



# In-Cab Alert System for Commercial Motor Vehicle Drivers

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Kentucky Transportation Center  
College of Engineering, University of Kentucky, Lexington, Kentucky

in cooperation with  
Kentucky Transportation Cabinet  
Commonwealth of Kentucky

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**Research Report**  
KTC-21-28/RSF19-73-1F

**In-Cab Alert System for Commercial Motor Vehicle Drivers**

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<b>16. Abstract</b> In-cab telematic devices use an increasingly robust data platform and can be used to share safety alerts with other commercial vehicle drivers (CMV) drivers. Real-time alert data can come from state transportation agencies as well as from private companies. To address common quality and coordination issues among differing data sources, the Kentucky Transportation Center (KTC) partnered with the Kentucky Transportation Cabinet (KYTC) and a private vendor, PrePass, to share its App used to send information to CMV drivers. The project demonstrated a proof of concept for the delivery of timely in-cab alerts to warn CMV drivers of approaching roadway hazards. The KTC research team convened a body of experts as a study advisory committee (SAC); surveyed the CMV community for their preferences; coordinated with KYTC, PrePass, and other organizations to develop the pilot study; conducted a proof of concept; and analyzed and assessed the results. Evaluating CMV survey findings and determining study feasibility led the committee to include the data categories of traffic congestion, real-time incidents, and work zones in the pilot study. The study confirmed that safety benefits are realized when transportation agencies share roadway hazard alerts through CMV in-cab devices. Findings reveal an overall need for consistency among DOTs in data collection and how data is processed. Recommendations focused on prioritizing the types of information delivered via in-cab alerts and standardizing the collection and reporting of traffic data.			
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## Executive Summary

In-cab telematic devices use an increasingly robust data platform, as designated by the Department of Transportation. These devices offer a promising path for sharing safety alerts with commercial motor vehicle (CMV) drivers, but data and coordination issues remain. The Kentucky Transportation Cabinet (KYTC) collects extensive transportation data including information on work zones, traffic congestion, and real-time incidents. Increasingly, private-sector companies offer instant alerts to their commercial motor vehicle (CMV) customers through in-cab technologies such as proprietary devices and/or mobile-based applications. The Kentucky Transportation Center (KTC) coordinated with KYTC and a private vendor, PrePass, to demonstrate a proof of concept for the delivery of relevant and timely in-cab alerts that warn CMV drivers of approaching roadway hazards. The KTC research team convened a body of experts as a study advisory committee (SAC); surveyed the CMV community for their preferences; coordinated with KYTC, PrePass, and other organizations to develop the pilot study; conducted a proof of concept; and analyzed and assessed the results.

KYTC collects several categories of transportation data that could be easily delivered to the CMV community. This project focused initially on the following data categories: traffic work zones, traffic congestion, real-time incidents, high-crash corridors, rollover risk, oversize restrictions, overweight restrictions, CMV parking, hazardous weather, and low-clearance bridges. The KTC research team developed a CMV customer survey to gather their preferences on the data that would be the most useful. The survey characterized each respondent and asked about the use of in-cab technologies and their preferences of data categories. Findings revealed most respondents operated within small fleets (77 percent) and had possession of existing in-cab devices (78 percent). The survey also generated high levels of interest for the transportation data categories of traffic congestion, real-time incidents, work zones, CMV parking, and hazardous weather. CMV parking and hazardous weather were removed from the pilot study due to technical and feasibility challenges; however, researchers kept the remaining categories to evaluate for use in safety alerts.

The in-cab alert system pilot relied on two primary mechanisms for a proof of concept: source data and telematic distribution. For the former, the KYTC GoKY system provided the source data. The GoKY system is an online, open portal architecture using unique metadata fields to provide useful and relevant data to the driving public. KYTC generates GoKY data internally through field offices and departments, while receiving some data externally through established user-based contracts with private-sector organizations. For the latter, the research team identified the need to partner with an existing telematics provider to reach its intended CMV audience. The team partnered with PrePass to share its in-cab alerts using the PrePass MOTION App — a telematics platform for sharing information with CMV drivers. The App is accessible on iOS, Android, or electronic logging devices. For this study, the PrePass MOTION App relied exclusively on GoKY data for issuing alerts to CMV drivers within Kentucky but continued to rely on its legacy data sources for other states.

KTC collaborated with KYTC and PrePass to clarify definitions for the pilot in-cab alerts and develop their system logic. All three data categories were defined conventionally:

- Work zones were defined as areas with ongoing roadway construction that were marked to signal lower traffic speeds.
- Traffic congestion referred to any traffic condition that constricts free flow speed.
- Real-time incidents included only vehicle crashes, due to the overwhelming number and severity of crashes within the full vehicle incident spectrum.

The PrePass MOTION App uses a system logic to generate in-cab alerts in real-time as CMV drivers approach a potential roadway hazard. The logic differed based on the data format received: single points or polylines. Single point data is the simplest data and represents a single latitude/longitude coordinate on a map. Polylines encompass a range of data points that follow a path (e.g., roadway) or area (e.g., polygon) in characterizing a location. This study assigned two unique logic algorithms based on the data source. Single point alerts activated at a predetermined and established radius around a roadway location. Polyline alerts activated at a predefined longitudinal distance before

and after a given roadway condition. PrePass incorporated these definitions and logic inputs into their MOTION App for use on Kentucky's roadways.

KTC assessed the results of this pilot project throughout two phases: an initial site survey evaluation and a final in-cab study assessment. In June 2019, PrePass completed its initial development on work zone alerts within the MOTION app. The KTC research team evaluated this initial alert by conducting an onsite survey at 39 percent of KYTC's work zone locations across the state. This initial evaluation revealed only 65 percent of the assessed locations activated a corresponding in-cab alert. KTC shared the results with KYTC and PrePass, which they used to further refine the MOTION App. KTC conducted its final pilot evaluation for all three alert categories from May 2-8, 2021. This comparative analysis identified the incidence of Type II errors, or false positives, for issuing alerts. KTC evaluated the entirety of the 644 issued alerts during this period through a geospatial and temporal framework to ensure issued alerts matched a corresponding source data point. This evaluation demonstrated high consistency and accuracy for in-cab alerts warning of traffic congestion and work zone data. Using polyline data, traffic congestion demonstrated a 100 percent match between GoKY and the MOTION App. The work zone data also produced a high-level of reliability, with a 90 percent match, although these locations used single point coordinates. The real-time incident data, however, offered only a 12 percent match between the two sources. The research team concluded the primary reason for this stemmed from the lack of a precise and consistent end date time stamp for closing out a real-time incident within the GoKY portal.

The primary findings and corresponding recommendations for this proof-of-concept are as follows:

#### Findings

1. There is a high adoption rate of in-cab devices across the CMV community.
2. CMV drivers have clear preferences on the types of in-cab alerts.
3. Within KYTC, there is inconsistent collection and reporting of work zone data.
4. Duplicate files across systems hinder accurate and timely reporting of notifications.
5. KYTC real-time incidents have incomplete data to close out incident.
6. KYTC data reported as single points and polylines although polylines frequently prove to be superior.
7. Lack of uniformity, standardization, and availability of data between state DOT agencies presents challenges to national implementation of alert notifications.

#### Recommendations

1. Transportation agencies should support the use in-cab devices for sharing roadway hazard alerts through improved data collection, quality control, and coordinated sharing efforts, as proven feasible within this study.
2. Transportation agencies supporting the distribution of in-cab alerts should focus on high-priority items identified by CMV users. In this pilot, a Kentucky-based survey revealed CMV users prioritized notifications on real-time incidents, traffic congestion, work zones, and CMV parking availability.
3. KYTC should develop and implement a uniform work zone data collection and reporting policy across the organization to improve consistency and outcomes. Work zone data should be collected in the form of polylines to better characterize stated work zone conditions.
4. Transportation agencies sharing data internally or between agencies should ensure the use of timestamps for all records and files. These time indicators clearly identify the uniqueness of a given event and reduce opportunities for error when comparing and analyzing files.
5. KYTC should evaluate its definition and collection process for the GoKY "end date" field for real-time incident reporting and consider additional measures for clarifying conditions in closing an incident.
6. KYTC should use polylines for all roadway events — best described as segmented in nature — and identify this information by beginning and ending mile points. Work zones represent an ideal case for using polylines, but others may also be appropriate.
7. The Federal Motor Carrier Safety Administration (FMCSA) should coordinate with state DOTs and develop a common set of national standards or guidelines for agencies to use when collecting, analyzing, and reporting their traffic data, particularly for roadway hazards. FMCSA should also recognize that many competing standards and guidelines already exist across state agencies and encourage agencies to move to



a common set. Any agreed upon standards or guidelines should use an interface control document (ICD) format to codify those definitions for state agency adoption. Using this common approach, state agencies should share their relevant traffic data to the public through open portals in promoting increased transparency for public consumption. These portals would allow vendors, entrepreneurs, and researchers to use this data for trend analysis and/or issue identification in developing safety-focused deliverables such as in-cab alerts or research studies, as applicable.

## Chapter 1 Background

### 1.1 Introduction

The development and proliferation of smartphones, global positioning system (GPS) routing and navigation systems, automatic on-board recorders, dedicated short-range communications (DSRC) technologies, and enhanced ITS infrastructure are revolutionizing the way motor carriers communicate with their drivers. Collectively, these telematic technologies are found in the form of in-cab dashboard devices or smart phone mobile applications. Telematics allow carriers to monitor driver and vehicle activity and thereby enhance logistical operations and government regulatory compliance. In addition, motor carriers are increasingly communicating vehicle and carrier information to commercial vehicle enforcement agencies via in-cab telematics. However, state transportation agencies have been slow to adopt data sharing capabilities brought on by the rapid emergence of these technologies.

Kentucky transportation agencies presently collect a wide array of transportation data about work zones, traffic congestion, crash statistics, size and weight restrictions, real-time traffic incidents, and commercial motor vehicle (CMV) available parking. This information could be utilized by motor carriers to improve efficiency, safety, and work life quality for CMV drivers. However, continuing challenges with data collection, interagency coordination, and technological challenges must first be addressed to provide this information safely and efficiently to the trucking community.

### 1.2 Problem Statement

Kentucky transportation agency administrators, commercial vehicle enforcement officers, and researchers at the Kentucky Transportation Center (KTC) have approached members of the Kentucky trucking community, as well as software developers, about making transportation information available through technological interfaces used by the trucking industry. Developing and implementing this technology will require extensive information gathering on the trucking industry's data needs, the methods used to collect and format the data, the technical specifications and requirements of software vendors, and the feasibility of providing the pilot data selected by Kentucky. Currently, the Kentucky Transportation Cabinet (KYTC) shares traffic data to the public through its GoKY online portal. This portal compiles information from a variety of internal sources and external third-party providers to provide transportation information to the public. However, CMV drivers actively operating a vehicle cannot readily access this system while driving, thereby limiting its overall usefulness to the CMV community.

This project will develop a pilot in-cab device notification system to CMV drivers warning them of approaching hazards or traffic incidents. Researchers will assess Kentucky transportation agencies' data collection efforts, prioritize existing data, and identify any data gaps deemed most critical through input from the trucking industry. Researchers will coordinate with the Study Advisory Committee (SAC), select KYTC stakeholders, and partner with vendors to develop an online transportation portal containing this data and facilitate data sharing with the trucking industry through in-cab notifications. As the project's official oversight body, the SAC is comprised of members from KYTC, Kentucky State Police (KSP), the Federal Motor Carrier Safety Administration (FMCSA), and the Kentucky Trucking Association (KTA). Ultimately, this project will focus on providing timely and relevant information to CMV drivers to improve safety and efficiency.

### 1.3 Objective

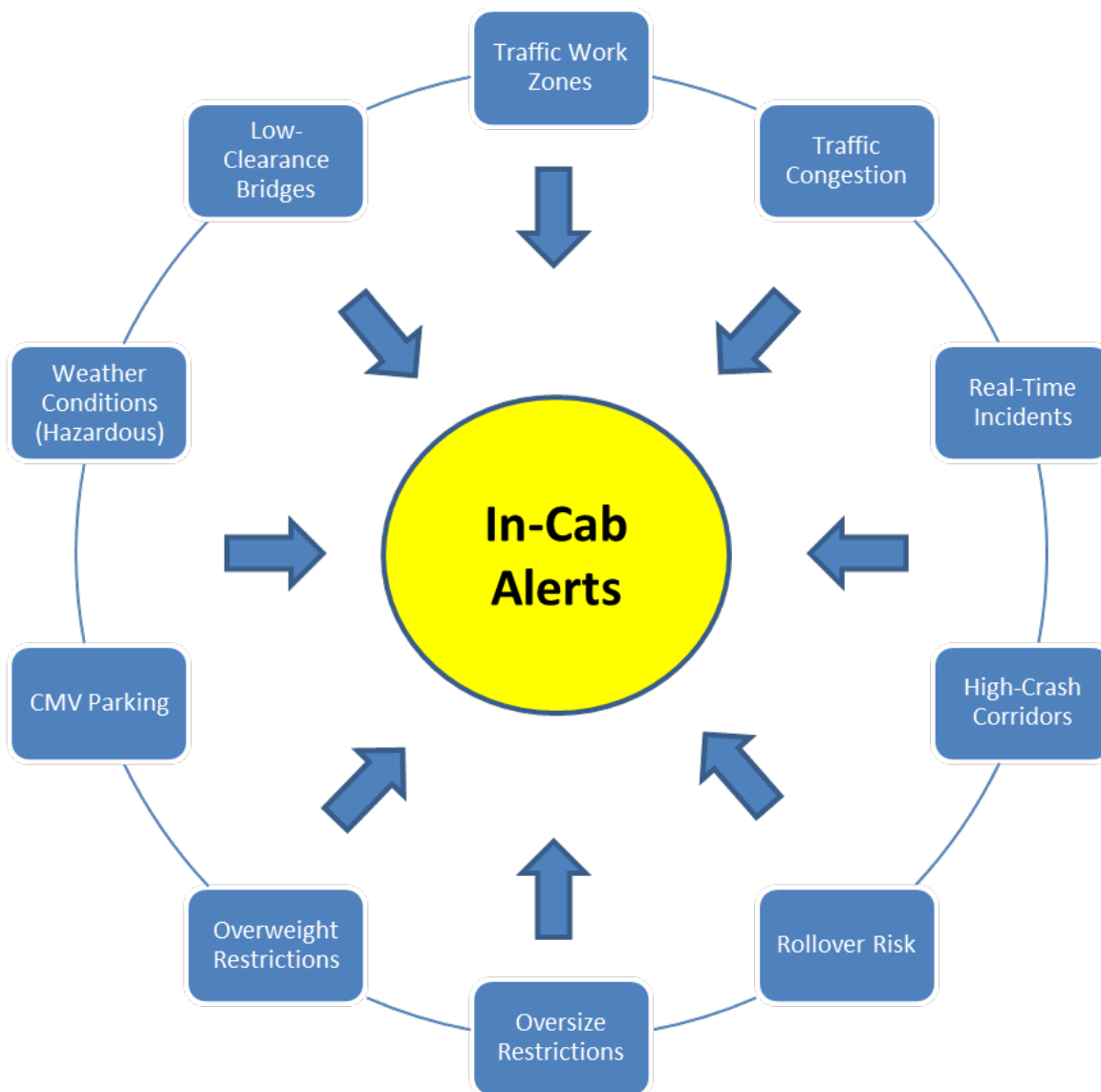
The objectives of this project are to:

- Convene members of the trucking community, software developers, and government agencies to develop a survey about in-cab data needs.
- Survey members of the trucking community to identify data needs of the CMV driver.
- KYTC, KTC and other agencies will work together to identify and collect the data requested by the trucking industry and government agencies.
- Create data files and make them available to software vendors.
- Implement a pilot project demonstrating the ability to provide in-cab transportation notifications to CMV drivers.

