team to develop the final data structure and XML feed.

4.5 ARLINGTON

The City of Arlington is a participant to Tarrant County 911 District. The City is also using the "full" version of RapidSOS via an online customer portal.

The City has a geoevent server and is consuming the Waze data directly. The traffic department is the only one utilizing this feed currently. It can also monitor Waze events via NCTCOG's DFW511 and EcoTrafiX. It has a two-way feed and provides full roadway closures to Waze via an XML. The City will soon add construction warnings to the Waze map for construction projects. They recently added a contractor which has connected arrow boards that can provide warnings and messages to Waze about lane closures.

The PSAP does not monitor or enter any information into Waze. The City was going to meet internally to figure out how to share their Waze feed with the PSAP. They think the Waze data can help verify incident location and determine if incidents are duplicates or a secondary incident. Lastly, the City is open to sharing its 911 event data for the pilot.

5 EXISTING CAD VENDOR AND DESIRED INTEGRATION SOLUTION

During the meetings with the PSAPs, the research team identified the current CAD vendor that each PSAP is using and their future plans for upgrades. The PSAP staff also provided information about their desired level of integration.

5.1 GRAND PRAIRIE

Grand Prairie's current CAD vendor is Superior One Solution, but they plan to transition to a cloud-based CAD system such as AXON CAD within two years. The PSAP does not currently use Waze. They believe that a high-level integration to CAD is important because having a separate window or application will be less likely to be used during spikes in calls or mass emergency situations.

5.2 FORT WORTH

Fort Worth's current CAD vendor is Central Square. The CAD software was recently upgraded in May 2021. Several departments in the City are currently using Waze. The PSAP is using the Tarrant County's Waze dashboard informally. However, telecommunicators are not required to use it. The IT department uses Waze mostly to send incident and lane closure information. They plan to integrate Waze into CAD. The PSAP is interested in a high-level integration to minimize the number of non-CAD apps that the telecommunicators need to track.

5.3 ARLINGTON

Arlington's current CAD vendor is Hexagon Integraph which can consume web map services (WMS). The traffic department is using Waze to provide road closures. The traffic department receives the Waze feed via their ESRI geoevent server. This datastream is not being utilized by the PSAP or other departments other than traffic. The City is interested in a high-level integration so the Traffic and GIS departments will start discussing possible ways to integrate the Waze feed into the PSAP's CAD. Although the PSAP does not monitor or enter information into Waze, they notify Waze of closures—reported by FD/PP—via the traffic department that enters them into Waze.

5.4 DALLAS AND DALLAS COUNTY SHERIFF

Dallas' current CAD vendor is Central Square. The PSAP is not currently using Waze. They believe in a phased approach starting with the low-level prototype tool to evaluate the benefits of Waze. If there is value, then work on the middle or high-level integration options.

6 APPENDIX A

EXISTING WAZE/911 INTEGRATIONS IN DFW MEETING NOTES

Daltrans Waze Call with Craig Burgan 4/1/21

- What is the purpose(s) of the app? – to help detect incidents sooner
- Will it be available in every district? What is the timeline? – intends to go statewide but no timeframe
- What WAZE event/incident types are used? – filtering it for hazard on road events (debris, construction, accident, etc.)
- Are the WAZE confidence and reliability index scores considered as part of filtering process? – see Waze definitions below. - Confidence and reliability score is being used and can be adjusted as well (provided by Jaime Martinez).
- Is the data live or refreshed at preset interval? – real time
- Does Lonestar ingest arterial and freeway Waze data? We weren't sure if TxDOT is monitoring frontage roads too. – not yet filtered for freeways and frontage roads only; otherwise operators clear the event
- Does LoneStar send back data such as lane closures (i.e. is it intended to be a 2-way feed)? – Lonestar currently does not send data back to Waze and has not been discussed for this phase of the project (provided by Jaime Martinez).
- Are TMC operators using the app consistently? E.g. are some only using it as visual check while others are acting on it to update or create new events? – operators are evaluating it but didn't find it useful
- What are the experienced benefits so far?
- Any data issues in general?
 - quality
 - Accuracy – location is wrong, or wrong information
 - availability
 - Latency – some events are created same time as Waze events appear but so far no Waze events were detected before the TMC operator events; so far all Waze events were also captured by TMC events
 - Uptime – no issues
 - API -NA

- Does TxDOT find it useful? What would be helpful to track or measure in order to quantify this? – after 2-3 weeks of informal evaluation, operators did not find it useful
- Does TxDOT have any performance metrics to compare Waze vs TMC incident data? – none; informal and subjective
- Wish list enhancements – e.g. Reporting capabilities, filtering, accuracy, ultimately to automatically generate new events that operators just have to verify and accept. On automatically generation new events (per Jaime Martinez): The intent is for a Waze alarm to come through to Lonestar then have the operator verify if it qualifies as an event or not. If it does, the user would seamlessly open an event directly from the alarm. If not, the alarm would be dismissed.
- Any other lessons learned?

Other:

- Operators have been using it for about 1 month (but it existed since mid-January)
- Operators do not like it
- Not yet in production – operators have to open up a test map interface – once in production it will be integrated into Lonestar’s map page
- Operators will check the Waze feed/data against their phone app
- Operators frustrated by seeing multiple events for the same incident

Frisco Waze Call with Brian Moen, Shonda Robertson, David Schuster & Susan Olson

4/5/21

- What is the primary purpose(s) of the app?
- For how long have you been using your Waze data, and is it still being used? Approximately 3 years. They still use it.
- Who did the integration into Frisco’s SAFER? SAFER was developed by Frisco. Waze is fully integrated into SAFER and was done in house. SAFER is an app that’s been in development for 13 years and is used by CAD operators, Police, Fire and Traffic to have a better situational awareness and a common operating picture of incidents.

Receiving

- What WAZE event/incident types are used? SAFER almost shows everything (accidents, construction, objects in the road, stopped vehicles, traffic jams, waze construction lanes including Frisco’s Public Work construction projects with partially closed roadways).
- Is the WAZE confidence and reliability index scores considered? Not now, but maybe in the future.
- Is the data real-time or refreshed at preset interval? They believe it is real time but sometimes they see incidents in waze app that haven’t been published on the feed.
- Does Frisco ingest arterial, freeway, and frontage road Waze data? everything

Sending

- Do you send the above in real-time? XML feed updated once a minute, but Waze might take 5 min to pick it up. Once a reportable event is entered in SAFER, it is automatically published on the XML feed.
- Are TMC operators using the app consistently? Some operators do use it but some not all. Operators have 6 screens. SAFER is not part of the CAD system but displays CAD information. SAFER and CAD system are on different screens. E.g. are some only using it as visual check while others are acting on it to update or create new events? If they see an incident they can enter it into the CAD system after it is manually verified. Once created, that incident is sent back to Waze and they will see it in SAFER.
- Any data issues in general? We are unable to programmatically relate the data sent to Waze from CAD back to the data Waze is displaying. It would be ideal if a unique ID sent to Waze from SAFER was retained so we can be assured a point in Waze that is being displayed originated from Frisco CAD.
 - quality
 - Accuracy

- availability
 - Latency: it appears that Waze takes several minutes to ingest the data sent by Frisco
 - Uptime
 - API
-
- What are the experienced benefits so far? They ran some metrics in 2019 but haven't been updated. Waze helps them to be proactive.
 - Does Frisco find it useful? What would be helpful to track or measure in order to quantify the benefits? Yes, See above. They would like to update and expand their evaluation.
 - Does Frisco have any performance metrics to compare Waze vs TMC incident data? Yes, they have a Waze dashboard for the EOC, which is separate from SAFER.
 - Reporting capabilities? yes, in the EOC dashboard
 - Filtering capabilities? no, they can show/hide different types of events but everything is consumed
 - Wish list enhancements – e.g. automatically generate new events that operators just have to verify and accept. 1) It would be great if Waze could report if the user that reported the incident is a 'Wazer' or Frisco, because sometimes—when doing analysis—it appears that Waze is reporting 3 minutes later than CAD but it could be that it was reported by Frisco and not a 'Wazer'. 2) That Waze update their data reported by Frisco faster. 3) Enhanced reporting such as statistical data.
 - Any other lessons learned? Good communication to end users/responders is important (such as patrol cars) so they know what is coming.