## Chapter 2 In-Cab Data

### 2.1 KYTC Data

The Kentucky Transportation Cabinet (KYTC) monitors, implements, and enforces CMV regulations and guidelines on Kentucky highways to improve motor carrier safety and efficiency. KYTC performs this role in partnership with other regulatory agencies, including the Kentucky State Police. In this effort, KYTC frequently collects and shares relevant transportation data with the industry. The Kentucky Transportation Center (KTC) research team developed an initial list of data categories that could prove useful to CMV drivers in their routine operations. This preliminary list was further defined through consultation with members of the project's study advisory committee (SAC). The entire 10-category list is shown in the figure below.



**Figure 2.1** In-Cab Alert Data Categories

KTC identified each transportation category as CMV-related and possibly beneficial to CMV drivers in terms of safety and efficiency. KTC worked with the SAC to further develop and define these categories.

### ***Traffic Work Zones***

Traffic work zones comprise partitioned roadway or roadside areas for conducting maintenance, utility, and/or construction activities. Work zones are frequently characterized by lane closures due to lane resurfacing or other rehabilitative measures. Work zones pose particular safety concerns for CMVs due to their frequent abrupt departure from normal operating conditions. Rapid speed changes, increased congestion, narrow corridors, and other condition changes combine to significantly increase risks to both traveler and worker safety in work zones. In fact, the Federal Highway Administration (FHWA) has estimated that 700 fatalities occur each year in work zones.<sup>1</sup> Drivers receiving advance notice on approaching work zones may be better equipped to quickly adjust their driving speed and level of attentiveness to reduce overall risk when crossing into these areas.

### ***Traffic Congestion***

Highways are designed on the principle of free flow rate, or the maximum number of vehicles that can traverse a point over a given time period. Any traffic condition that constricts this free flow speed is considered traffic congestion.<sup>2</sup> Traffic congestion provides a measure of a roadway's performance, or the relationship between supply and demand. Typically, as traffic increases, traveling vehicles will experience a reduction in speed leading to congestion. Government officials and transportation researchers have devoted many resources to understanding and mitigating this issue. In many cases, researchers have established seven root causes for congestion: (1) physical bottlenecks, (2) traffic incidents, (3) work zones, (4) inclement weather, (5) traffic control devices, (6) special events, and (7) fluctuations in normal traffic.<sup>3</sup>

### ***Real-Time Incidents***

Real-time incidents are events that impact roadway conditions, including traffic. They are often associated with vehicle crashes but can also include stalled vehicles and debris found in the roadway. Drivers must recognize incidents and respond appropriately to safely navigate the unexpected scene. Oftentimes, real-time incidents result in cascading effects downstream from the incident, such as lagging traffic congestion and in some instances, additional incidents (e.g., crashes).

### ***High-Crash Corridors***

High-crash corridors are those corridors or roadways with an elevated number of crashes in relation to other similar-type corridors. There is no federal or academic consensus on what defines a high-crash corridor. One recent Chicago transportation plan focused its analysis on spatially identifying crashes within traffic corridors and assigning increased weights to those crashes involving severe injuries and/or fatalities.<sup>4</sup> A high-crash corridor may experience an excessive number of crashes than expected for several reasons. These reasons may include, but are not limited to, the following: (1) poor geometric design, (2) excessive traffic volumes, (3) adverse environmental conditions, and (4) human processing error (i.e., driver characteristics).

### ***Rollover Risk***

Commercial motor vehicles hauling cargo tanks often experience an elevated risk of rollover. Cargo tank rollovers represent a financial and safety burden to the trucking industry, potentially leading to loss of cargo, truck damages, and even injuries or fatalities. The Federal Motor Carrier Safety Administration (FMCSA) reports over 1,300 cargo tank rollovers occur each year, or almost 4 each day. Contrary to conventional wisdom, poor roadway conditions, driver speeding, and driver inexperience are not the leading contributing factors to rollovers. Rather, the FMCSA attributes 78 percent of rollovers due to simple driver error. Driver error can include drowsiness, incorrect turning, driving over a curb, and other related misdeeds.<sup>5</sup> Identifying rollover causes and high-risk locations may help in identifying alerts to help combat future occurrences.

### ***Oversize/Overweight Restrictions***

Both the federal and state government specify limits on CMV sizes and weights. Prescribed limits allow the trucking industry to safely share the roadway with passenger cars and preserve the highway system. Federal laws establish precedence for oversize restrictions through maximum width limits (typically 102 inches). State laws incorporate these restrictions but have the ability to issue special overwidth permits in certain cases. Consequently, state laws typically establish standards for both CMV heights and lengths.<sup>6</sup>

Each state department of transportation (DOT) monitors and issues oversize permits for truckers operating within their borders. These permits ensure proper precautions exist to minimize disruption to traffic operations, infrastructure strikes (e.g., bridge crossing damage), and roadway utilities and vegetation. KYTC establishes oversize restrictions for CMVs in Kentucky. Using in-cab notifications, KYTC could share oversize restricted routes (e.g., limited clearance bridge crossing) with trucks to verify their routes before movement.

The federal and state governments also specify maximum limits on CMV weights. Federal maximum weight standards are established for the interstate highway system per 23 CFR Part 658.17. CMVs must not exceed 80,000 pounds gross vehicle weight and 20,000-pound single axle weight or 34,000-pound tandem axle weight, as applicable.<sup>7</sup> Similar to before, state DOTs maintain responsibility for issuing overweight vehicle permits. KYTC issues overweight permits in Kentucky that adhere to all federal guidelines for interstate travel. KYTC may, on occasion, allow additional weight tolerances for state-maintained roadways outside of the interstate highway system. These exceptions only apply to CMV transport categories defined by Kentucky Revised Statute (KRS) 189.222.<sup>8</sup>

### ***Commercial Motor Vehicle Parking***

CMV drivers continue to experience major challenges in finding available and safe CMV parking spaces. Long-haul truck drivers seek out these parking spaces during their commutes to meet hours of service constraints, as well as overnight rest periods. Frequently, CMV drivers will park at limited spaces on entrance or exit ramps to rest areas, alongside the interstate, or other non-dedicated spaces. However, federal law reserves this space for emergency-use only and parking in those spaces presents safety concerns.

KYTC received a federal grant to implement commercial vehicle parking at designated weigh station locations on its interstate system. Each commercial vehicle parking lot will be equipped with sensors attached to poles located adjacent to the parking lot's entrance and exit ramps. These sensors will track the number of trucks entering and exiting the parking lot and could provide real-time parking lot availability data to motor carrier drivers.

### ***Weather Conditions (Hazardous)***

Inclement weather conditions pose safety hazards to commuters on roadways. The effects of climate change have negatively impacted travel conditions on a more frequent and severe basis and will continue to do so in the future. Severe thunderstorms, ice patches, fog, and other conditions increase a driver's risk for experiencing a crash. KYTC collects weather condition updates from multiple sources. These conditions include ambient air temperatures, as well as roadway surface/pavement temperatures. This information could be provided to CMV drivers to establish their routes and/or driving times.

### ***Low-Clearance Bridges***

Modern bridge structures specify minimum vertical clearances to ensure CMVs and other large vehicles can safely traverse underneath. The American Association of State Highway and Transportation Officials (AASHTO) provides standards for bridge vertical clearance requirements in their *Policy on Geometric Design of Highways and Streets*.<sup>9</sup> In some cases, low-clearance bridges, often historic bridges, are found in rural regions. Because these bridges pose a risk to drivers, they must be marked accordingly to warn drivers of possible clearance restrictions. When vehicles exceeding these clearances attempt to pass under the structure, the results can be disastrous, and may cause damage to the structure, the vehicle, and possible injuries or fatalities. Bridge clearance alerts could notify CMV drivers where these bridges are located and allow drivers to seek out alternative travel routes.

## **2.2 Alerts Preference Survey**

CMV driver preferences form the fundamental basis for any determination on high-value in-cab notifications. In-cab alerts must meet the goals of an underlying business case and provide value to the customer to be successful. Therefore, the SAC reached out to the CMV community and solicited their preferences on a range of in-cab notification options. KTC developed the user preference survey for the CMV community to understand their needs, address any concerns, and identify potential issues. This survey helped inform the research team on the types of in-cab alerts that would benefit the CMV industry, a critical objective in developing in-cab notification requirements.



### **2.2.1 Survey Development**

The KTC research team collaborated with the project SAC to develop a CMV user survey that helped identify and prioritize in-cab alert categories of interest. Throughout the survey development process, one SAC member — the KTA representative — represented the CMV community and was able to provide their perspective on alerts. This input greatly enhanced development of the final survey questions, both in content and user understanding. Ultimately, the survey's purpose was to help KTC identify data needs for in-cab notifications and maximize utility and participation for the end user: the CMV community.

The CMV survey respondents included several stakeholder categories: drivers/operators, managers/supervisors, owners, owner-operators, and others. In the survey, each respondent provided their designated role; these self-identification responses provided KTC with additional insights into the impact different roles may have on stated survey preferences. The survey gaged preferences involving in-cab notifications across several categories: work zones, traffic congestion, real-time incidents (e.g., crashes), high-crash corridors, rollover risk, size/weight restrictions, and commercial vehicle parking. In addition, the survey asked several open-ended questions on preferences. This allowed respondents to provide additional feedback on the given alerts, list any concerns, and/or list other topics of interest not mentioned in the survey. The final survey is shown in Appendix A.

### **2.2.2 Survey Distribution**

KTC coordinated with KYTC to distribute the survey through the KYTC motor carrier distribution list. This list comprised commercial motor vehicle registrants filing applications and/or making payments through KYTC's online Motor Carrier Portal. CMV registrants operating in Kentucky must file quarterly tax reports with KYTC to stay current on their CMV taxes. These taxes are primarily associated with licensing, registration, and fuel tax requirements administered by the International Registration Plan (IRP) and the International Fuel Tax Association (IFTA).<sup>10,11</sup> In 2018, KYTC received approximately 70,000 tax returns, on average, for their quarterly collections.

KTC developed the survey through Qualtrics online software tool and is easily accessible via personal computers, laptops, and mobile devices.<sup>12</sup> KTC provided the online survey link to KYTC, who then sent the link to all registered CMV account holders on their motor carrier portal distribution list. The survey remained open for three weeks, from December 14, 2018, through January 4, 2019. The survey respondent pool was comprised of approximately 70,000 individual members and/or organizations. KTC received 1,230 responses. KTC was able to infer statistical significance on the survey results and better inform the project's direction for identifying high-priority notifications.

### **2.2.3 Survey Results & Discussion**

The survey was structured into two parts. The first half of the survey sought to characterize the respondents, identify fleet organizational characteristics, and determine the rate of adoption of existing in-cab technology. The second half of the survey solicited preferences and input on in-cab notifications that would better assist drivers. Structuring the survey in this way also ensured stakeholders were represented and provided feedback.

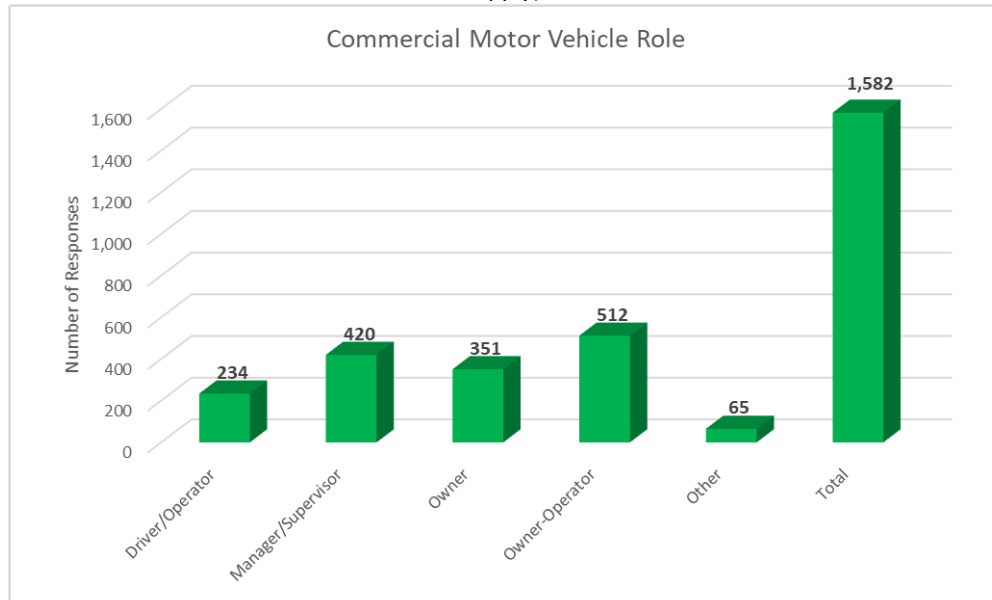
The initial question queried the respondents about their CMV role, and revealed three respondent categories: drivers, managers, and owners. The second survey question characterized the fleet. Most respondents (77 percent) identified as small-fleet operations consisting of between 1 to 10 trucks. Small fleets are characteristic of a predominantly rural state and best describe Kentucky's primary CMV community. The third question asked respondents whether they currently had in-cab device technology within their CMV, including dashboard devices or smart phones with CMV-based apps. Most respondents (78 percent) acknowledged they possessed an in-cab device, and this high percentage validated the viability of providing meaningful alerts to CMV drivers through in-cab technology.

The second half of the survey solicited input on CMV preferences for in-cab alerts. The information categories generating the most interest and highest overall rankings included traffic work zones, traffic congestion, real-time incidents, and CMV parking. The summarized list of survey results for notifications is shown in Table 2.1. The overall discussion of survey questions and responses is shown in the following pages (Figures 2.2 – 2.8).

**Table 2.1** Summary of Survey Results

Highest Notification Interest	Survey Rankings	Other Categories of Interest
Traffic Work Zones	1. Traffic Congestion	None (62.0%)
Traffic Congestion	2. Real-Time Incidents	Hazardous Weather (14.2%)
Real-Time Incidents	3. Traffic Work Zones	Other (7.5%)
CMV Parking	4. CMV Parking	Weigh Stations (4.5%)
		Distracted Driving (3.1%)
		Road Closure/Detour (2.5%)
		Parking Availability (2.5%)

*Question #1: How would you describe your role with the commercial motor vehicle community? (select all that apply)*



**Figure 2.2** Commercial Motor Vehicle Role

Question #2: Approximately how many commercial motor vehicles does your organization have?

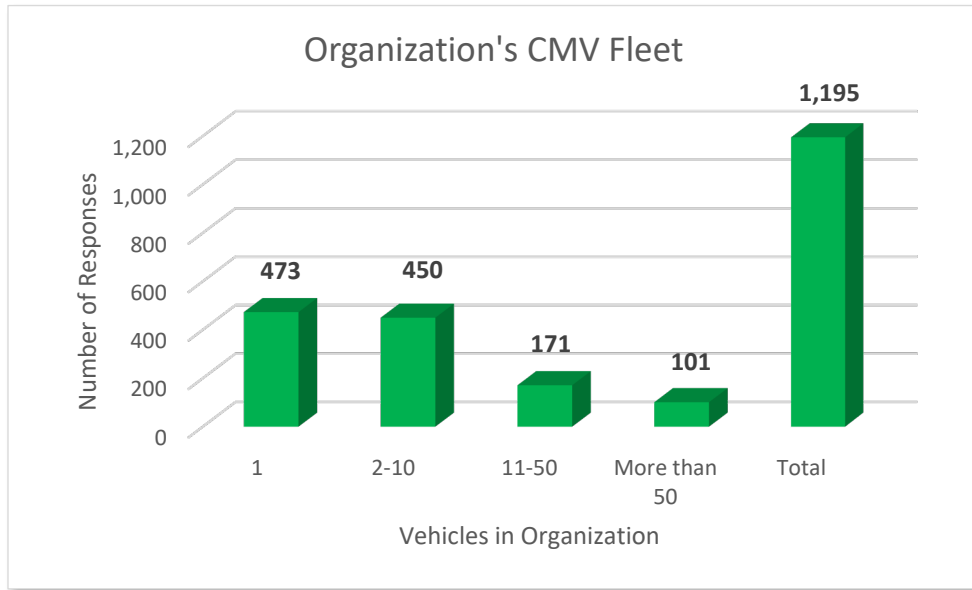


Figure 2.3 Organizational Fleet

Question #3: Do you have a device that allows you to receive in-cab notifications from your truck dispatch, GPS navigation, or other data sources?