Integration

- What do CAD vendors need to know if they want to integrate WAZE data? City has not integrated Waze/SAFER into CAD.
- Do you have any code or configuration documentation that you can share? David Shuster will check if code can be shared.
- E.g. based on Steve Foster's email:
 - ESRI Geoevent server used to digest Waze feed
 - ESRI's ArcGIS server to create a map service to display the WAZE data

Others:

- SAFER is running in the police cars and fire apparatus
- SAFER has a filter but it consumes all the WAZE data. The filters is more to toggle on/off the various types of events.
- Tip: Topology is important in network mapping. E.g. A to B issue when entering road closures: Waze is picky about the order and might not show it on Waze. 'Wazers' with enough credentials are allowed to edit Waze maps. E.g. Chad Ritchi is the regional WAZE map editor czar for Texas.
- Tip: exact location might be confusing when Wazers enter data at intersection or interchange.
- Current CAD system is 25 years old and there are no plans to replace it in the near future.

NCT911 Waze Call with Rodger Mann & Brooks Shannon 4/8/21

General

- How many PSAPs are currently ingesting Waze feed from NCTCOG911? 42 PSAPs, mostly rural, 5 small Dallas County cities
- Is the Waze feed integrated into PSAP's CAD system? they replaced the original Waze app/map, based on ESRI geo-event server, with Radius Plus from Rapid Deploy (RD):
 - Radius Plus went live in January 2021.
 - Radius Plus is not integrated into the PSAP's CAD. Each agency has its own CAD from different vendors.
 - Radius Plus is better than the ESRI solution because the rendering is more quickly and clearer in Radius Plus. Plus the ESRI solution didn't display the native Waze icons.
 - Rapid Deploy integrates with Google and Apple transportation tools. Google + Apple integration with higher-precision location updates. Google updates every 5 seconds, Apple updates every 10 seconds. Traditional methods from cell towers update every 30 seconds. These tools pass the exact phone location (breadcrumb trail) instead of using the cell carrier's rough tower location. The higher-precision location updates are limited to cellular 911 calls, excluding land-line or VOIP 911 calls. If a caller dials 911, and has a data connection, the phone can push its location to Radius Plus. Most IOS and Android phones can do this (model 6 and later).
 - RD pricing: monthly license by month based on concurrent seats (e.g. a PSAP has 20 positions but only 10 are regularly staffed, then they will pay for 10 seats). We can discuss pricing later with other RD staff.
- Do you have any stats comparing number of waze events vs. traditional 911 calls (e.g. monthly)? NCT911 does not have any data now. There was a study in California that has some statistics which is the same study that Tom is quoting. TTI/CTR will do something similar. RD Eclipse platform provides a lot of analytical information. A lot of this is already public (provided board of director's presentation Attachment E). No action needed from NCT911 or RD to provide data. TTI will share our evaluation study with NCT911.
- Do PSAP operators using the Waze feed consistently? E.g. are some only using it as visual check while others are acting on it to update or create new events? It's assumed the PSAPs are using the Waze feed, but NCT911 does not know for sure because the PSAPs don't provide feedback unless something is not working. NCT911 would have to send a survey.
- Any data issues relative to: In general, Waze data via Radius Plus has no issues.
 - Accuracy (location, event type, etc.)
 - Latency – e.g. Waze takes several minutes to ingest the data sent by Frisco
 - Receiving
 - Sending (for two-way feeds)
 - Uptime
 - API
- Do operators find it useful? What would be helpful to track or measure in order to quantify the benefits? NCT911 has heard some anecdotal feedback where a few PSAPs found it useful but generally PSAPs don't provide feedback unless something is not working. Also, most PSAPs are rural, so getting Waze data is better than no data because they solely rely on callers. NCT911 would have to send a survey to solicit feedback.
- Wish list enhancements – e.g. automatically generate new events that operators just have to verify and accept. Clustering of Waze notifications for the same incident might be helpful. However, it might be possible that the PSAPs operators prefer to figure it out by themselves without the clustering. They would need to send a survey to ask PSAPs.

- Are there any key lessons learned? 1) provide good training, 2) ensure to get the proper capacity and bandwidth (not a problem with Rapid Deploy), and 3) have enough screen real estate to fit the mapping application.
- Do you, or PSAPs, edit the WAZE map network periodically? NCT911 does not edit Waze roadway network. But Chad Ritchi is now with Rapid Deploy.

Receiving

- What WAZE event/incident types are used? Radius Plus has a direct Waze connection. NCT911 old Geo-event server solution is connected to the DFW511 feed.
 - Major Accident
 - Minor Accidents
 - Car Stopped on Road
 - Object on Road
 - Construction Hazard
 - Construction Road Closure (Full only?)
 - Traffic Signal Light Fault
 - Other
- Is the WAZE confidence and reliability index scores considered? Unknown
- Is the data real-time or refreshed at preset interval?
- Do you ingest arterial, freeway, and frontage road Waze data? yes
- Are there reporting capabilities?
- Are there filtering capabilities? There is some filtering features, but they don't know the details.

Sending

- Do you, or PSAPs, send any information/data back to Waze? Only one way. NCT911 is not sending data. Only Frisco and Arlington do that.
- Do you, or PSAPs, send the above in real-time? see above bullet

Integration

- What do CAD vendors need to know if they want to integrate WAZE data? And how would that differ for a cloud-based CAD system, if any?
- Define levels of integration such as:
 - Low –web map page
 - Medium – Cloud based Display
 - High – Full integration with CAD

RD can provide from a full Cloud-hosted-CAD system solution to other hybrid solutions that work together with an existing CAD. For the Medium solution, RD could provide a cloud host PSAP mapping that provides (NCT911 has this which allows to PSAPs to keep their legacy CAD systems):

- Waze integration
- automatic 911 call display
- Apple/Google geo location (If someone dials from an Apple/Google phone, RD can display the traditional location source plus the apple/google location right along with the Waze incidents in one map)

Radius Plus does not integrate with existing CAD systems. In addition, it can't get incidents created in the PSAP's CAD (e.g. received by radio or someone calling the 911 administrative line) and show these in the Radius Plus map. However, RD can do 911 calls.

- Do you have any code or configuration documentation that you can share? not discussed

Other

- Rapid SOS, which allows for more accurate cell phone geolocation— similar to Rapid Deploy's integration with Google and Apple- is a free solution very popular with small PSAPs (about 90%), but it is stand-alone as it is not integrated into other systems. The difference between RD and Rapid SOS is that RD can integrate directly with the 911 phone and call handling at PSAPs. RD knows when a 911 call is answered and automatically plots it in a map and associates it with the other pins coming directly from the handset. Rapid SOS only displays in a map all of the pins coming from all of the calls and it is up to the user to match whatever callback number you just answered with the 10-digit pin. For example:
 - a caller places a 911 call from his smartphone
 - the call goes to two places:
 - RD or Rapid SOS system, which displays a pin for that call in a map
 - PSAP's CAD call handling system answered by a telecommunicator
 - RD reconciles the two of them automatically. Rapid SOS requires user to reconcile them manually

7 APPENDIX B

I-30 CORRIDOR PUBLIC-SAFETY ANSWERING POINT MEETING NOTES

IH30 PSAP Waze Meeting: GP (5/18 at 9:30a)

Attendees:

- Aubry Insko Ainsco@gptx.org (Emergency Comm. Mgr.)
- Lt. Marc Taddonio Mtaddonio@gptx.org (GP Police Department, Traffic Div.)
- Caryl Devries cdevries@gptx.org (senior city traffic engineer)
- Peter Joyce Pjoyce@GPTX.org (traffic management center)
- Minh Le
- Roberto Macias

Note: PSAP used the term “light” but after TTI talked to the other PSAPs and RapidSOS researchers used the term “limited” instead of “light”.

- GP has a MOU agreement with Dallas Fire Rescue where the Dallas Fire Rescue (DFR) responds to all FIRE/EMS calls for service in the WB TEXpress lanes from Beckley to 161 and Grand Prairie FD responds to all FIRE/EMS calls for service in the EB TEXpress lanes from 161 to Beckley. Note, Grand Prairie PD responds to all PD incidents in TEXpress lanes, within Grand Prairie limits. (0:23:00)
- Rapid SOS (0:30:00)
 - GP is a participant to Tarrant County 911 District – which is the public switched telephone network (PSTN) for TC. They provide mapping and routes the 911 calls to the nearest PSAPs
 - GP has been using light version of Rapid SOS since March/April, 2021 which is integrated into the TC 911 telephony infrastructure, Vesta. For example,
 - 911 call received with:
 - [ANI \(Automatic Number Identification\) and ALI \(Automatic Location Identification\)](#) – GPS coordinates by [Phase 1 or 2 wireless upgrades](#); has to be manually refreshed
 - Rapid SOS – GPS coordinates; aligns with ANI & ALI data 90% of time; auto-refresh (10 sec)
- CAD (0:30:00, 0:45:29)
 - Superior One Solution but they plan to transition to a cloud-based CAD system such as AXON CAD within 2 years – which already integrated Waze
- How can Waze help (0:40:00 min):
 - improve Identifying the exact incident location
- ATMS (0:46:00)
 - Lonestar
- TMC is using DFW511, Ecotraffix, and Waze.com to see Waze incidents
- TMC is feeding roadway closures to Waze but not sharing it with PSAP
- PSAP relying on city’s water and street department to inform them of street closures but they aren’t always told when the closures are removed (this is a wish list item during discussions with CAD vendors) – they want a ‘one source of truth’ for this information
- PSAP could use Waze feed to monitor for roadway closures in another app/window but it’s less likely to be used during spikes in calls or mass emergency situations; that’s why it’s important to ultimately have CAD integration (High Level)

- PSAP has no way of verifying incidents so they dispatch resources based on information provided by callers whereas TMC has cameras and listen to police channels (0:54:25)
- May want to involve GP Fire Department in future discussions, as needed
- Misc. Questions: Outside of Wazers reporting incidents/jams, how does WAZE get some of their data e.g. congestion, speed, events? E.g. CCP partners, Google, or collected passively through app, etc.? And is the Waze app collecting passive information (i.e. without user's knowledge)?

IH30 PSAP Waze Meeting: FTW (5/19 at 1:30p)

Attendees:

- Ermis, Edgar - Opie.Ermis@fortworthtexas.gov (FTW police public syst comm)
- Vandever, Steven - Steven.Vandever@fortworthtexas.gov (IT dept including CAD backend)
- Gupta, Rajnish - Rajnish.Gupta@fortworthtexas.gov (transportation mgmt.)
- Raj Aziz - Aziz.Rahman@fortworthtexas.gov (city traffic engineer)
- Minh Le
- Roberto Macias

Note: PSAP used the term "light" but after TTI talked to the other PSAPs and RapidSOS researchers used the term "limited" instead of "light".

Meeting notes:

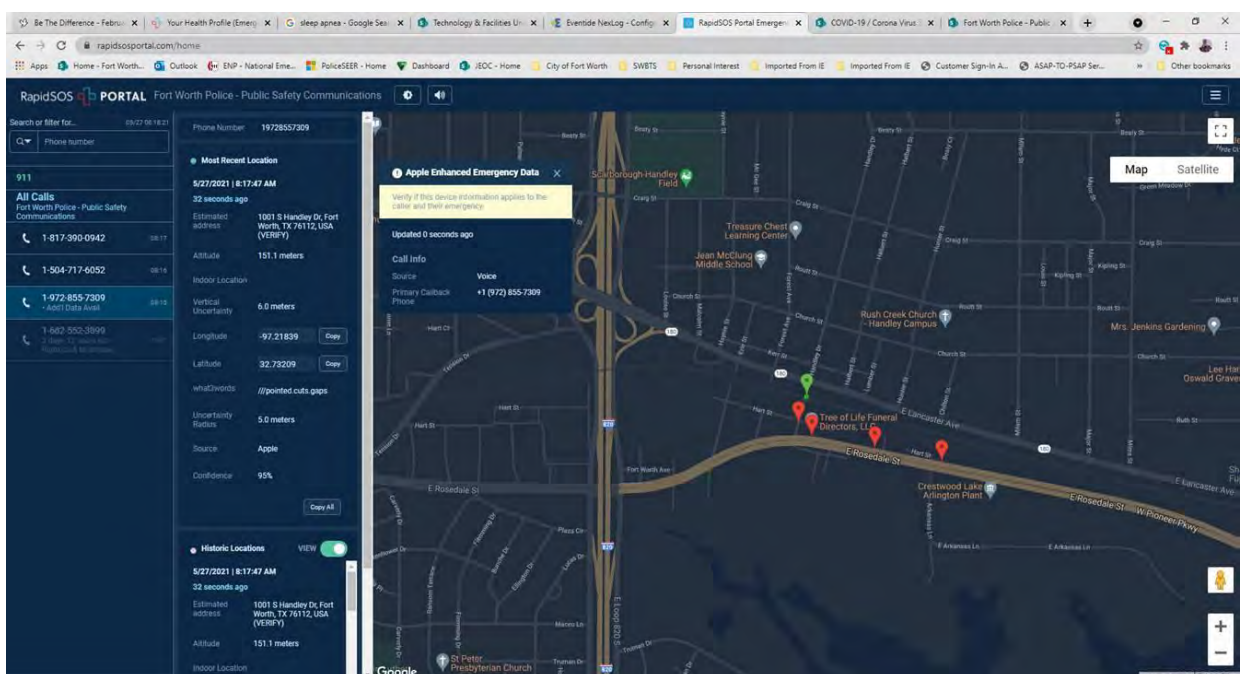
- CAD was upgraded last week.
- Fire dept contact to add in future communications: David Tidewater
- FTW already has some Waze integration mostly going out to Waze (IT dept) (Steve 18 min)
 - FTW sends live accident and severity information to Waze every 2 to 5 min.
 - FTW sends lane closures.
 - FTW receives traffic jam, accidents, and road hazard information every 5 min. and storing locally in a DB. The plan was to integrate this into CAD.
 - FD is interested in road impedance info (e.g. what roads are affected by traffic jams) for trip planning. They had a lot of issues importing traffic jam data to their last version of CAD. The accidents and road closure was easier. They will try again with their new version of CAD to see if it is easier.
 - FTW will work with some department for reporting potholes
 - FTW has been doing this for a couple of years.
 - IT is getting the Waze data, storing it, and it could be used if a department tells them what they want.
- Ecotrafix (Aziz 23 min)
 - Cities enter road closures or accidents into Ecotrafix, which sends these to Waze.
 - Ecotrafix has a two-way feed with Waze.
- PSAP boundaries: slide is correct. FTW responds to GPL and FR up to Randol Mill rd. (Edgar min 31)
- FTW PD is borrowing the Tarrant county Waze dashboard (developed by Ramon Campos). (Edgar min 34)
 - They pull it as needed and is not running constantly on someone's screen. Telecommunicators are not required to use the Waze dashboard. It is up to the telecommunicator. They already have too many apps open.