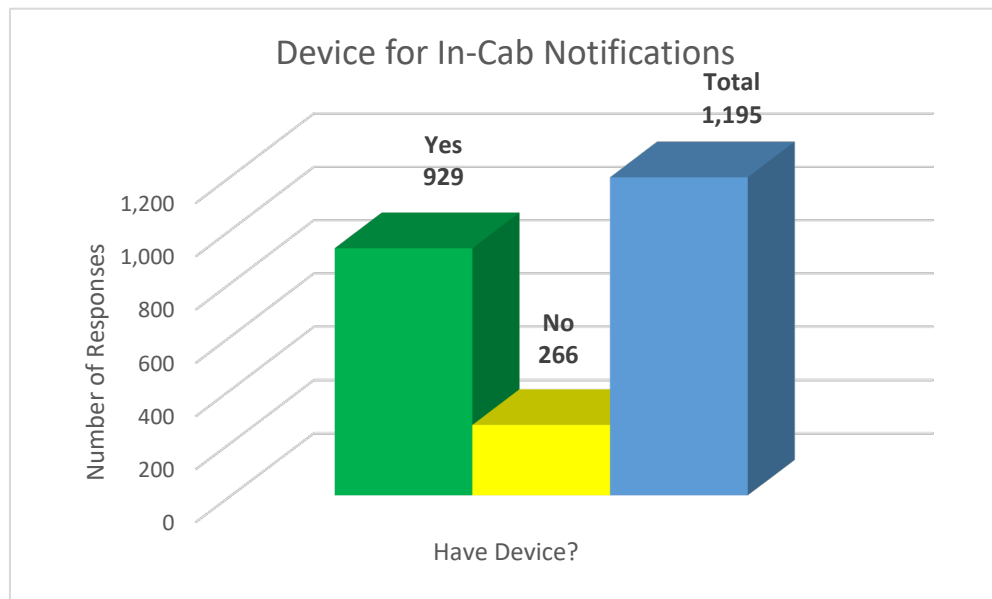


Figure 2.4 Presence of In-Cab Device

Question #4: If you answered yes on question #3, what type of device do you have?

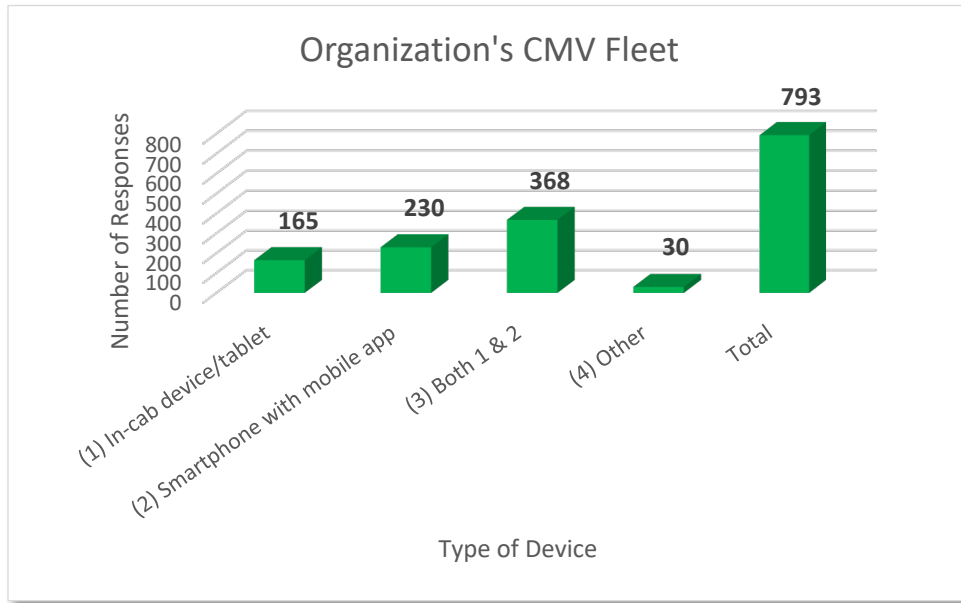


Figure 2.5 Type of In-Cab Device

Question #5: Overall, how interested, if at all, are you in receiving in-cab notifications on the following topics?

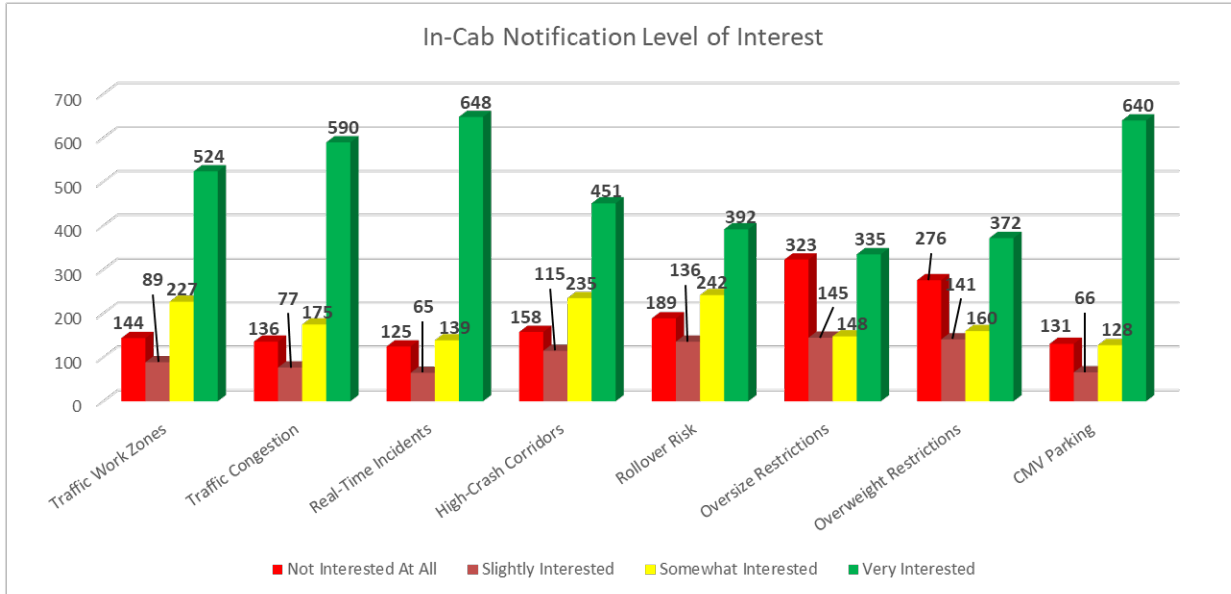


Figure 2.6 Interest in In-Cab Notifications

Question #6: Please rank your top three in-cab notifications of interest. Assign a "1" to your highest interest, "2" to your second highest interest, and "3" to your third highest interest.

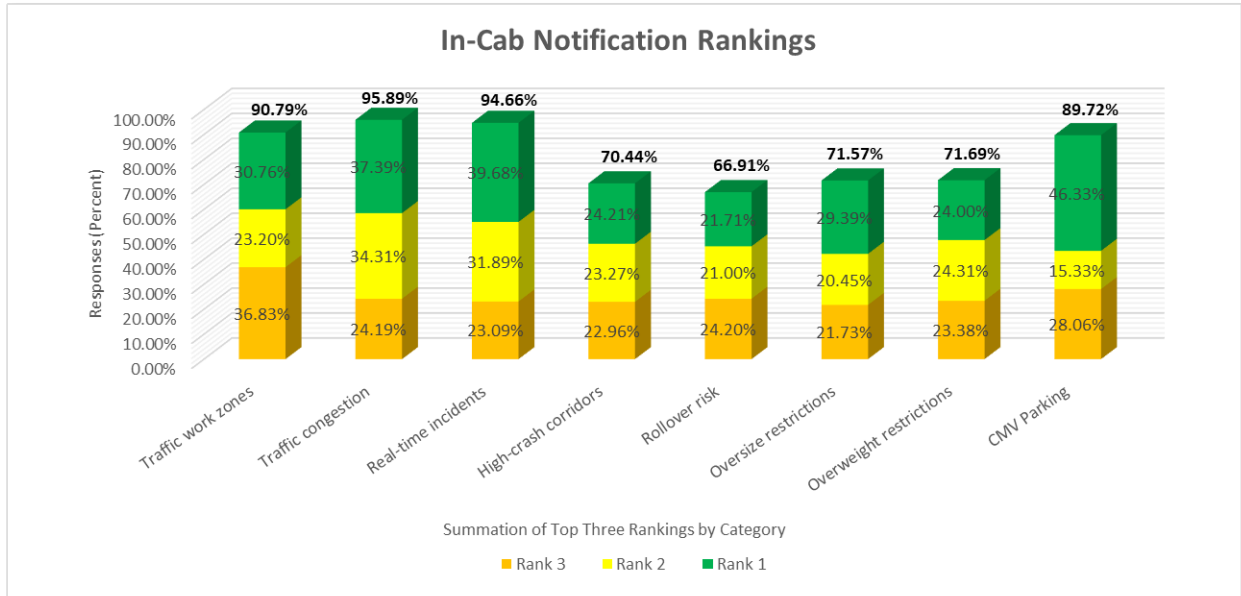


Figure 2.7 Rankings in In-Cab Notifications

Question #7: Are there any in-cab notifications you might be interested in receiving that were not already mentioned in this survey?

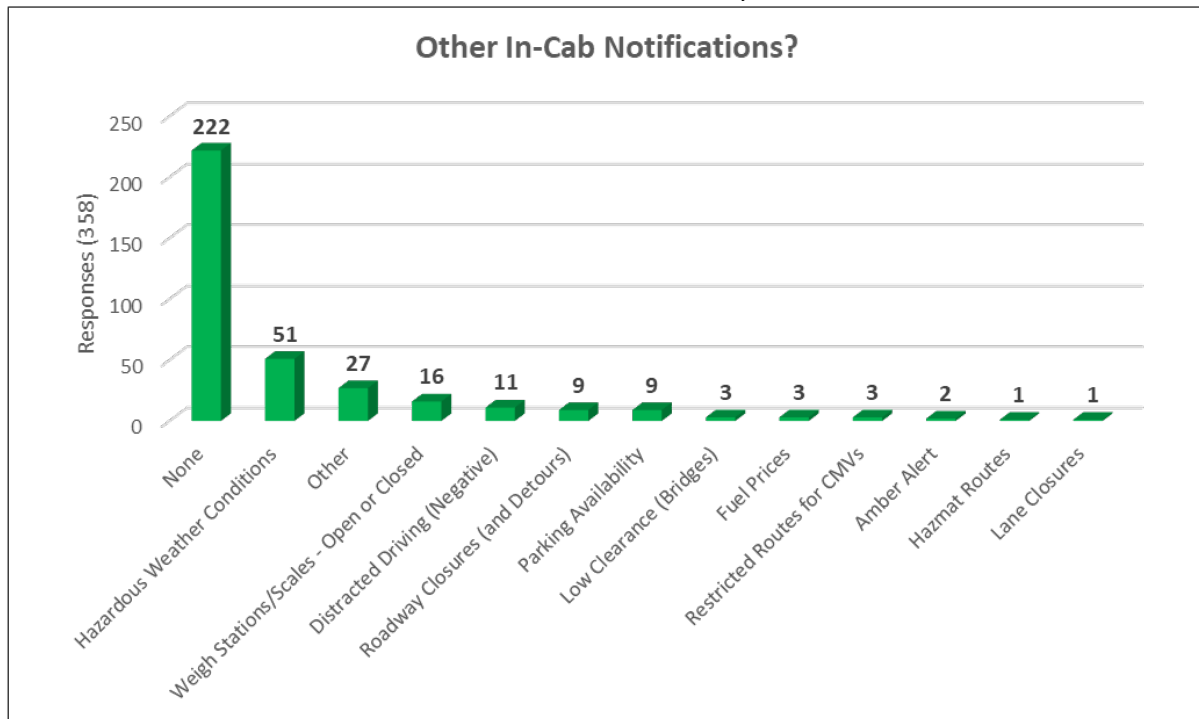


Figure 2.8 Other In-Cab Notifications



### **2.3 Selection Process for In-Cab Alerts**

The SAC discussed the completed survey results and identified high-value data categories for future in-cab alerts. The SAC agreed that the categories selected must have a positive impact on the CMV community, and from the original 10-category list, chose 5 categories for further examination. Those categories generated the highest level of interest among the survey respondents and included traffic work zones, traffic congestion, real-time incidents, CMV parking, and hazardous weather.

The project team assessed the feasibility of incorporating those five categories into a proof of concept for in-cab alerts. The group concluded that two categories, CMV parking and hazardous weather, were not readily accessible due to technical or readiness challenges. CMV parking data was not singularly located within the KYTC GoKY database, a data repository used to share roadway condition updates with Kentucky drivers. Rather, CMV parking data was collected and stored by TRIMARC, a Louisville-based organization managing a traffic operations center for the Louisville and Northern Kentucky urban areas.<sup>13</sup> Although sponsored by KYTC, this data was not self-contained within the GoKY database and could not be feasibly collected like the rest of the data. The second category, weather alerts, posed its own unique challenge. KYTC has developed weather alerts for use within its GoKY database, primarily snow and ice events stemming from KYTC's role in clearing roads during wintry conditions. Other adverse weather events, such as severe storms or winds, are not yet developed nor incorporated into their database. Due to these limitations, the project team decided that the weather alert function would not be feasible.

The project team determined that the remaining three categories would be incorporated into the pilot for in-cab alerts. These selected categories were traffic work zones, traffic congestion, and real-time incidents. These data streams would be accessible through KYTC's GoKY online portal.

## Chapter 3 KYTC Portal

### 3.1 Open Portal Concept

In-cab alerts require an underlying IT architecture to provide the needed data to the driver. In this pilot, the alerts relied on the GoKY open portal architecture. KYTC's Office of Information Technology (OIT) is responsible for development and maintenance of the GoKY portal. In supporting KYTC's mission, the portal provides a mechanism to collect, store, and disseminate transportation data. In recent years, KYTC has developed 40 unique metadata fields to support both agency personnel and its clients across the state. This KYTC IT initiative remains ongoing, with plans to exceed 50 metadata fields in the future. The metadata currently collected include roadway attributes such as route, county name, latitude, longitude, and many more. KYTC collects this data from internal sources (e.g., TRIMARC) and through contractual agreements with third-party providers such as WAZE and HERE.

### 3.2 PrePass as Pilot Partner

Although KYTC possessed the requisite data for issuing the alerts to CMV drivers, it did not have an established in-cab device technology or other application-based technology to communicate these alerts to drivers. Therefore, the SAC decided that partnering with a qualified vendor would be necessary to successfully demonstrate proof-of-concept project. Also, developing these applications internally would prove too cost prohibitive and KYTC would benefit from a vendor's existing technology.