I-30 Waze/911 Integration Pilot for Texas Connected Freight Corridors

- FTW is evaluating a Carrousel app to help them manage multiple screens. They have 3 licenses now for testing purposes. They plan to expand to the call takers so they can display apps like the Tarrant County dashboard, weather app, etc.
- Rapid SOS (Edgar 35 min)
 - Was rolled out yesterday 5/17 for the call takers.
 - Tarrant County 911's telephony system, Vesta, has the light version that only shows where the cell phone is and track it.
 - FTW has the full version (accessed on different PCs) that allows getting personal data (e.g., medical info, emergency contact, height, weight, medications, etc.) from Android and Apple devices that the user is willing to share. Also, if they are riding with Uber, it will show the driver's name.
 - Not sure if Rapid SOS has plans to integrate Waze.
 - RapidSOS funding: not sure from where it comes. Everything was free for FTW. FTW provided the GIS data and RapidSOS built the map around FTW jurisdictional boundaries.
 - Updates to the GIS map: FTW only provides when there are changes, but even with that, RapidSOS has a 10-mile buffer around the jurisdictional boundaries. So even if FTW doesn't update the map, the calls will still show up because of the buffer. Very seldom the boundaries change (e.g., annexation).
 - Rapid SOS uses google maps.
 - Provides lat./long., estimated address, source of information, and confidence level of how accurate this info is.

(Follow up email 5/27/21)

- FTW is 1 of 3 Automatic Call Distribution (ACD) centers in the TC911 system, and it's also the largest
- Sample Rapid SOS Portal snapshot showing some of the extended data mentioned above. Note, the user does not have Apple Enhanced Emergency data turned on.



- Not fully integrated with CAD(?). There's an integration subscription cost from CAD vendor but the integration doesn't really work well for FTW's needs. However, call-takers do not need to manually enter the cell phone numbers into Rapid SOS portal; it's autopopulated.
- CAD (50 min)
 - Central Square (tritec): enterprise solution
 - FTW discussed a couple of years ago Waze integration at a high level, but now it may be revisited.
- How can Waze help (52:30 min):
 - improve Identifying the exact accident location
 - automated way to generate CAD event before the call takers get the call
- Their ultimate goal is to have Waze fully integrated with CAD (57:30 min)
- CAD updates (Steve 59 min): FTW will keep current on updates. Central Square has 3-week sprints for updates and new features. Multiple updates per year. These are minor upgrades. Major upgrades (like the one FTW just had) are about once a year.
- The city's ATMS is Max view (60 min).
 - City working with UTA to integrate Waze trajectory data with their traffic signal system and adjust timing. UTA will create a dashboard. It is a pilot project in one corridor with eight intersections.
 - City will use the Acela system (map-based) for performance measure to check if something is wrong with the signal equipment
- Edgar (66 min) confirmed that Jason had contacted them to share the event data via the FTP site for Transvision. No action taken so far. Jason needs to ping again. Hopefully, this data can also be used for our Waze project. Steve thinks it is doable.
- (75 min): send sample file from Arlington to show the data structure
- (71 and 77 min): general discussion about how the evaluation will be done. Edgar feels that asking the telecommunicators to use Waze as part of their SOP might be difficult as they are overloaded; this might delay 911 calls. They are 30% shorthanded.
- (87 min): legal agreements to share data: if FTW is part of the connected citizen program, then most likely, this has already been done.

IH30 PSAP Waze Meeting: ARL (5/20 at 3:30pm)

Attendees:

- Daniel Burnham Daniel.Burnham@arlingtontx.gov (Interim City Traffic Engineer)
- Eric Borton Eric.Borton@arlingtontx.gov (Police Department, Traffic Div.)
- Rhonda Shipp Rhonda.Shipp@arlingtontx.gov (Emergency Comm. Admin. & Public Safety Radio System)
- Jeremy Hensley Jeremy.hensley@arlingtontx.gov (Emergency Comm. Mgr.)
- Mannar Tamirisa Mannar.Tamirisa@arlingtontx.gov (ITS Engineer II)
- Minh Le
- Roberto Macias
- Jason Crawford

Note: PSAP used the term "light" but after TTI talked to the other PSAPs and RapidSOS researchers used the term "limited" instead of "light".

- ARL has access to Waze via DFW 511, they feed data to Waze but do not display it in the TMC. (0:20:00)
- (From DB's email) City provides road closure data to Waze using multiple methods. Our IT/GIS team has written a program that creates the JSON feed document based on staff choosing specific special events and their closure category. We also will add closures manually using the Waze road closure tool. Waze only accepts closures if an entire direction is completely inaccessible. If construction has rerouted a direction to the opposite side of the road or elsewhere, yet the direction can still be traveled, then Waze will not accept a road closure for that implementation. We will add construction warnings to the Waze map for construction projects. We recently added Buyers Barricades/Wanco as a sublicensee, so their connected arrow boards provide warnings and messages to Waze about lane closures. These are not considered closures in Waze, just warnings. We are working on a program to get all City construction vehicles with light bars that park in a lane of traffic for more than two minutes with their light bar on to show up in Waze as a warning similar to the construction warnings or the arrow board warnings. So far, we have not had any issues with Waze consuming our data. The only time I have seen issues is when the feed has errors. As for length of time the warning and closures are shown on Waze, it depends. Our event closures have a specific start and stop time. The construction warnings only persist as people give them "thumbs up." There is a minute or two delay for our feed to show up on Waze. It is negligible. The data we receive from Waze is currently on a specific time frame such as every 15 minutes or something like that
- PSAP does not monitor or enter information into Waze (0:24:30) but they notify Waze of closures (reported by PD/FD) via page/text (0:22:29) but Traffic Dept. enters them into Waze via xml
- ARL responds to all traffic incidents along I-30 but TExpress lane is currently not open (0:25:15)
- Rapid SOS (0:30:00)
 - ARL is starting to use Rapid SOS (full version via portal)
 - They also get Rapid SOS as part of the TC911 maps - Vesta (location only)
 - Full version provides 'bread crumb' location trajectory data and "extended data" such as medical info, emergency contact, height, weight, medications, etc.) from Android and Apple devices that the user is willing to share. Also, if they are riding with Uber, it will show the driver's name.
 - ARL receives the Waze feed via their geoevent server – they can use it to analyze the data; this data stream is not being utilized by other departments other than traffic; Traffic/GIS will start discussing possible ways to integrate it into the PSAP (0:32:15)
 - ARL would need to investigate how to share their Waze feed; Jeremy was going to follow up with Tom Conzel (GIS Team)
 - Will our prototype tool provide web map services (WMS) or web map tile services (WMTS)? ARL's CAD can consume it. TTI confirmed that its' prototype tool won't have WMS or WMTS.
- CAD (0:37:40, 0:47:00)
 - Hexagon Integraph 9.4
 - Hexagon offers web map services which might offer a path to consume Waze data
 - biannual updates – a minor update is planned soon
- How can Waze help? (0:40:00 min):
 - It could help verify

- exact incident location (e.g. some callers don't know cardinal direction)
- same incident or secondary incident
- it could provide a warning/heads up for minor incidents e.g. abandoned vehicle or debris on shoulders that could cause major incident
- ATMS (from a previous email)
 - Siemens Tactics 3.2
- TMC is using DFW511, Ecotraffic, and Waze.com to see Waze incidents
- TMC is feeding roadway closures to Waze but not sharing it with PSAP
- May want to involve ARL IT department /Business Analysts in future discussions, as needed

IH30 PSAP Waze Meeting: Dallas (5/20 at 8a)

Attendees:

- Robert Uribe (Police communications and technology admin for Dallas PD)
- Capitan Rufino Salas (Dallas County Sherrif Office, Fwy mgmt. program)
- Minh Le
- Roberto Macias

Meeting notes:

- (5:30') Funding discussion. Robert wanted to know the funding implications for this project. TTI clarified that NCTCOG is providing the funding. This project will provide the PSAPs another data source for telecommunicators to use.
- (8') Capitan Salas will brief lieutenant Amy Charles (DCSO communications), who couldn't join the call.
- (9:30') Dallas County Sheriff will piggyback on the CAD system with the City of Dallas. It is currently under development.
- (20') Fire dept contact: Chief Tami Kayea
- (23:30') Rapid SOS
 - They are using the full version (although later Robert said it was the light version). It includes heat maps.
 - Robert has concerns about data load on their network for our Waze prototype
- (31:30') Responding agencies map: Capitan Salas confirmed that DCSO responds to incidents on GPL and FR and DCSO on the TEXpress lanes. He will confirm that Dallas FD responds to incidents requiring the FD on WB TEXpress lanes within Grand Prairie.
- (35:50') Discussion about the integration options:
 - TTI clarified that our low prototype tool is a live snapshot and not for post-analysis.
 - TTI explained that our low prototype is only for testing and we will provide support during the project's duration. After that, it is up to the PSAP to continue. TTI will provide the code to the PSAPs, as needed.
 - Robert stated that this will have cost implications—including O&M—that the PSAP will have to budget for the interim and final solutions.
 - Robert believes that most likely, the final goal would be to have a high integration with their CAD.
- (46:30') Rapid SOS
 - Implemented the light version and working to implement the full version sometime within the next six months.

- (57:20'): besides better location and trajectory, it also provides reporting capabilities for hot spot indicators. They can do a geofence to find out what calls came within a certain area.
- (58') TTI asked if DCSO has asked Central square to add the Rapid SOS functionality. No, because Rapid SOS is integrated with Central Square's recording system and that recorder consumes all the ANI/ALI data, GSP coordinates, and provide mapping.
- (59') If Rapid SOS were to add Waze in the future, then Robert would be happy because Rapid SOS is already integrated into the recording system (is the recording system part of Central Square system?).
- Rapid SOS provides free instant upgrades because it is cloud-based.
-
- (47:40') CAD
 - CAD vendor is Central Square (Triatec).
 - They are currently at the latest version and don't plan for a version upgrade this year.
 - They haven't talked about integrating Waze with Central Square. This could be done once they see the value of Waze. (55:30') Central Square periodically talks to their clients about their needs and then prioritizes new features. Central Square currently provides an avenue to integrate traffic data but might not be as data rich as Waze.
 - (54:40') does Central Square distribute all the new features to all the PSAPs when upgrading or does each PSAP has different features? Yes. If you are in the same version, then the features will be the same.
- (49:30') Next steps: low prototype seems to be the best option to evaluate Waze. If there is value, then work on the middle or high options.
- (52:00) How can Waze help? Get a quicker notification. However, this applies more to their communication section who then requests CAD (Capitan Salas is with dispatch) to dispatch resources.
- (61:30') Other people to include:
 - Tyron Williams: is the CAD admin. Robert will brief him about this meeting.
 - Amy Kaie FD
 - Amy Charles (DSO communications)
 - Captain Eric Williams
- (63'): provide before/after data: they did not answer. Ok, for Jason to contact Robert to get event data.
- (68') TTI will send California study
- (69') TTI to send slides

Texas Connected Freight Corridors



I-30 Waze and 911 Integration Pilot – Task 2

Version 1.0

December 17, 2021

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REVISION HISTORY

Version	Date	Author(s)	Comment
1.0	December 17, 2021	TTI	Initial Draft
1.1	July 21, 2022	TTI	Final Draft

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1 INTRODUCTION

In task 2, the research team developed a Level 1 prototype tool, demonstrated the tool, and delivered tool's source code and related documentation to TxDOT as well as assisted stakeholders, as needed. The Team also developed a process to collect Waze and public-safety answering point (PSAP) data for the evaluation task. This technical memorandum documents the following results from task 2 Develop Prototype and Provide Assistance:

1. A Technical Memorandum showing results from Task 2, Develop Prototype and Provide Assistance.
2. Demonstrate Prototype tool: demonstrate the tool, explain the features, and how it works.
3. Data repository: collect and store 3-6 months of Waze data along I-30 Corridor.

2 DEVELOP PROTOTYPE AND PROVIDE ASSISTANCE

2.1 PROTOTYPE DEVELOPMENT

The low-level integration solution identified in task 1 was a web browser-based prototype tool. The prototype tool offers the advantage of being a minimum-cost solution that can be deployed right away. It does not require any integration with the PSAPs systems. The prototype tool will work on any computer with a web browser and an internet connection. The prototype will be available to the PSAPs during the duration of the project and provide an easy alternative to test the potential benefits of the Waze data. The Team started developing the prototype tool based on basic features discussed with TxDOT, NCTCOG, and I-30 stakeholders from task 1. The tool can be accessed at <https://waze911.z21.web.core.windows.net/>.

Basic features of the prototype tool include:

- Visualization of Waze incidents (tested in Chrome and Firefox).
- Data is filterable by incident type, subtype, roadway type.
- Click on incidents to get detailed event information.
- No CAD or ATMS integration needed.
- Grouping of Waze events to highlight hotspots where several incidents occurred based on proximity.