KYTC reached out to PrePass to share the background behind this pilot project and gauge their interest in the project, and they agreed to partner in developing in-cab alerts. PrePass offered their MOTION App device — a telematics tool for CMV drivers accessible through iOS, Android, and electronic logging devices. This App provides a suite of user options for the driver, including a subscription for receiving in-cab alerts. Along with the three alerts identified for this project, the MOTION App also provides notifications on high winds, rest areas, steep grades, and several other CMV categories.<sup>14</sup>



Figure 3.1 PrePass MOTION App Alert

### 3.3 GoKY Portal

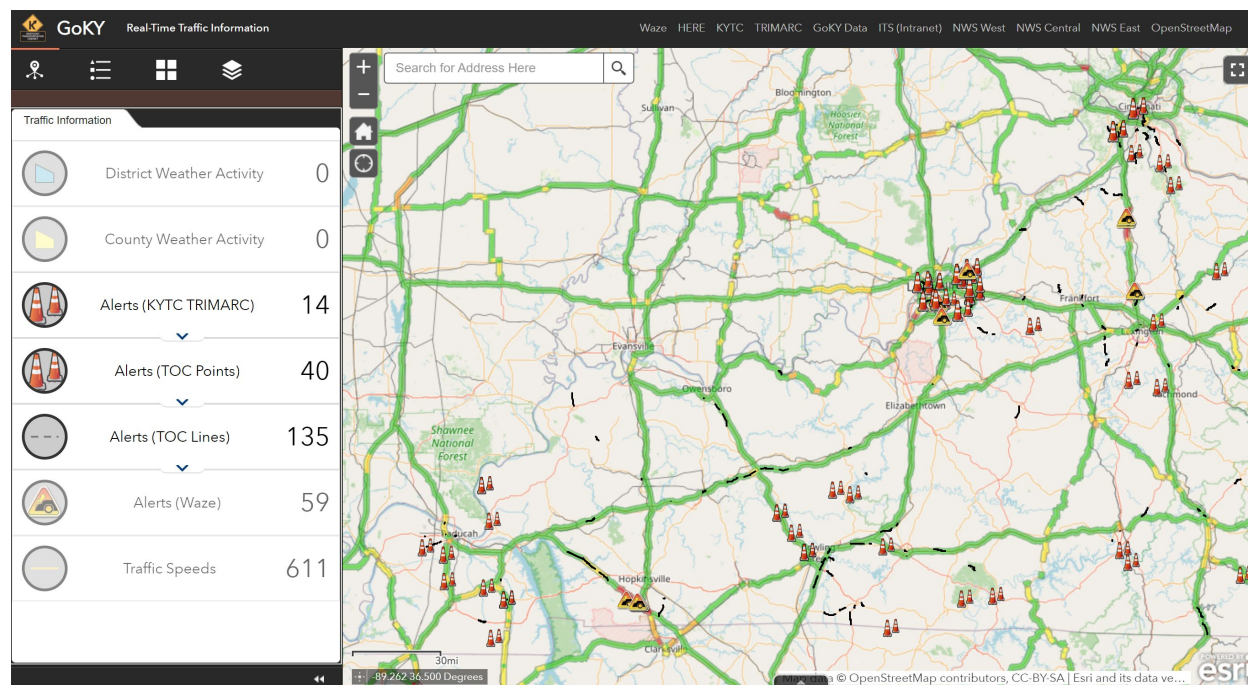
KYTC's open portal architecture, GoKY, provided the data used to enable the in-cab alerts. This portal displays transportation conditions, alerts, and other features to the driving public. GoKY employs a representational state transfer (REST) format to allow for increased uniformity and scalability for its data-layered architecture. This open

framework supports various data formats including HTML, XML, and JSON. The GoKY portal is free of charge and readily available to the public as well as the vendor community.

GoKY uses ArcGIS, an Esri-based geographic information system, to display its featured information. This allows users to toggle the website's alert notifications "on" or "off" to identify any alerts at a given location. In addition to this project's three alerts, the portal also provides updates on weather activities, road lane blockages, bridge load restrictions, and other traffic events. These alerts update every two minutes. The GoKY portal may be accessed online at:

<https://kytc.maps.arcgis.com/apps/webappviewer/index.html?id=327a38decc8c4e5cb882dc6cd0f9d45d>.

See Figure 3.2 below for a screenshot illustration of the website.



**Figure 3.2** KYTC GoKY Portal

The portal visually displays ArcGIS layers using data comprised of single-point coordinates, polygons, or line segments. These formats correspond to the data's originating source across different departments and organizations. Some alerts are best characterized as single-point locations while others are formatted as shapes or lines. For instance, a bridge typically uses a single-point format as a relatively finite longitudinal structure. Conversely, a work zone may occupy a lengthy roadway segment and be annotated with a beginning and ending mile point. KYTC uses metadata fields to distinguish these different transportation features while incorporating inherent attributes to include data formats, data sources, and other characteristics.

KYTC obtains data used within the GoKY portal from both internal and external sources. The KYTC's Transportation Operations Center, or TOC, collects and compartmentalizes most internal data. GoKY receives its external data from TRIMARC, HERE, and WAZE. HERE and WAZE are private-sector organizations sharing proprietary data with KYTC through their user subscription. The data sources for the three featured in-cab alerts are as follows:

- Traffic Work Zones – KYTC Traffic Operations Center and TRIMARC
- Traffic Congestion – HERE and WAZE through GoKY portal
- Real-Time Incidents – WAZE, TRIMARC, and KYTC Traffic Operations Center

Due to proprietary concerns, KYTC only publishes third-party data as derivatives which cannot be linked back to the original source data. Therefore, the GoKY portal can share this “derivative” data for the in-cab alerts used within this project.

## Chapter 4 Pilot Project

### 4.1 PrePass MOTION App

The PrePass Safety Alliance, commonly known as PrePass, is a non-profit corporation founded in 1993 to promote CMV safety and efficiency on U.S. highways. PrePass started as a public/private partnership between trucking companies and state transportation agencies with a goal to improve and institutionalize compliance measures across state lines. This mission was advanced through technologies such as identification transponders and weigh-in-motion devices. The PrePass alliance has since expanded nationwide and provided a CMV safety e-clearance system commonly employed by DOT weigh stations.<sup>15</sup>

KYTC partnered with PrePass to demonstrate the In-Cab Alert proof of concept. The pilot project made use of the PrePass MOTION App, originally developed as a tool to notify CMV drivers on roadway conditions. The MOTION App issues alerts for drivers that may encounter roadway safety hazards based on their location and direction. These alerts include work zones, traffic incidents, congestion, weather, truck parking, rest areas, high wind areas, steep grades, brake check areas, chain up areas, and runaway truck ramps, among others. PrePass offers this App through smartphone devices such as iOS and Android, as well as select telematic and electronic logging devices. This App is an add-on service to its primary PrePass transponder services.<sup>16</sup>

As a part of this study, PrePass agreed to incorporate KYTC's GoKY portal data on work zones, traffic incidents, and congestion as the source data for those corresponding MOTION App alerts. In this study, these alerts would only apply to Kentucky roadways, so any alerts issued in other states (through alternate PrePass data sources) did not apply. The MOTION App would alert CMV drivers about alert conditions with the visual displays shown in Figure 4.1 below.



Figure 4.1 PrePass MOTION App Alerts<sup>17</sup>

### 4.2 In-Cab Alerts

#### 4.2.1 Traffic Work Zones

KYTC employs traffic work zones for construction activities, routine maintenance, and other infrastructure activities involving onsite labor. Work zone personnel must perform their labor in the proximity of high traffic volumes and speeds. These hazardous working conditions have led to increasing fatalities and injuries and prompted additional safety initiatives to mitigate work zone risks. The In-Cab Alert for traffic work zones is one such effort; it notifies CMV drivers and provides them with additional time to slow down and become more aware of their surroundings.

KYTC work zones are operated and maintained by different district offices, KYTC's central office, and TRIMARC. In most cases, individual KYTC district offices establish and operate work zones corresponding to their area of responsibility. KYTC has 12 individual district offices across the state (see Figure 4.2 below for regional areas).



Occasionally, the KYTC's Division of Construction may also establish and oversee work zones associated with new construction.



**Figure 4.2** KYTC District Offices<sup>18</sup>

KYTC employs a decentralized approach for managing and operating work zones. Hours of operation and days in service vary across individual sites. The district offices and Division of Construction both maintain responsibility for monitoring and reporting the open/closed status of their respective work zones. Authorities report their information through the KYTC Traffic Operations Center (TOC) which subsequently collects and provides that data to the GoKY data portal. This information is currently collected in the form of single-point grid coordinates (latitude/longitude).

#### **4.2.2 Traffic Congestion**

Alleviating traffic congestion has become increasingly important to the CMV community due to its contribution to shipping delays, increased fuel expenses, and compromised safety. Kentucky interstates, particularly in urban zones, serve as the primary conduit for CMV travel. As incidents (e.g., crashes) occur, traffic congestion frequently builds while emergency management responders clear crash sites within these high-volume corridors. The In-Cab Alert for traffic congestion seeks to warn drivers of upcoming congestion and allow them to identify an alternate route and avoid excessive delays.

KYTC receives traffic congestion data through the private-sector agreements with WAZE and HERE. WAZE, a subsidiary of Google, offers an app free of charge to the public to assist in their commutes. The WAZE app allows users to receive and share traffic information across its 140 million plus user base. Users may report traffic congestion, crashes, and other traffic-related information to WAZE.<sup>19</sup> Similarly, HERE provides prospective users with a transportation-based app that provides geospatial information to drivers and notifies them of upcoming roadway conditions. HERE's platform has over 160 million users across multiple countries.<sup>20</sup> At the forefront of traffic data, KYTC's GoKY portal receives its traffic congestion data from both WAZE and HERE. The data is non-attributional and compartmentalized as derivatives to meet proprietary agreements.

The GoKY portal updates traffic congestion data at least once every two minutes to maximize near real-time reporting. The data may be in the form of single-point coordinates (i.e., latitude/longitude) or polylines (i.e., line segments for a roadway). KYTC relies on the engineering concept of free-flow speed to characterize and report its traffic congestion. Free-flow speed describes uninterrupted traffic flow conditions that allow travelers to drive at designed roadway speeds. The GoKY portal aggregates and reports the condition of "traffic congestion" when travel conditions fall below a 70 percent free-flow speed threshold. In other words, traffic conditions equal to or greater than 70 percent will not display as traffic congestion on the portal.

### 4.2.3 Real-Time Incidents

Real-time incidents are acute roadway conditions that adversely impact surrounding traffic. KYTC primarily defines real-time incidents as crash events but also includes temporary lane closures, roadway debris, and vehicle fires within this definition. More severe incidents may lead to property damage, injury, or loss of life. The spillover effects from real-time incidents often result in lagging traffic congestion as first responders and transportation officials attempt to manage the scene. PrePass developed its In-Cab Alert for real-time incidents so that it notifies CMV drivers of upcoming crashes. Their alert did not consider temporary lane closures, roadway debris, and vehicle fires listed here due to the low number of those incidents.

KYTC receives real-time incident data through its Traffic Operations Center and TRIMARC as well as through its partnership with WAZE. As with work zone data, the GoKY portal records and maps incidents as single-point grid coordinates. Each incident begins with a start date timestamp. The end date timestamp represents the last known change in status and does not necessarily indicate the incident has been cleared. Once an incident is cleared or expires, the end date timestamp will no longer receive any new updates.

### 4.3 System Logic for Alerts

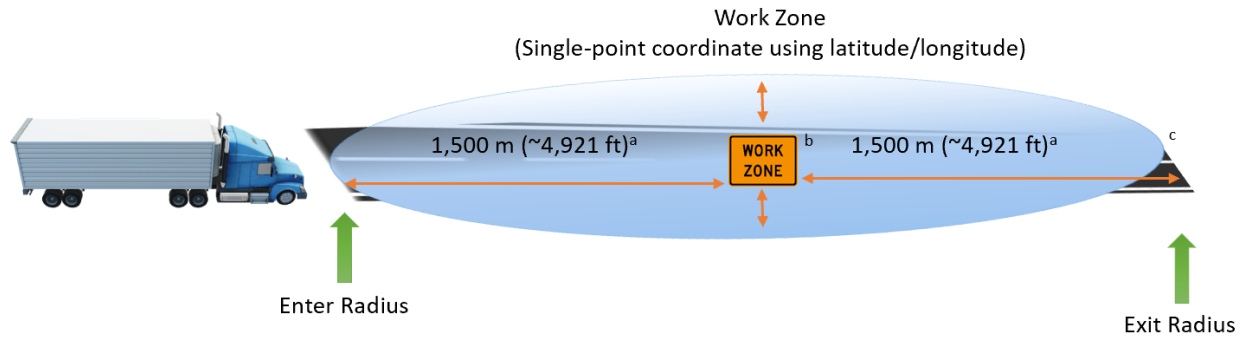
PrePass developed system logic for its MOTION App to interpret and process GoKY data before generating In-Cab Alerts. This logic relied on event locations—either single-point or polyline coordinates—to activate an alert. Both coordinate systems use latitude and longitude to identify a geospatial location. The logic, however, differs slightly based on the type. Single-point alerts activate as the vehicle approaches a predetermined and established radius around the roadway condition. Polyline alerts activate at a predefined longitudinal distance before and after the roadway condition.

Initially, PrePass established alert distances for the single-point (radii) and polyline (longitudinal) at a 1,000-foot and 164-foot offset from the roadway condition, respectively. Under these conditions, the single-point alert activated once a CMV entered within 1,000 feet of the alerted roadway condition and ceased alerting once the vehicle departed this radius. In the polyline logic, the MOTION App alert would activate 164 feet before the start of the polyline. However, the driver would only receive this alert once the polyline remains active or engaged for 10 consecutive seconds. This slight pause improved alert accuracy by verifying the driver was continuing on the established travel path toward the alert condition.

The SAC met with KTC to review and analyze the proposed MOTION App logic. Several SAC members expressed concerns about the limited 1,000-foot distance associated with single-point alerts. This 1,000-foot interval would only allow a driver 10 seconds to react if the CMV was traveling at 65 miles per hour. This distance appeared insufficient for warning drivers of an upcoming roadway condition. The SAC recommended expanding the single-point radius to approximately 1 mile (5,280 feet) for a larger offset. Assuming a 65 mile per hour travel speed, this expansion would allow drivers a 55-second reaction time to an alert condition. The driver might use that time to depart the roadway via an exit ramp, an unlikely scenario under the original radius. The SAC did not express any concerns on the distance associated with the polyline logic.

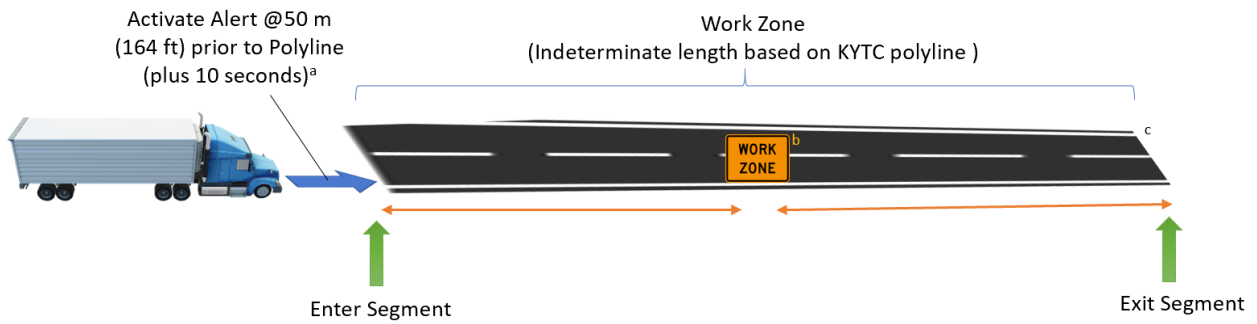
KTC and the SAC consulted with PrePass to request expansion of the radius from its initial 1,000-foot offset to one mile. PrePass raised the concern that expanding the radius might create additional “false positives”, or alerts to drivers that will not encounter the site location. As the radius expands, more MOTION app drivers would receive the alert whether they were actually driving on the route with the alert location. The committee recognized these concerns but still believed that increased time for CMV driver decision-making outweighed any concerns from false positives. PrePass agreed with this modified approach but recommended a radius expansion to 1,500 meters (~4,921 feet) instead of one mile. The SAC approved this change to the MOTION App logic for Kentucky-based alerts. The three alert categories across each condition are shown in Figure 4.3 – 4.8.