Additional features were implemented later based on further deliberations.

- Classified three alert types by color.
- Added an automatic page refresh timer and timestamp.
- Prefiltered data for I-30 West events only.
- Added a reliability filter.
- Added a Help page to define terms and the disclaimer.

The next section describes the stakeholder meeting where the tool was demonstrated. Enhancements were made to the tool after this meeting based on the feedback gathered.

3 PROTOTYPE TOOL DEMONSTRATION

The research team demonstrated the prototype tool to the stakeholders on September 24, 2021. The following are the stakeholders in attendance:

- City of Arlington
- City of Dallas
- Dallas County
- City of Fort Worth
- City of Grand Prairie
- NCTCOG
- TTI
- TxDOT
- UT CTR

4 THE PURPOSE OF THE DEMONSTRATION WAS TO 1) DEMONSTRATE THE TOOL'S CAPABILITIES AND FEATURES, 2) SHOW THE ATTENDEES HOW TO OPERATE THE PROTOTYPE TOOL, AND 3) SOLICIT FEEDBACK FROM THE STAKEHOLDERS TO IMPROVE THE TOOL BASED ON THE PSAPs' OPERATIONAL NEEDS. THE MEETING NOTES FROM THE DEMONSTRATION MEETING ARE INCLUDED IN COLLECT AND STORE EVALUATION DATA

4.1 DATA REPOSITORY

Task 3, Evaluation, is the final task of this pilot project. It will involve researchers assessing the added benefits of using Waze data, specifically whether Waze detects incidents quicker and with greater position accuracy than PSAPs. The evaluation will be documented in a separate technical memorandum.

The research team first investigated how best to archive the Waze data. DFW511 keeps a rolling six-month archive of Waze data for the DFW region. TTI reviewed DFW511's Waze filtering rules and a sample dataset of their Waze archive. Based on the review, there were a number data elements, deemed critical to the evaluation, that were being filtered out, including:

- Road Types: service road
- Confidence score (based on other user's reactions) < 5
- Reliability score (based on other user's reactions and the level of the reporter) < 5. It was later discovered that Waze also prefilters their data for Reliability score <5. However, Waze might modify this criterion in the future.
- Jam Alerts
- Weather Hazard/Hazard Alerts
 - HAZARD_ON_SHOULDER
 - HAZARD_WEATHER
 - HAZARD_ON_ROAD_POT_HOLE
 - HAZARD_ON_ROAD_ROAD_KILL
 - HAZARD_ON_SHOULDER_CAR_STOPPED
 - HAZARD_ON_SHOULDER_ANIMALS
 - HAZARD_ON_SHOULDER_MISSING_SIGN
 - HAZARD_WEATHER_MONSOON
 - HAZARD_WEATHER_HEAT_WAVE
 - HAZARD_ON_ROAD_OIL
 - NO_SUBTYPE
- Miscellaneous alerts

It was determined that the DFW511's Waze archive could not be used because it would filter out too many potential events needed for the evaluation and would not represent the most complete dataset possible. Thus, the research team created a geofence around the I-30 corridor to start collecting the Waze data as shown in Figure 2. All alert types and their available fields are archived every two minutes in a data repository and can be accessed using Microsoft Azure and Storage

The Team also coordinated with the four I-30 corridor PSAPs (Dallas, Grand Prairie, Ft. Worth, and Arlington) to collect the 3-6 months of data. Not all the same data was available from the PSAPs thus researchers coordinated with PSAPs to develop the desired dataset to be collected as shown in Table 3. Only the City of Fort Worth PSAP agreed to implement an XML to provide the data in real-time. The Cities of Arlington and Grand Prairie provided their dataset in a single data dump. The City of Dallas did not provide any data.

Table 3. Desired PSAP Data Fields

Field	Format
Event number (call ID)	Number
Case number	Number
Creation_Time	YYYY/MM/DD HH:MM:SS
Update Time	YYYY/MM/DD HH:MM:SS
Call Status	Text
Call_Type (Type and Sub Type)	Text
Address (street number/block number and street)	NNNNN Text String
Event Latitude	Decimal degrees
Event Longitude	Decimal degrees
Mobile Caller Lat	Decimal degrees
Mobile Caller Long	Decimal degrees

4.2 EVALUATION

The evaluation task was led by University of Texas Center for Transportation Research (CTR). This work will be documented in a separate technical memorandum for Task 3.

Appendix A. During this meeting, UT CTR also discussed the evaluation framework, which is documented in a separate technical memorandum.

4.3 ACTION PLAN

During the demonstration meeting, the stakeholders provided initial feedback, and the group agreed to the following action plan:

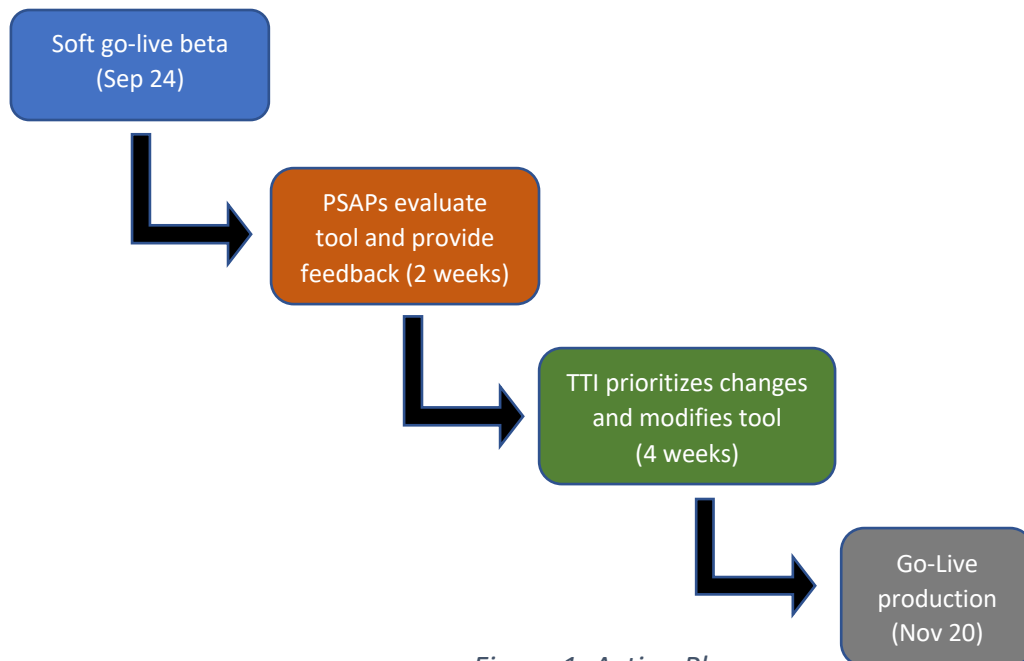


Figure 1: Action Plan

4.4 TOOL ENHANCEMENTS AND MODIFICATION

The research team documented in Table 1 the enhancements and changes received during the demonstration meeting and the two-week evaluation period. The research team accommodated all

the requests received, implemented the software changes, and re-tested the prototype tool. The final production version of the tool went live on November 22, 2021.

Table 1: Issue Tracker Documenting Enhancements and Changes.

No.	Action or Issue	Description
1	Legend: send to back when event popup is overlapping with the legend box.	
2	Legend: move "accident" to the top	
3	Two min timer: move it away from the map "Leaflet"	
4	Filter headers: use bold font and unbold the options in drop-down menus.	
5	Event with blank subtype (null): are not shown in the filters. Create a new category for "No_Subtype". When applying filters, the icon for this type of event disappears.	Search in the feed for subtype": "" ,"
6	Expand Alert Type drop-down menu so you don't need to scroll down.	
7	Replace "Accident" with "Crash" in Alert Filter, Subtype filter, and Legend	Original comment: Crash - We think that it would be worth changing "accident" to "crash". This is a tool that we'd like to see TxDOT and other cities, TMCs, etc. use and this terminology has become more common in the industry.
8	Separate Hazards and Weather Hazards by only listing non-weather related subtypes under Hazard and weather related subtypes under Weather Hazards. No subtype events goes under Hazards.	Original comment: Differentiate between (Road) Hazards and Weather Hazards - Thinking about how a PSAP/TMC will use the tool, the actions that need to be taken for (Road) Hazards and Weather Hazards are very different and we believe that it would be worth separating them into two distinct categories. Agreed.
9	Change title page to : "(I-30W Tom Landry Events Only)"	Original comment: I-30 - When we read "I-30 West Events Only" we initially thought it meant "westbound only." Not sure what the local lingo is but thought we'd bring it up as something that was confusing to outsiders, perhaps it could say something like I-30 between Fort Worth and Dallas.
10	Change icon color to differentiate Hazard & Weather Hazard	Allows PSAPs to differentiate between the two hazard types without having to use the Filters.
11	On the HELP page, add "Currently, WAZE is filtering out events with Reliability score <5." at the end of the Reliability definition.	
12	Capitalize the first letter on the paragraphs on the Help page	

5 COLLECT AND STORE EVALUATION DATA

5.1 DATA REPOSITORY

Task 3, Evaluation, is the final task of this pilot project. It will involve researchers assessing the added benefits of using Waze data, specifically whether Waze detects incidents quicker and with greater position accuracy than PSAPs. The evaluation will be documented in a separate technical memorandum.

The research team first investigated how best to archive the Waze data. DFW511 keeps a rolling six-month archive of Waze data for the DFW region. TTI reviewed DFW511's Waze filtering rules and a sample dataset of their Waze archive. Based on the review, there were a number data elements, deemed critical to the evaluation, that were being filtered out, including:

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 - NO_SUBTYPE
- Miscellaneous alerts

It was determined that the DFW511's Waze archive could not be used because it would filter out too many potential events needed for the evaluation and would not represent the most complete dataset possible. Thus, the research team created a geofence around the I-30 corridor to start collecting the Waze data as shown in Figure 2. All alert types and their available fields are archived every two minutes in a data repository and can be accessed using Microsoft Azure and Storage Explorer as shown in Figure 3. The research team decided to filter out the highlighted road types in Table 2 to minimize storage requirements and are not relevant to this study.

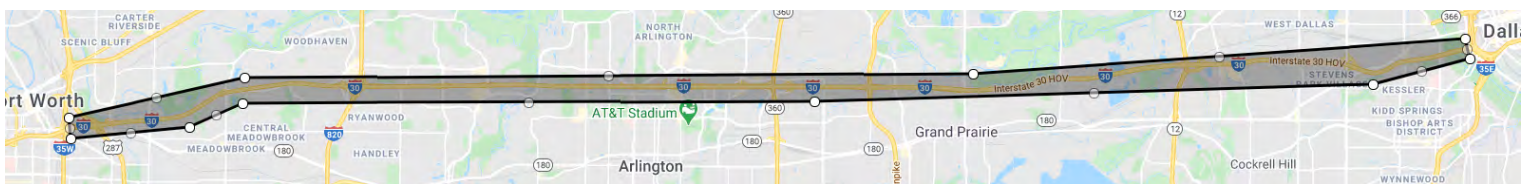


Figure 2. I-30 Corridor Geofence Limits

I-30 Waze/911 Integration Pilot for Texas Connected Freight Corridors – Prototype Tool Task 2

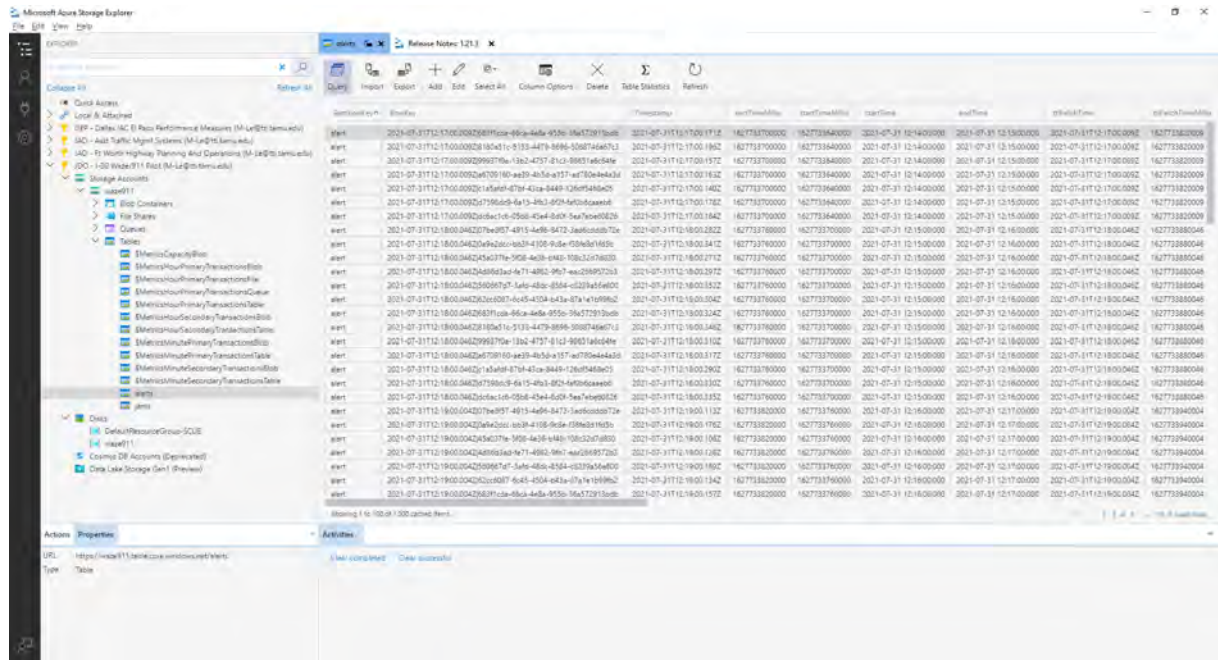


Figure 3. MS Azure Storage Explorer.

Table 2. Waze Road Types

Value	Type
1	Streets
2	Primary Street
3	Freeways
4	Ramps
5	Trails
6	Primary
7	Secondary
8,14	4X4 Trails
15	Ferry crossing
9	Walkway
10	Pedestrian
11	Exit
16	Stairway
17	Private road
18	Railroads
19	Runway/Taxiway
20	Parking lot road
21	Service road

The Team also coordinated with the four I-30 corridor PSAPs (Dallas, Grand Prairie, Ft. Worth, and Arlington) to collect the 3-6 months of data. Not all the same data was available from the PSAPs thus researchers coordinated with PSAPs to develop the desired dataset to be collected as shown in Table 3. Only the City of Fort Worth PSAP agreed to implement an XML to provide the data in real-time. The Cities of Arlington and Grand Prairie provided their dataset in a single data dump. The City of Dallas did not provide any data.