Work Zone: Single Point



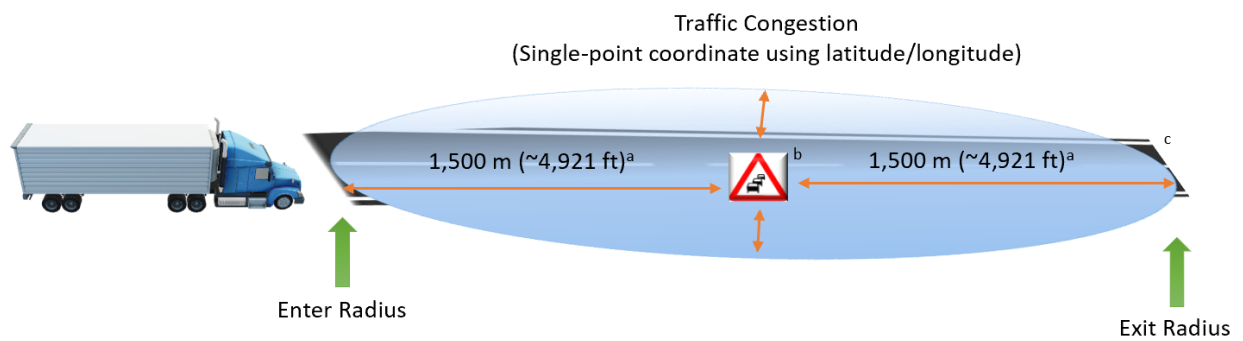
**Figure 4.3** Work Zone Logic for Single Point Coordinates

Work Zone: Polyline



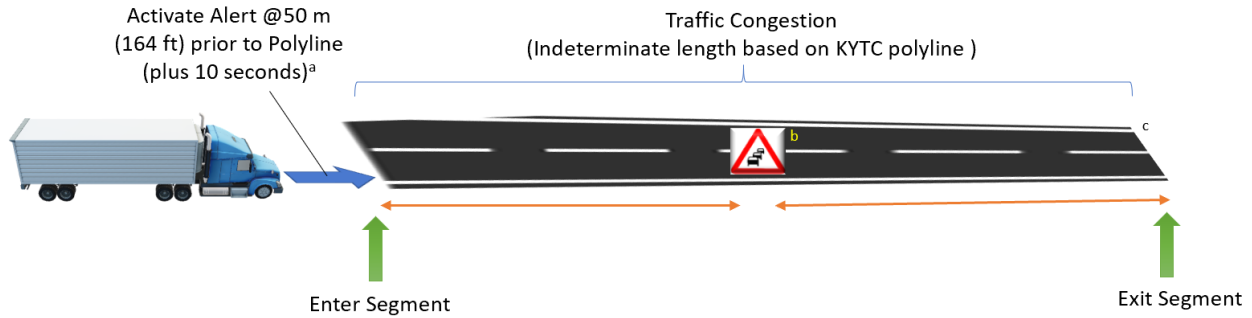
**Figure 4.4** Work Zone Logic for Polyline

Traffic Congestion: Single Point



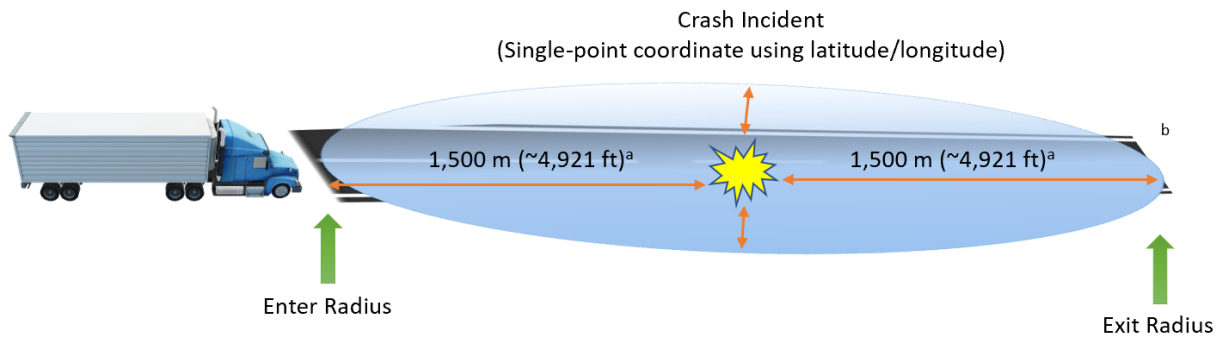
**Figure 4.5** Traffic Congestion Logic for Single Point Coordinates

### Traffic Congestion: Polyline



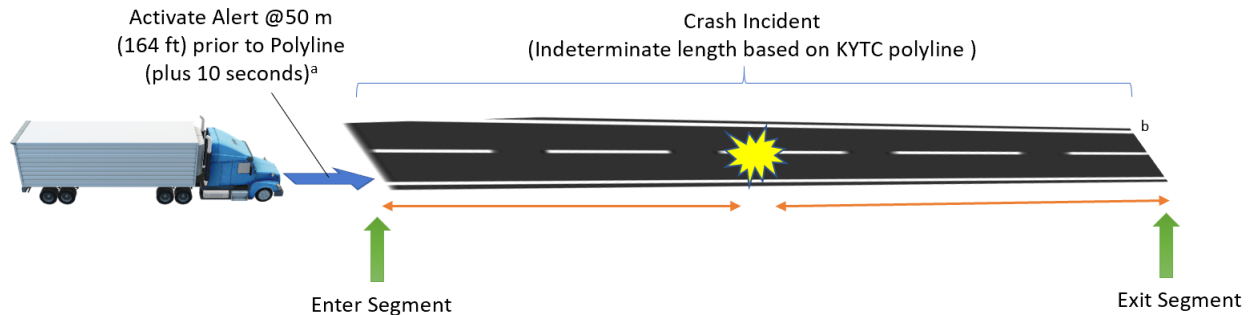
**Figure 4.6** Traffic Congestion Logic for Polylines

### Crash Incident: Single Point



**Figure 4.7** Vehicle Incident Logic for Single Point Coordinates

### Crash Incident: Polyline



**Figure 4.8** Vehicle Incident Logic for Polylines

## 4.4 Site Evaluation

In June 2019, PrePass completed its initial development on the MOTION app's work zone alerts. The KTC research team evaluated the alerts chosen for the pilot by conducting a test of the MOTION App's capability at the selected locations. Initially, KTC coordinated with KYTC officials to determine and identify all active work zones across the state — 46 sites total, with a higher density of work zones in urban areas. Those locations are listed in Appendix B.

To assess the performance of the App, researchers used a MOTION App-enabled mobile device to monitor alert activations for work zones. The team identified 19 work zone sites within Kentucky's three largest urban areas (i.e., Louisville, Lexington, and Northern Kentucky) with additional work zones near the University of Kentucky. The rural geographical area in and surrounding Flemingsburg was also selected to incorporate a rural component into the survey.

This site evaluation occurred during two dates: July 16 and July 22 in 2019. The team visited work zones located within Louisville and Lexington on July 16 and the remaining sites on July 22. Of the 19 total locations, the team decided to remove two from further consideration because: (1) poor cellular coverage in one location may have impeded the App from functioning correctly and (2) the absence of a verified work zone at another location. The final evaluation was performed on 17 sites from a total of 44 locations, resulting in an evaluation of 39 percent of the work zones across the state. All locations were associated with single-point (latitude-longitude) coordinates. KTC researchers annotated the alert status as follows:

- "Yes" for alert activated,
- "No" for alert not activated, and
- "Unk" (Unknown) for alerts that did not activate and were removed from further consideration due to potential errors.

Upon survey completion, KTC discovered that 11 of the 17 work zones in the study, or 64.7 percent, delivered an activated alert to the driver. The remaining 6 sites failed to generate an alert even when the mobile device traveled within the radius required for activation. For these non-operational alerts, the driving team conducted multiple trips along those site routes to ensure that intermittent cellular coverage or other potential errors did not prevent an alert from activating. The complete site survey results for all 19 work zone locations are shown below, in Table 4.1.



**Table 4.1** Work Zone Site Survey

Name	Latitude	Longitude	DataSourceId	Date of Survey Collection	Location	Alert Status
KY-0032_ Road Blocked	38.332109	-84.05251	KY-0032_6.6_-84.0525136_38.3321091	22-Jul-19	Flemingsburg	No
KY-0681_ Road Blocked, Bridge	38.411712	-83.91917	KY-0681_1.55_-83.919168_38.4117119	22-Jul-19	Flemingsburg	Yes
KY-0367_ Road Blocked, Bridge	38.433671	-83.83692	KY-0367_1_-83.8369151_38.4336709	22-Jul-19	Flemingsburg	Yes
KY-2508_ Road Blocked, Bridge	38.430865	-83.74099	KY-2508_0.081_-83.740992_38.4308654	22-Jul-19	Flemingsburg	Yes
I-0064_ Lane Blocked, Bridge	38.185628	-83.519	I-0064_135_-83.5190024_38.1856278	22-Jul-19	Flemingsburg	No
KY-0794_ Road Blocked, Bridge	37.735722	-83.96804	KY-0794_0.3_-83.9680442_37.7357218	22-Jul-19	Berea	Unk
US-0025_ Lane Blocked	37.585707	-84.28391	US-0025_4.9_-84.2839123_37.5857072	22-Jul-19	Berea	No
I-75 NC_ Road Construction	38.596109	-84.58315	I-75 NC_152_-84.5831485_38.5961092	22-Jul-19	Northern KY	Yes
I-75 NC_ Road Construction	39.083631	-84.52275	I-75 NC_191_-84.5227531_39.0836307	22-Jul-19	Northern KY	Unk
WEAVER RD_ Road Construction	38.966099	-84.6359	WEAVER RD_1.4_-84.6358952_38.9660992	22-Jul-19	Northern KY	No
I-65 RAMP from I-264_ Road Construction	38.190747	-85.72997	I-65 RAMP from I-264_0.3_-85.7299725_38.1907473	16-Jul-19	Louisville	Yes
I-275 NC_ Road Construction	39.053217	-84.6243	I-275 NC_1.9_-84.6243029_39.0532167	22-Jul-19	Northern KY	Yes
I-64 RAMP to I-264_ Road Construction	38.238615	-85.62055	I-64 RAMP to I-264_0_-85.6205463_38.2386154	16-Jul-19	Louisville	Yes
I-275_ Road Construction	39.056424	-84.43277	I-275_73.3_-84.4327664_39.0564241	22-Jul-19	Northern KY	Yes
US-0027_ Lane Blocked	38.721418	-84.37471	US-0027_11.8_-84.3747146_38.7214182	22-Jul-19	Northern KY	Yes
KY-0004_ Lane Blocked	38.074514	-84.50596	KY-0004_8.731_-84.5059585_38.074514	16-Jul-19	Lexington	No
KY-1065_ Lane Blocked	38.126431	-85.77664	KY-1065_1_-85.7766402_38.1264314	16-Jul-19	Louisville	Yes
KY-0061_ Lane Blocked	38.179447	-85.71779	KY-0061_7.3_-85.7177872_38.1794475	16-Jul-19	Louisville	Yes
KY-1447_ Lane Blocked	38.297156	-85.54961	KY-1447_6.6_-85.5496144_38.2971564	16-Jul-19	Louisville	No

The KTC research team met with the SAC and PrePass following this evaluation and shared the results. PrePass used the results to identify the potential data transmission issues contributing to the work zone alert gaps. In several instances, PrePass pulled the KYTC data from the GoKY URL at nearly the same time the data was being updated within the KYTC architecture. This caused several issues, including duplicate files, and may have caused the work zone alert problems. The SAC recommended keeping historical data within the PrePass data architecture and only pulling information from the GoKY portal when those corresponding data fields change. Furthermore, the SAC recommended that PrePass incorporate the use of timestamps within their data architecture to further delineate updated data from archived data. PrePass acknowledged these recommendations and subsequently refined their MOTION App for Kentucky’s source data.

#### 4.5 In-Cab Alerts Evaluation

##### 4.5.1 Comparative Analysis

The research team conducted a final evaluation on the MOTION App service following the release of the remaining in-cab alerts. As described previously, the in-cab alerts for Kentucky included work zones, traffic congestion, and real-time incidents. KTC coordinated with both the MOTION App developer, PrePass, and the data alerts’ owner, KYTC, to determine optimal dates for a study. All parties agreed to a one-week study period from May 2-8 in 2021. KTC assessed the performance of the three alerts, with a focus on accuracy and reliability. The performance levels for the alert categories varied significantly as discussed further below.

##### 4.5.2 Data

KTC researchers obtained incident, congestion, and work zone data from PrePass and KYTC from May 2-8, 2021. All incident and work zone data were recorded as single-point data vis-à-vis grid coordinates, while congestion data came in the form of polylines. Incidents typically involved one or more vehicles at a specific site, which justified the use of single-point locations. Conversely, work zones and congestion were commonly seen across long roadway segments with the potential to affect more drivers. Although congestion was provided in the form of polylines, the work zone data was represented as single-point coordinates, which may have introduced error in the results.

This data contained a total of 644 alerts: 439 incidents, 27 congestion events, and 178 work zones. The data was especially concentrated on May 3-5 (Monday-Wednesday), comprising nearly 78 percent of the total alerts. Alerts were geographically distributed throughout the state and crossed both the Eastern and Central time zones. The more populous Eastern time zone region generated 55.9 percent of the alerts while the less dense Central time zone region (rural, Western area) provided the remaining 44.1 percent. The complete distribution of alert data by date is shown in Table 4.2.

**Table 4.2 Total Alerts by Date**

Date of Alerts	Number of Alerts	Percent
2-May-21	38	5.9%
3-May-21	141	21.9%
4-May-21	206	32.0%
5-May-21	155	24.1%
6-May-21	70	10.9%
7-May-21	20	3.1%
8-May-21	14	2.2%
Total	644	100.0%

### 4.5.3 Methodology

KTC researchers performed a comparative analysis through a geospatial and temporal based methodology. As described in section 4.3, PrePass issued in-cab alerts to its MOTION App users whenever a vehicle reached an established distance from a single-point (radius) or polyline (longitudinal) event. For the initial geospatial comparison, the research team assessed the incidence of Type II errors, or false positives. Type II errors occur when the driver erroneously received an alert but should not have. Researchers determined accuracy rates by comparing the locations when drivers received alerts (PrePass) to the actual event locations (GoKY). This comparative analysis was individually performed for each event based on its assigned single-point or polyline logic. For instance, the team would review all single-point incident locations using the established 1,500-meter radius threshold. Alerts matching this criterion would satisfy the condition for geospatial accuracy. However, if the driver was notified outside of this radius, the alert was deemed a false positive. A false positive is also assigned when an alert event is not present, but the driver receives a notification. This methodology did not account for Type I errors—cases where a CMV driver should have received an in-cab alert for an approaching event but did not. These error omissions would require a full accounting of all CMV drivers possessing and using a MOTION App device in Kentucky during the study period. This information was not available due to PrePass proprietary and privacy concerns so further analysis could not be performed.

Researchers conducted this geospatial analysis through a four-step process. In step #1, all PrePass in-cab alerts were mapped in the QGIS software application using their assigned latitude and longitude. The same alert information from the GoKY portal was also mapped in step #2. Next, the researchers constructed an individual 1,500-meter buffer radius around each single-point grid coordinate corresponding with its alert activation radius (step #3). Using visual examination, a PrePass alert location was paired with a corresponding event (GoKY) if it fell within this 1,500-meter radius (step #4). Once all criteria were met, the geospatial component was satisfied for a match. All geospatial steps are shown in the Figure 4.9.



**Figure 4.9** Steps for Matching Alerts by Distance

Once spatial conditions are satisfied, researchers needed to compare data pairs temporally to ensure a valid match. Data pairs between the in-cab alerts (PrePass) and originating source data (GoKY) are considered accurate and valid once two timestamp conditions are met:

- 1) Incident report time precedes the in-cab alert notification
- 2) In-cab alert notification precedes the anticipated time for clearing the incident and normalizing traffic conditions.

In the Figure 4.9, the single red diamond shown in step #1 indicates six individual in-cab alerts, not one. These alerts are represented as a single icon on the map. This single representation occurred because all six alerts activated at the same location (i.e., latitude/longitude) but at different times. The next graphic in step #2 shows the corresponding GoKY data closest to the in-cab alerts. The GoKY data had three distinct records represented by two green circles. The top circle contained one data point while the bottom one contained two. In step #3, the lower green circle containing two GoKY records was found to reside within the necessary 1,500-meter radius. Twelve potential matches existed within this data sample indicating the distance matching requirements were met per step #4.