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Call_Type (Type and Sub Type)	Text
Address (street number/block number and street)	NNNNN Text String
Event Latitude	Decimal degrees
Event Longitude	Decimal degrees
Mobile Caller Lat	Decimal degrees
Mobile Caller Long	Decimal degrees

5.2 EVALUATION

The evaluation task was led by University of Texas Center for Transportation Research (CTR). This work will be documented in a separate technical memorandum for Task 3.

6 APPENDIX A

IH30 911 WAZE PROTOTYPE TOOL DEMONSTRATION MEETING NOTES

9/24/21 at 10:30 a.m. via TEAMS

Attendees:

Agency	Full Name	Email
City of Arlington	Brett Dove	Brett.Dove@arlingtontx.gov
	Daniel Burnham	Daniel.Burnham@arlingtontx.gov
	Jeremy Hensley	Jeremy.Hensley@arlingtontx.gov
	Mannar Tamirisa	Mannar.Tamirisa@arlingtontx.gov
	Monsur Ahmed	Monsur.Ahmed@arlingtontx.gov
	Rhonda Shipp	Rhonda.Shipp@arlingtontx.gov
City of Dallas	Brandon, Shawnda	shawnda.brandon@dallascityhall.com
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	Shaw, Jessica	jessica.shaw@dallascityhall.com
	Williams, Tyrone	tyrone.williams@dallascityhall.com
Dallas County	Rufino Salas	3142@dallascounty.org
City of Fort Worth	Ermis, Edgar	Opie.Ermis@fortworthtexas.gov
	Rahman, Aziz	Aziz.Rahman@Fortworthtexas.gov
City of Grand Prairie	Caryl DeVries	cdevries@gptx.org
	Daniel Alvarez	dalvarez@GPTX.org
	Marc Taddonio	mtaddonio@GPTX.org
NCTCOG	Thomas Bamonte	TBamonte@nctcog.org
TTI	Crawford, Jason	J-Crawford@tti.tamu.edu
	Le, Minh	M-Le@tti.tamu.edu
	Macias, Roberto	R-Macias@tti.tamu.edu
	Ward, Travis	T-Ward@tti.tamu.edu
	Wu, Jason	J-Wu@tti.tamu.edu
TxDOT	Brandi Bush	Brandi.Bush@txdot.gov
	Craig Burgan	Craig.Burgan@txdot.gov
UT CTR	McAuley, Anna W	alw2899@utexas.edu
	Michael Moore	mikemoore119@utexas.edu
	Morgan Avera	averam@utexas.edu
	Chin, Kristie	Kristie.Chin@austin.utexas.edu
	Gold, Andrea L	Andrea.Gold@austin.utexas.edu
	RuizJuri, Natalia	nruizjuri@mail.utexas.edu
Phone attendees	12145359019	unknown
	12146531167	unknown
	14174965606	unknown

Meeting notes:

- Prototype tool demonstration
 - (min 1:00) TTI reviewed the planned and actual functionality of the prototype tool.
 - (min 2:00) TTI mentioned that the tool is a prototype intended for PSAPs to evaluate the benefits of using Waze events. It is a basic app that may not have all the bells and whistles found in a commercially available product.
 - (min 2:30) TTI noted that the tool works best in Chrome. Firefox and Edge can also be used, but there might be some small differences. The tool is intended for desktop or laptop use that have a large screen. It is not designed for smartphones.
 - (min 3:00) TTI conducted a live demonstration of the tool.

- (min 14:40) Mannar Tamirisa asked why the term accidents instead of crashes is used. TTI explained that we are using the same terminology that Waze is providing in the feed and documentation to be consistent.
- (min 15:30) Tom Bamonte indicated that Waze uses other terms that might be confusing to the PSAPs—such as using weather hazard type for accidents. Tom asked the PSAPs to let us know if there are changes from the schema that would make it easier for the PSAPs to use this tool.
- Tom Bamonte commented that it would be useful to study the accuracy of reports by reliability level. Such analysis might be useful when agencies consider setting minimum reliability levels for what Waze incidents to track. Currently, that process of setting a minimum reliability level lacks that information.
- (min 17:30) TTI will provide to TxDOT the documentation and source code for setting up the tool. The intent is to allow the PSAPs to continue using this tool after the pilot and having the source code will allow them to customize it to its needs, such as expanding the geofence to cover the PSAP's entire jurisdiction.
- Evaluation framework
 - (min 19:00) CTR described the evaluation framework and the four metrics: time, accuracy, reporting by incident type, and hot spot analysis.
 - (min 21:00) TTI clarified that the hot spot analysis in the tool only shows the current hot spots during the 2-minute window of the live data. If a historical version of the hot spot analysis is needed, the evaluation study will cover that.
 - (min 29:00) CTR will do a hot spot analysis based on the PSAP jurisdictional boundaries. TTI indicated that we need to get the exact cross-streets of the boundaries from the PSAPs since the map displayed during the meeting was an approximation. TTI will send an email to the PSAPs requesting this. CTR will continue writing the performance evaluation framework and incorporate feedback from this meeting. The actual evaluation will start next summer.
- Data needs from PSAPs
 - (min 32:00) Fort Worth's XML feed is up and running and Arlington's is almost done. Dallas is still working on setting up the XML feed. Marc Taddonio (Grand Prairie) indicated that it is in the process of identifying a new CAD provider, so the XML effort is currently on hold. TTI will follow up with Grand Prairie to understand the timeline. TTI mentioned that to stay on schedule, the goal is to have all the XML feeds running by December 2021. Otherwise, the backup plan is to get a historical data dump from the PSAP.
 - (min 36:00) Captain Salas from Dallas County indicated that the people in charge of their communications section are Captain Shelley Knight and Lt. Amy Charles. He asked to make sure that they are added to future meetings. TTI mentioned that Sergeant Gable from the City of Dallas is supposed to brief Chief Martinez. Perry Cornell (City of Dallas) mentioned that he will follow up on that.
 - (min 38:00) NCTCOG offered to help the cities and TTI move things along if needed. Michael Morris could contact key people to assist with this. Expanding the use of Waze to improve safety and operations to other roads beyond I-30W is a high priority for NCTCOG.
- Access to CCTV feed to improve situational awareness
 - (min 39): Tom Bamonte indicated that at the last meeting on PSAP access to TxDOT video feed, the City of Fort Worth was going to reach out to TxDOT to reestablish the video feed. Please feel free to contact: Natalie Bettger (nbettger@nctcog.org and

Marian Thompson (MThompson@nctcog.org) at NCTCOG or Matthew McCarty (Matthew.McCarty@txdot.gov) at TxDOT.

- Closing remarks by TTI (min 42:00): The tool is now live, and TTI requested the PSAPs to play with it and provide feedback in two weeks. TTI will evaluate the feedback and modify the tool as necessary. The tool will be available to the PSAPs during the duration of the pilot.