Once the data points of interest were determined, the research team could perform a temporal comparative analysis. The GoKY portal logged each incident by its location (latitude and longitude), begin date, and end date. The

begin date is the initially recorded time to begin the incident timestamp. The end date is when the incident status was last updated. The end date does not necessarily mean that the incident has ended, only that it was last updated with that time stamp. GoKY receives updates every two minutes from its originating sources although those updates may not result in a corresponding status change. To this extent, the end date does not necessarily mean that the incident has ended. If the incident has expired, then the end date field will no longer receive updates. Consequently, an estimated end date is needed to approximate when the incident expired and cleared. This measure serves as a forecast for the roadway’s return to normal conditions. The research team added one hour to the last updated timestamp as an estimate to assume the incident was cleared and no longer warranted in-cab alerts. The timestamps and their associated relationships between the two datasets must satisfy the conditions below to successfully pass the test.

Variables:

X = PrePass entry time

Y = KYTC begin date (incident started)

Z = KYTC end date (incident updated)

Logic (all conditions satisfied to generate a match):

Time Component

(a)  $Y < X$  and

(b)  $X - Z < 60$  minutes

Spatial Component

(a) PrePass coordinate and KYTC coordinate (single point) within 1,500 m of each other

Illustrating the example from above, only one in-cab alert was verified against a corresponding GoKY record to meet all criteria. Step #5 provides the listing of all timestamps and their comparative counterparts, as applicable, for the final alerts’ matching (see Table 4.3).

**Table 4.3** Final Step for Matching Alerts by Time

<b>Step 5</b>			
<b>Accident first reported</b>	<b>PrePass alert received</b>	<b>Accident last updated + 1 hour</b>	<b>Match</b>
2021-05-03 11:50:00	2021-05-03 12:54:54 (PrePass ID: 38)	2021-05-03 14:26:00	Yes
2021-05-07 20:06:00	2021-05-03 12:54:54 (PrePass ID: 38)	2021-05-07 22:04:00	No
2021-05-03 11:50:00	2021-05-03 18:59:51 (PrePass ID: 148 )	2021-05-03 14:26:00	No
2021-05-07 20:06:00	2021-05-03 18:59:51 (PrePass ID: 148)	2021-05-07 22:04:00	No
2021-05-03 11:50:00	2021-05-03 21:02:38 (PrePass ID: 149 )	2021-05-03 14:26:00	No
2021-05-07 20:06:00	2021-05-03 21:02:38 (PrePass ID:149 )	2021-05-07 22:04:00	No
2021-05-03 11:50:00	2021-05-03 19:33:18 (PrePass ID: 170)	2021-05-03 14:26:00	No
2021-05-07 20:06:00	2021-05-03 19:33:18 (PrePass ID: 170)	2021-05-07 22:04:00	No
2021-05-03 11:50:00	2021-05-04 11:47:05 (PrePass ID: 384 )	2021-05-03 14:26:00	No
2021-05-07 20:06:00	2021-05-04 11:47:05 (PrePass ID:384 )	2021-05-07 22:04:00	No
2021-05-03 11:50:00	2021-05-04 09:55:24 (PrePass ID: 388 )	2021-05-03 14:26:00	No
2021-05-07 20:06:00	2021-05-04 09:55:24 (PrePass ID: 388)	2021-05-07 22:04:00	No

\*All the timestamps were recorded in Coordinated Universal Time.

#### 4.5.4 Results and Discussion

Researchers performed this geospatial and temporal comparative analysis across all 439 incident, 27 congestion, and 178 work zone records. This analysis revealed significant differences between the efficacies of the different types of alerts. Congestion results produced a high level of accuracy between in-cab alerts and the source data. In fact, all 27 records matched between the two sources for a 100 percent validation. Work zone matches also demonstrated a high level of accuracy although slightly reduced at around 90 percent. However, the incidents data did not produce a desired result. This validation was generally inaccurate with only a 12 percent match between the two sources. The full list of results is shown in Table 4.4.

**Table 4.4** Matching Alerts by Category

Alert Type	Number of Matches	False Positive	Total
Incident	55 (12.53%)	384 (87.47%)	439 (100%)
Congestion	27 (100%)	0 (0%)	27 (100%)
Work zone	161 (90.45%)	17 (9.55%)	178 (100%)

The high error rate for the incident validations appears to be the lack of a timestamp annotating the true end of the incident. The methodology used for this study estimated a reasonable approximation of the end timestamp. However, the true end of the incident was unknown. Excessive false positive alerts could be generated for multiple reasons. Those reasons include:

- GoKY portal is not updated in a timely manner from active to inactive status once an incident is cleared
- MOTION App data is not updated frequently enough resulting in outdated alert issuances

Other factors also contribute to false positives including the lack of route, directional travel, and mile points for this application. For example, a CMV may receive an alert within a 1,500-meter radius of an incident but actually be traveling on a different route and direction away from the alert event. In this case, the defined system logic worked as intended but did not produce the desired results. This route/direction shortcoming, however, was not examined within this study since it was not employed by the MOTION App logic.

The use of polylines for congestion events also produced more accurate results than single-point coordinates for the other two alerts. This favorable outcome should be expected. Polylines cover a greater longitudinal distance or coverage area than single-point coordinates and are therefore a more accurate representation of an event. Many transportation events, including congestion and work zones, typically lead to the formation of vehicle queues as vehicles traverse the area in question. These queues can sometimes extend out for several miles. The single-point alert notification only activates at 1,500 meters, or approximately one mile, meaning it is insufficient for extreme queue formations. The radius around the single point also assumes that all traffic is impacted equally in a concentric manner around the event. This may or may not be true. The polyline event does not hold to a certain shape or formation and may provide a better overall depiction of the event.

This analysis revealed two potential ways to improve the GoKY data: (1) provide timestamp indicating the end of an incident and (2) record work zones as a polyline. For the former, KYTC may need to coordinate with KSP to improve incident reporting to better receive incident data when the KSP Officer officially clears the scene. In the latter, KYTC needs to ensure reporting consistency among its district offices and departments for work zone data. All work zones should be marked with a route, beginning Milepoint, and ending Milepoint to better identify their location and



annotate accordingly within the GoKY portal. These two changes should improve the capability to provide increased accuracy and relevancy for in-cab alerts, resulting in safety benefits to the CMV community.

#### **4.6 PrePass Transition to INRIX Platform**

PrePass collaborated with KTC and KYTC for this FMCSA-sponsored research project to demonstrate a proof-of-concept in providing relevant and timely in-cab alerts to CMV drivers. The research revealed the viability of providing these alerts to CMV drivers, but also demonstrated the degree of difficulty in scaling up this methodology across all 50 states. Therefore, PrePass has formed a partnership with INRIX to share mobility data on a nationwide scale, including traffic congestion, incidents, and work zones. INRIX will provide timely and comprehensive data to be used in populating the MOTION application and its user alert notifications. This data will be the authoritative data source for the PrePass MOTION application going forward and supersede any previously used data sources.

PrePass previously used data shared by the GoKY portal as the basis for their driver alert notifications within the state of Kentucky. However, two factors rendered this approach infeasible and cost-prohibitive on a national scale: the lack of standardization or availability for mobility data and the complexity of integrating multiple data systems. Therefore, PrePass concluded the business case for developing alert notifications for all states was not feasible. INRIX offers a single integration point as well as scaling and coverage.<sup>21</sup>

## Chapter 5 Conclusion

The KTC research team conducted a pilot project to study the types of in-cab alerts most beneficial to commercial vehicle (CMV) drivers. Initially, KTC coordinated with KYTC, KSP, and KTA to develop a survey to issue to the trucking community and identify their preferences about in-cab alerts. This survey solicited a robust response and paved the way ahead for selecting the highest priority alerts. Next, the research team partnered with PrePass to facilitate the sharing of alerts through their proprietary MOTION App, which is available on in-cab devices. The GoKY portal served as the data repository for all Kentucky data, which PrePass utilized as the originating source. For this pilot, PrePass activated those alerts for CMV drivers within Kentucky. KTC coordinated with KYTC and PrePass to select a study period, compile alert information, and analyze and discuss the results. The major findings and recommendations from this research study are provided below.

### 5.1 Findings

*Finding #1: There is a high adoption rate of in-cab devices across the CMV community*

The CMV survey identified that most CMV operators have in-cab devices within their vehicle — nearly 78 percent of survey respondents. These devices can be standalone telematic devices (e.g., electronic logging devices) or apps on their mobile device or smart phone. This finding indicates that in-cab devices present a viable mechanism for delivering alerts to CMV drivers in real-time.

*Finding #2: CMV drivers have clear preferences on the types of in-cab alerts*

The CMV survey demonstrated that CMV drivers have clear preferences about potential in-cab alerts. The percentage of respondents who were either “very interested” or “somewhat interested” in receiving alert notifications was high across the top five alert categories. The alert preferences included: (1) traffic work zones – 76.3%, (2) traffic congestion – 78.2%, (3) real-time incidents – 80.6%, and (4) CMV parking – 79.6%. Those numbers drop across the remaining categories of crash corridors (71.5%), rollover risk (66.1%), overweight restrictions (56.1%), and oversize restrictions (50.8%),

*Finding #3: Within KYTC, there is inconsistent collection and reporting of work zone data*

The Kentucky Transportation Cabinet is a large organization with many departments and district offices. KYTC relies on its internal organizations to report work zone data. However, KYTC lacks central standards or guidelines regarding the data format. Work zone data may be reported by segment lengths with corresponding beginning and ending mile points or by single point coordinates with latitude and longitude. This lack of uniformity impedes consistency for receiving, analyzing, and reporting work zone data internally and to the public. In addition, internal KYTC organizations may not be updating their active versus inactive work zone statuses in a timely manner, further complicating work zone data reporting.

*Finding #4: Duplicate files across systems hinder accurate and timely reporting of notifications*

For this pilot, the PrePass MOTION App architecture pulled its originating source data from KYTC’s GoKY system. These file transfers involved many records across all categories of interest over an established period. This file transfer process sometimes resulted in duplicate files for alert notifications. These duplicate files resulted in the MOTION App system often incorrectly interpreting and reporting the appropriate information to drivers.

*Finding #5: KYTC real-time incidents have incomplete data to close out incident*

The GoKY portal has timestamps for real-time incidents including a start date and end date. The real-time end date, however, does not indicate when an incident has closed, only when it was last updated. This data gap required development of logic inferences to compensate. PrePass assumed an incident “closed” once an hour had elapsed from the original start date without a corresponding update to the end date. This condition assumed an incident is sufficiently cleared within one hour and/or the incident had been updated within the GoKY system in a timely manner. The incident close-out thus requires assumptions that both conditions hold true. The study analysis revealed an excessive number of false positives, indicating this measure is insufficient.

*Finding #6: KYTC data reported as single points and polylines although polylines frequently prove to be superior*

In-cab alerts represent safety hazards that have been previously identified on a given roadway location. Hazards may be characterized as single points for a spot location or polylines associated with a segment length. In some instances, single points may best characterize an event such as a real-time incident involving a crash. However, in many instances, the polyline proves superior in characterizing a roadway condition, especially for incidents occurring over a notable length. For example, KYTC work zone alerts typically relied on single point coordinates, but polylines would have better represented the segmented nature of most work zones. Polyline adoption in these cases would likely provide drivers with increased reaction time prior to entering the affected area and better characterize the overall roadway condition.

*Finding #7: Lack of uniformity, standardization, and availability of data between state DOT agencies presents challenges to national implementation of alert notifications*

Both PrePass and the research team demonstrated the viability of delivering in-cab alerts to CMV drivers approaching roadway hazards. The budget, time, and resources required to develop this alert system proved challenging to both parties. Currently, state DOT data collection and reporting lacks uniformity due to a lack of shared consensus via national-level standards or guidelines for crowdsourced or mobile data. PrePass ultimately realized that applying this in-cab alert development process individually across all 50 state DOTs would prove infeasible. Thus, they partnered with a private-sector company, INRIX, to receive their future alert data. Many state DOTs have a wealth of data that could prove valuable to CMV drivers if shared, but the lack of consistent standards and guidelines impedes their ability to successfully share this information with their CMV customers.

## **5.2 Recommendations**

The KTC research team recommends the following measures in accordance with the research study's findings:

### *Recommendation #1:*

Transportation agencies should support the use in-cab devices for sharing roadway hazard alerts through improved data collection, quality control, and coordinated sharing efforts, as proven feasible within this study.

### *Recommendation #2:*

Transportation agencies supporting the distribution of in-cab alerts should focus on high-priority items identified by CMV users. In this pilot, a Kentucky-based survey revealed CMV users prioritized notifications on real-time incidents, traffic congestion, work zones, and CMV parking availability.

### *Recommendation #3:*

KYTC should develop and implement a uniform work zone data collection and reporting policy across the organization to improve consistency and outcomes. Work zone data should be collected in the form of polylines to better characterize stated work zone conditions.

### *Recommendation #4:*

Transportation agencies sharing data internally or between agencies should ensure the use of timestamps for all records and files. These time indicators clearly identify the uniqueness of a given event and reduce opportunities for error when comparing and analyzing files.

### *Recommendation #5:*

KYTC should evaluate its definition and collection process for the GoKY "end date" field for real-time incident reporting and consider additional measures for clarifying conditions in closing an incident.

### *Recommendation #6:*

KYTC should use polylines for all roadway events — best described as segmented in nature — and identify this information by beginning and ending mile points. Work zones represent an ideal case for using polylines, but others may also be appropriate.

### *Recommendation #7:*

FMCSA should coordinate with state DOTs and develop a common set of national standards or guidelines for agencies to use when collecting, analyzing, and reporting their traffic data, particularly for roadway hazards. FMCSA should also recognize that many competing standards and guidelines already exist across state agencies and encourage agencies to move to a common set. Any agreed upon standards or guidelines should use an interface control document (ICD) format to codify those definitions for state agency adoption. Using this common approach, state agencies should share their relevant traffic data to the public through open portals in promoting increased transparency for public consumption. These portals would allow vendors, entrepreneurs, and researchers to use this data for trend analysis and/or issue identification in developing safety-focused deliverables such as in-cab alerts or research studies, as applicable.

## Appendix A Data Preference Survey

Instructions: This survey is intended to measure interest in commercial motor vehicle in-cab data notifications. The survey contains both multiple choice and open-ended questions and is anonymous. The survey should take about 3-5 minutes to complete. Thank you for your participation.

Q1. How would you describe your role within the commercial motor vehicle community? (Select all that apply.)

- Driver/Operator
- Manager/Supervisor
- Owner
- Owner-Operator
- Other

Q2. Approximately how many commercial motor vehicles does your organization have?

- 1
- 2-10
- 11-50
- More than 50

Q3. Do you have a device that allows you to receive in-cab notifications from your truck dispatch, GPS navigation, or other data sources?

- Yes
- No

Q4. If you answered yes on question #3, what type of device do you have?

- In-cab device/tablet
- Smartphone with mobile app
- Both in-cab device/tablet and smartphone with mobile app
- Other

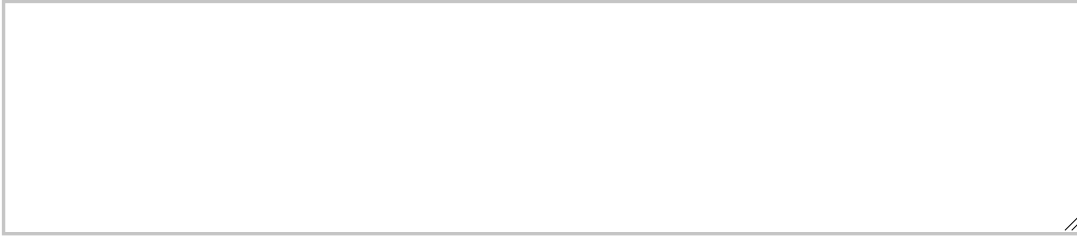
Q5. Overall, how interested, if at all, are you in receiving in-cab notifications on the following topics?

	Very interested (4)	Somewhat interested (3)	Slightly interested (2)	Not interested at all (1)
Traffic work zones	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Traffic congestion	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Real-time incidents (e.g., crashes, stalled vehicles, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
High-crash corridors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rollover risk (e.g., history of overturned vehicles)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Oversize restrictions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Overweight restrictions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Commercial motor vehicle parking (availability at rest areas and weigh stations)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q6. Please rank your top three in-cab notifications of interest. Assign a "1" to your highest interest, "2" to your second highest interest, and "3" to your third highest interest.

- Traffic work zones
- Traffic congestion
- Real-time incidents
- High-crash corridors
- Rollover risk
- Oversize restrictions
- Overweight restrictions
- Commercial motor vehicle parking

Q7. Are there any in-cab notifications you might be interested in receiving that were not already mentioned in this survey?





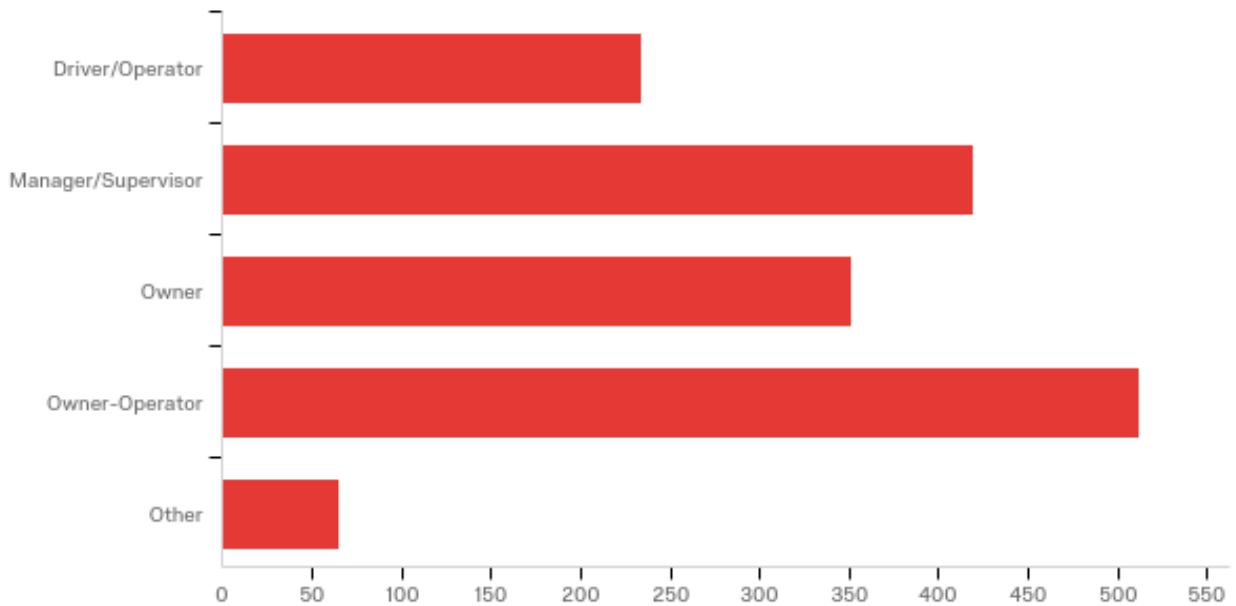
## A1. Survey Results

Default Report

*In-Cab Survey for Commercial Motor Vehicle Community*

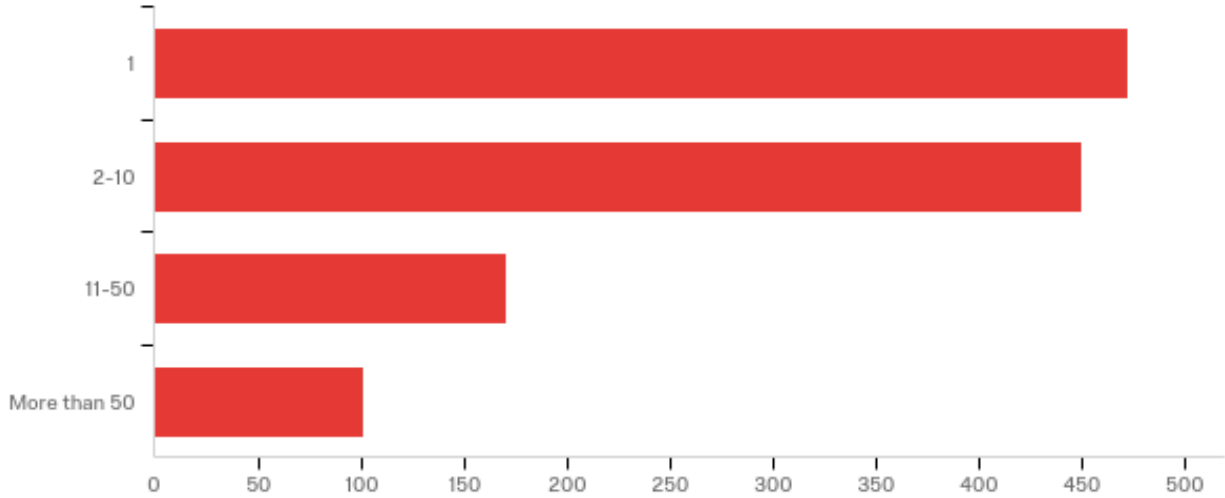
January 4th 2019, 9:57 am MST

Q1 - How would you describe your role within the commercial motor vehicle community? (Select all that apply.)



#	Answer	%	Count
1	Driver/Operator	14.79%	234
2	Manager/Supervisor	26.55%	420
3	Owner	22.19%	351
4	Owner-Operator	32.36%	512
5	Other	4.11%	65
	Total	100%	1582

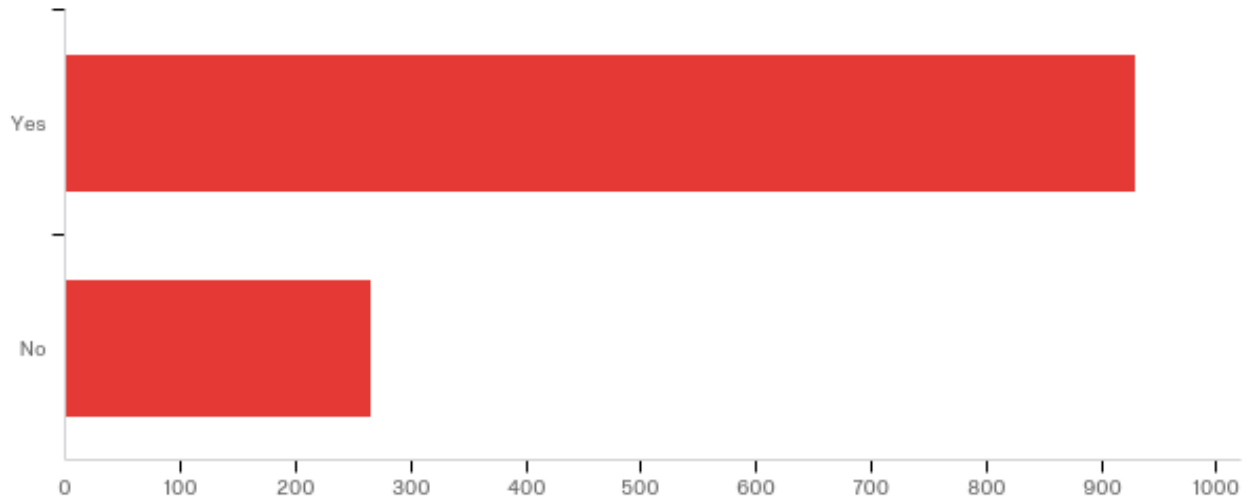
**Q2 - Approximately how many commercial motor vehicles does your organization have?**



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Approximately how many commercial motor vehicles does your organization have?	1.00	4.00	1.92	0.93	0.87	1195

#	Answer	%	Count
1	1	39.58%	473
2	2-10	37.66%	450
3	11-50	14.31%	171
4	More than 50	8.45%	101
	Total	100%	1195

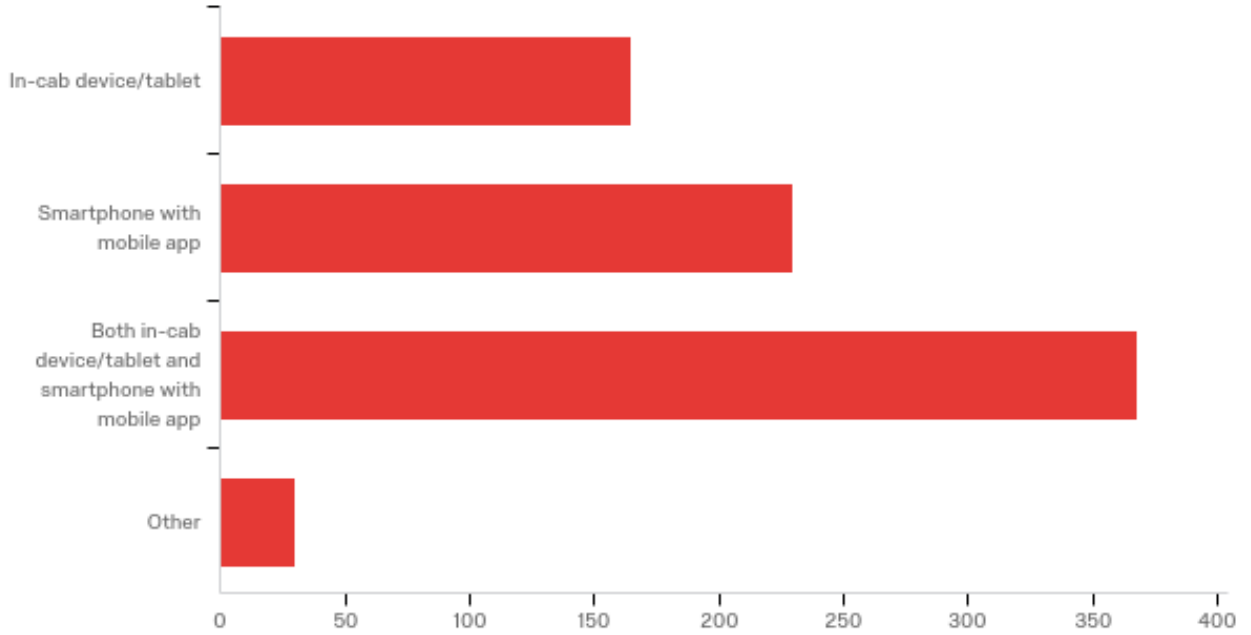
**Q3 - Do you have a device that allows you to receive in-cab notifications from your truck dispatch, GPS navigation, or other data sources?**



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you have a device that allows you to receive in-cab notifications from your truck dispatch, GPS navigation, or other data sources?	1.00	2.00	1.22	0.42	0.17	1195

#	Answer	%	Count
1	Yes	77.74%	929
2	No	22.26%	266
	Total	100%	1195

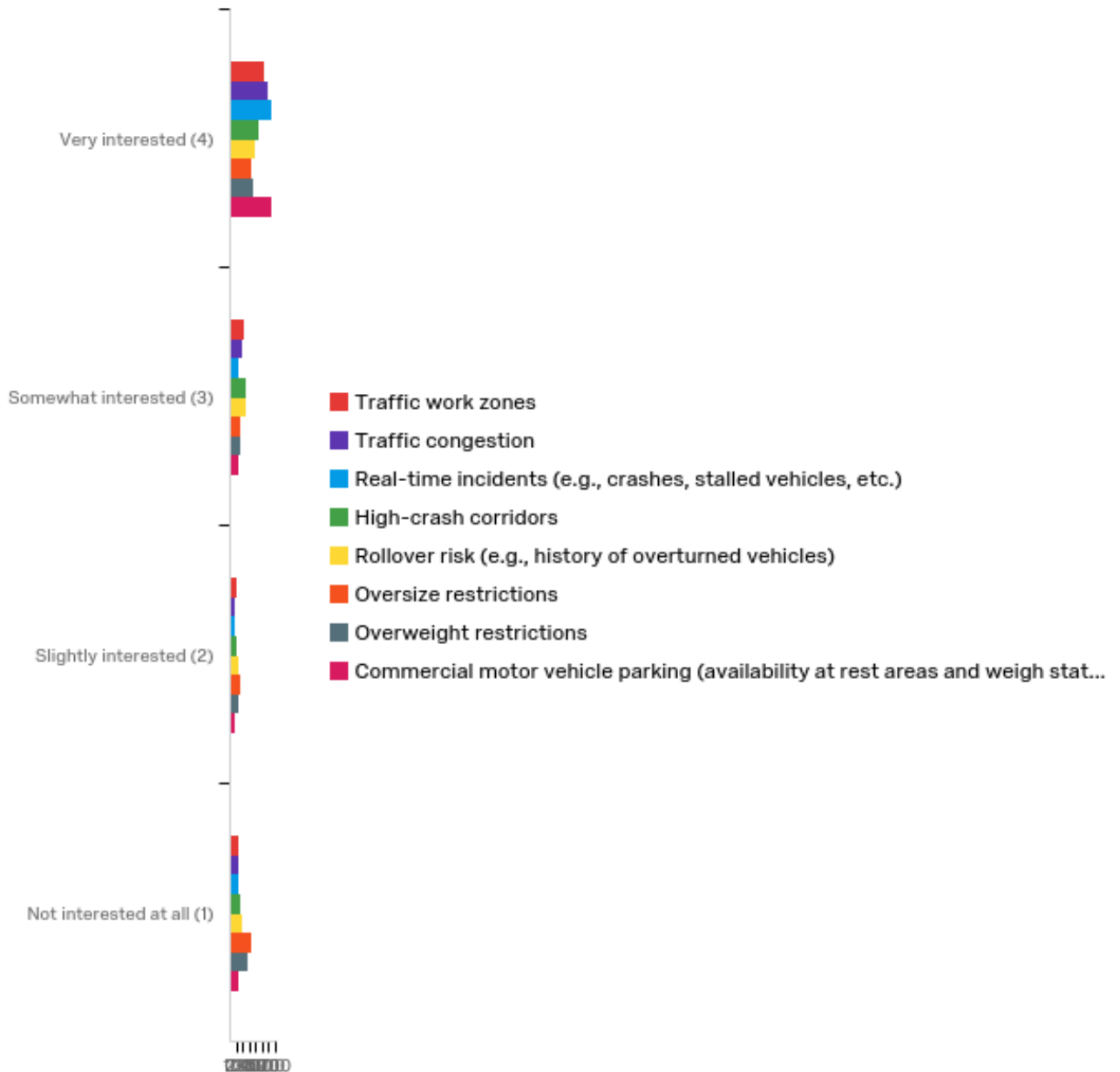
**Q4 - If you answered yes on question #3, what type of device do you have?**



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	If you answered yes on question #3, what type of device do you have?	1.00	4.00	2.33	0.84	0.71	793

#	Answer	%	Count
1	In-cab device/tablet	20.81%	165
2	Smartphone with mobile app	29.00%	230
3	Both in-cab device/tablet and smartphone with mobile app	46.41%	368
4	Other	3.78%	30
	Total	100%	793

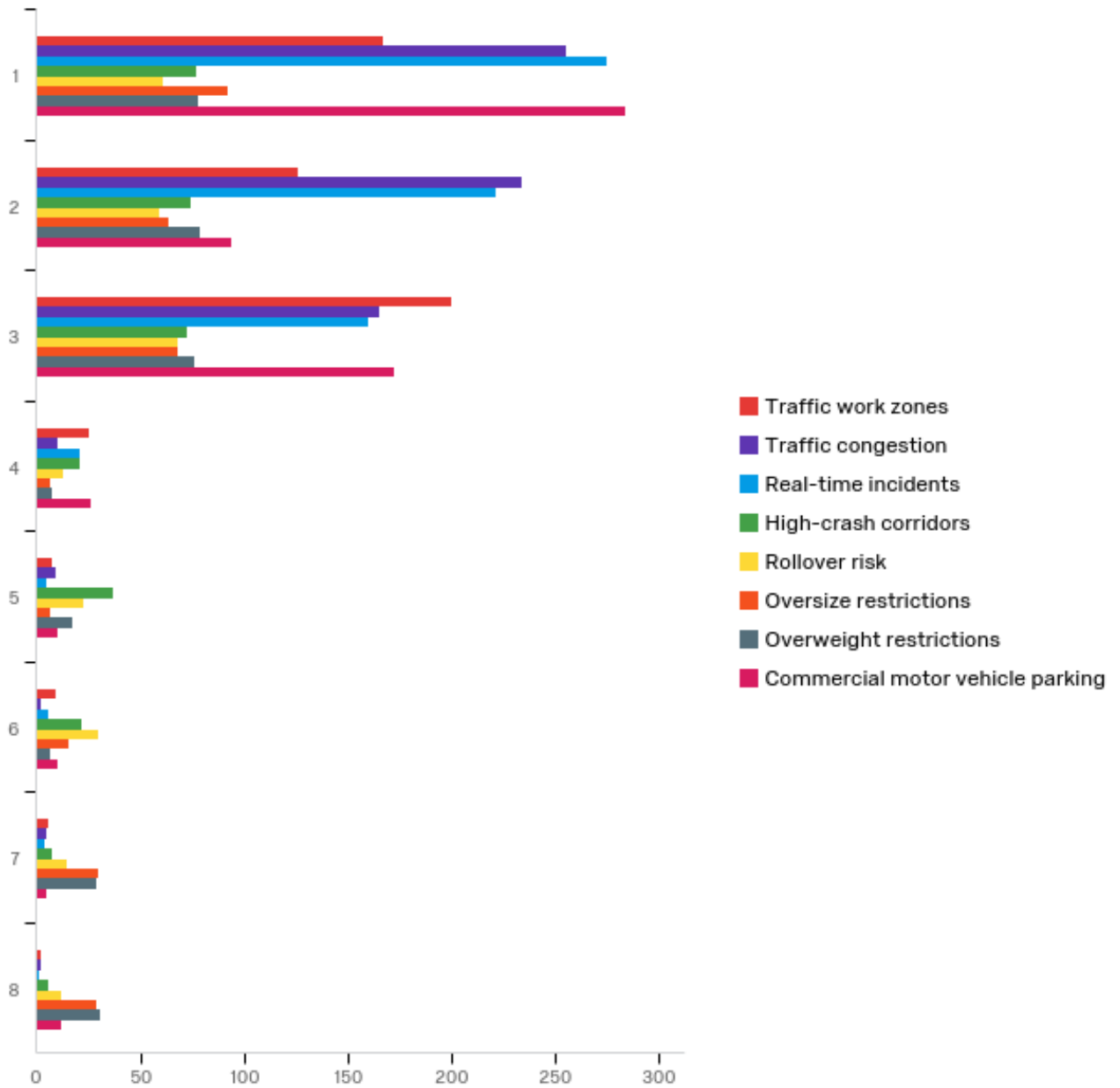
Q5 - Overall, how interested, if at all, are you in receiving in-cab notifications on the following topics?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Traffic work zones	1.00	4.00	1.85	1.09	1.19	984
2	Traffic congestion	1.00	4.00	1.75	1.09	1.18	978
3	Real-time incidents (e.g., crashes, stalled vehicles, etc.)	1.00	4.00	1.66	1.06	1.13	977
4	High-crash corridors	1.00	4.00	1.98	1.12	1.25	959
5	Rollover risk (e.g., history of overturned vehicles)	1.00	4.00	2.13	1.15	1.32	959
6	Oversize restrictions	1.00	4.00	2.48	1.28	1.63	951
7	Overweight restrictions	1.00	4.00	2.34	1.26	1.59	949
8	Commercial motor vehicle parking (availability at rest areas and weigh stations)	1.00	4.00	1.68	1.08	1.17	965

#	Question	Very interested (4)		Somewhat interested (3)		Slightly interested (2)		Not interested at all (1)		Total
1	Traffic work zones	53.25%	524	23.07%	227	9.04%	89	14.63%	144	984
2	Traffic congestion	60.33%	590	17.89%	175	7.87%	77	13.91%	136	978
3	Real-time incidents (e.g., crashes, stalled vehicles, etc.)	66.33%	648	14.23%	139	6.65%	65	12.79%	125	977
4	High-crash corridors	47.03%	451	24.50%	235	11.99%	115	16.48%	158	959
5	Rollover risk (e.g., history of overturned vehicles)	40.88%	392	25.23%	242	14.18%	136	19.71%	189	959
6	Oversize restrictions	35.23%	335	15.56%	148	15.25%	145	33.96%	323	951
7	Overweight restrictions	39.20%	372	16.86%	160	14.86%	141	29.08%	276	949
8	Commercial motor vehicle parking (availability at rest areas and weigh stations)	66.32%	640	13.26%	128	6.84%	66	13.58%	131	965

Q6 - Please rank your top three in-cab notifications of interest. Assign a "1" to your highest interest, "2" to your second highest interest, and "3" to your third highest interest.

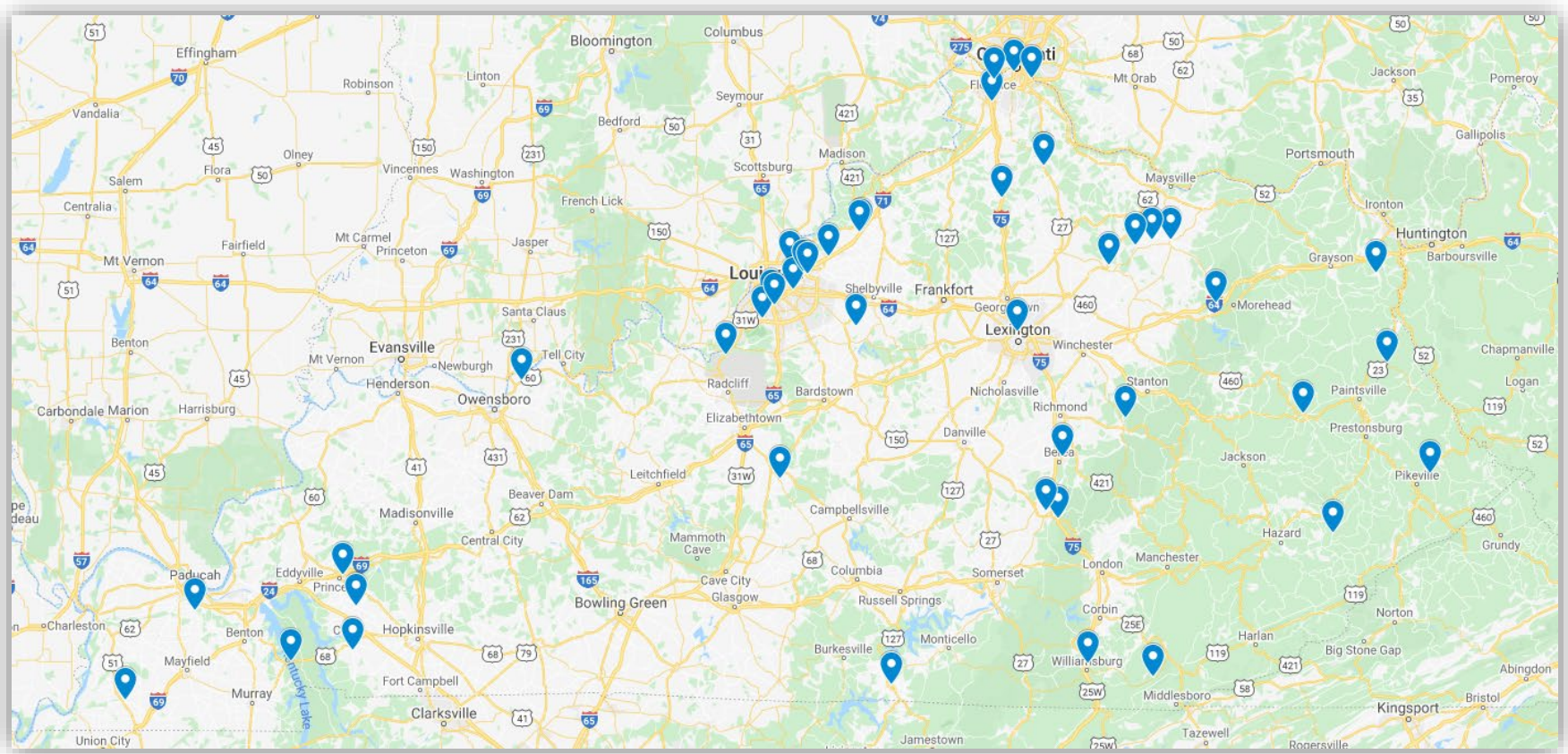




#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Traffic work zones	0.00	10.00	2.37	1.37	1.88	549
2	Traffic congestion	0.00	23.00	2.04	1.37	1.87	687
3	Real-time incidents	0.00	10.00	2.00	1.16	1.34	698
4	High-crash corridors	0.00	10.00	2.99	1.88	3.54	324
5	Rollover risk	0.00	9.00	3.29	2.10	4.43	286
6	Oversize restrictions	0.00	10.00	3.22	2.44	5.96	321
7	Overweight restrictions	0.00	10.00	3.26	2.36	5.58	333
8	Commercial motor vehicle parking	0.00	10.00	2.18	1.55	2.41	620

#	Question	1	2	3	4	5	6	7	8	Total								
1	Traffic work zones	30.76%	167	23.20%	126	36.83%	200	4.60%	25	1.47%	8	1.66%	9	1.10%	6	0.37%	2	543
2	Traffic congestion	37.39%	255	34.31%	234	24.19%	165	1.47%	10	1.32%	9	0.29%	2	0.73%	5	0.29%	2	682
3	Real-time incidents	39.68%	275	31.89%	221	23.09%	160	3.03%	21	0.72%	5	0.87%	6	0.58%	4	0.14%	1	693
4	High-crash corridors	24.21%	77	23.27%	74	22.96%	73	6.60%	21	11.64%	37	6.92%	22	2.52%	8	1.89%	6	318
5	Rollover risk	21.71%	61	21.00%	59	24.20%	68	4.63%	13	8.19%	23	10.68%	30	5.34%	15	4.27%	12	281
6	Oversize restrictions	29.39%	92	20.45%	64	21.73%	68	2.24%	7	2.24%	7	5.11%	16	9.58%	30	9.27%	29	313
7	Overweight restrictions	24.00%	78	24.31%	79	23.38%	76	2.46%	8	5.23%	17	2.15%	7	8.92%	29	9.54%	31	325
8	Commercial motor vehicle parking	46.33%	284	15.33%	94	28.06%	172	4.24%	26	1.63%	10	1.63%	10	0.82%	5	1.96%	12	613

## Appendix B KTC Active Work Zones (June – July 2019)



Name	Latitude	Longitude	DataSourceId
KY-0032_Road Blocked	38.332109	-84.05251	KY-0032_6.6_-84.0525136_38.3321091
KY-0681_Road Blocked, Bridge	38.411712	-83.91917	KY-0681_1.55_-83.919168_38.4117119
KY-0367_Road Blocked, Bridge	38.433671	-83.83692	KY-0367_1_-83.8369151_38.4336709
KY-2508_Road Blocked, Bridge	38.430865	-83.74099	KY-2508_0.081_-83.740992_38.4308654
I-0064_Lane Blocked, Bridge	38.185628	-83.519	I-0064_135_-83.5190024_38.1856278
KY-0794_Road Blocked, Bridge	37.735722	-83.96804	KY-0794_0.3_-83.9680442_37.7357218
US-0025_Lane Blocked	37.585707	-84.28391	US-0025_4.9_-84.2839123_37.5857072
I-75 NC_Road Construction	38.596109	-84.58315	I-75 NC_152_-84.5831485_38.5961092
I-75 NC_Road Construction	39.083631	-84.52275	I-75 NC_191_-84.5227531_39.0836307
WEAVER RD_Road Construction	38.966099	-84.6359	WEAVER RD_1.4_-84.6358952_38.9660992
I-65 RAMP from I-264_Road Construction	38.190747	-85.72997	I-65 RAMP from I-264_0.3_-85.7299725_38.1907473
I-275 NC_Road Construction	39.053217	-84.6243	I-275 NC_1.9_-84.6243029_39.0532167
I-64 RAMP to I-264_Road Construction	38.238615	-85.62055	I-64 RAMP to I-264_0_-85.6205463_38.2386154
I-275_Road Construction	39.056424	-84.43277	I-275_73.3_-84.4327664_39.0564241
KY-0160_Lane Blocked	37.282159	-82.93766	KY-0160_5.5_-82.9376622_37.2821592
I-0071_Entrance Ramp Blocked, Exit Ramp Blocked	38.466185	-85.28328	I-0071_28.7_-85.2832772_38.4661848
US-0062_Lane Blocked	37.117886	-87.86488	US-0062_8.3_-87.8648763_37.1178857
I-0071_Exit Ramp Blocked	38.460235	-85.29128	I-0071_28.1_-85.2912787_38.4602353
KY-1169_Lane Blocked	38.095681	-85.30955	KY-1169_8.5_-85.3095517_38.0956809
KY-0017_Lane Blocked	38.721528	-84.37476	KY-0017_0_-84.3747577_38.7215283
US-0027_Lane Blocked	38.721418	-84.37471	US-0027_11.8_-84.3747146_38.7214182
KY-0004_Lane Blocked	38.074514	-84.50596	KY-0004_8.731_-84.5059585_38.074514
KY-1441_Lane Blocked	37.519076	-82.45428	KY-1441_10.31_-82.4542831_37.5190758
US-0025_Lane Blocked	36.764494	-84.15426	US-0025_13.9_-84.1542578_36.7644941
KY-1954_Road Blocked, Bridge	36.975795	-88.5999	KY-1954_0.768_-88.5998985_36.975795
KY-0854_Road Blocked, Bridge	38.302287	-82.72117	KY-0854_7.075_-82.7211746_38.3022873
KY-2209_Road Blocked, Bridge	36.619524	-88.94462	KY-2209_0.662_-88.9446151_36.6195243
KY-0030_Road Blocked, Bridge	37.751204	-83.08427	KY-0030_10.9_-83.0842701_37.751204
KY-1065_Lane Blocked	38.126431	-85.77664	KY-1065_1_-85.7766402_38.1264314
KY-0139_Road Blocked, Bridge	36.817824	-87.81481	KY-0139_13.38_-87.8148107_36.8178245
KY-0225_Road Blocked	36.713305	-83.83212	KY-0225_0.9_-83.8321221_36.7133054
KY-0022_Lane Blocked, Bridge	38.309273	-85.57233	KY-0022_4.1_-85.5723302_38.3092733
KY-0061_Lane Blocked	38.179447	-85.71779	KY-0061_7.3_-85.7177872_38.1794475
KY-0061_Road Blocked, Bridge	37.4963	-85.68678	KY-0061_4.1_-85.6867776_37.4963002
KY-0126_Road Blocked, Bridge	36.995324	-87.79697	KY-0126_2.285_-87.7969651_36.995324
KY-0146_Lane Blocked, Bridge	38.367939	-85.44442	KY-0146_6_-85.4444241_38.3679394
US-0023_Lane Blocked	37.952909	-82.66865	US-0023_4.953_-82.6686507_37.9529089
US-0031_Lane Blocked, Bridge	37.984909	-85.95689	US-0031_36_-85.9568941_37.9849093
US-0068_Lane Blocked, Bridge	36.772669	-88.12025	US-0068_28.165_-88.1202453_36.7726687
KY-0738_Road Blocked	36.680157	-85.13237	KY-0738_6.4_-85.1323677_36.6801568
KY-1447_Lane Blocked	38.297156	-85.54961	KY-1447_6.6_-85.5496144_38.2971564
US-0060_Lane Blocked	37.882611	-86.97565	US-0060_29.64_-86.9756483_37.8826106

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