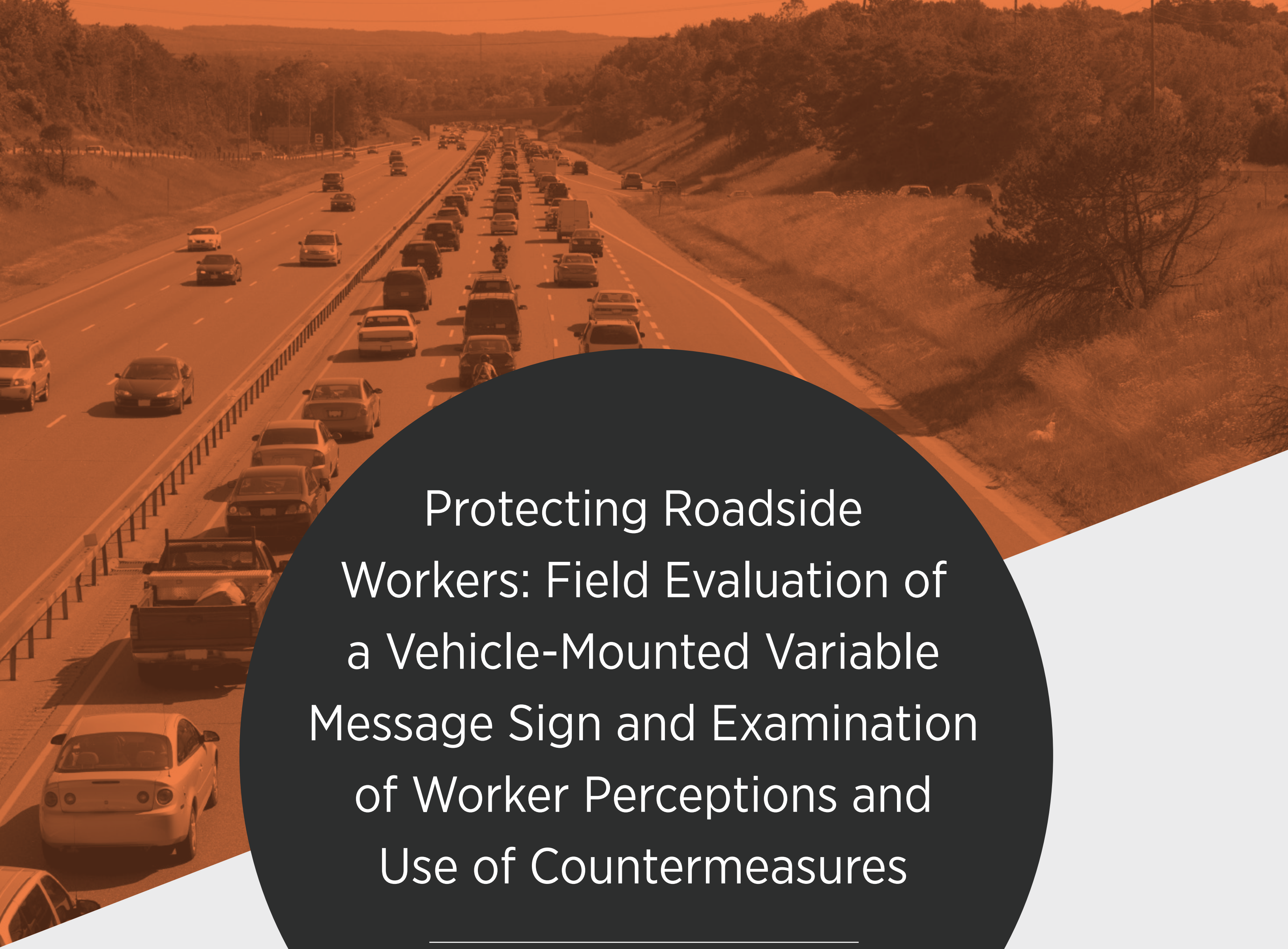

Protecting Roadside Workers: Field Evaluation of a Vehicle-Mounted Variable Message Sign and Examination of Worker Perceptions and Use of Countermeasures

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FOUNDATION FOR TRAFFIC SAFETY

Title

Protecting Roadside Workers: Field Evaluation of a Vehicle-Mounted Variable Message Sign and Examination of Worker Perceptions and Use of Countermeasures

(January 2023)

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Foreword

Roadside service and incident response personnel, such as towing, police, fire, and emergency medical service personnel, are at risk of being struck by passing motorists while responding to disabled vehicles, crashes, and other roadway incidents. Being struck while performing their jobs is one of the leading causes of injuries and fatalities for roadside responders. While countermeasures exist, there are many unanswered questions regarding their efficacy, adoption, and proper use.

This technical report summarizes a multi-faceted study examining the effectiveness of a countermeasure, deployed in a field setting (a vehicle-mounted variable message sign), as well as perceptions, self-reported behaviors, and safety outcomes of roadside service and incident response workers. Findings presented in this report should help researchers, industry stakeholders, and government entities to ameliorate safety outcomes for these at-risk workers.

C. Y. David Yang, Ph.D.

Executive Director
AAA Foundation for Traffic Safety

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List of Key Acronyms

ALDOT	Alabama Department of Transportation
ALGO	An application providing live traffic data in Alabama
ANSI	American National Standards Institute
ASAP	Alabama Service Assistance Patrol
CEVMS	Changeable Electronic Variable Message Sign
CMS	Changeable Message Sign
DEP	Dependency Parsing
DMS	Dynamic Message Sign
DOT	Department of Transportation
DPS	Department of Public Safety
DUI	Drive Under Influence
DWI	Drive while impaired
EMS	Emergency Medical Service
ERSI	Emergency Responder Safety Institute
FHWA	Federal Highway Administration
ICU	Intensive Care Unit
ISEA	International Safety Equipment Association
TF-IDF	Term Frequency–Inverse Document Frequency
LODD	Line of Duty Death
NFPA	National Fire Protection Association
OR	Odds Ratio
POS	Part-of-speech
SSP	Safety Service Patrol
TIM	Traffic Incident Management
USDOT	U.S. Department of Transportation
VMS	Variable Message Sign
YOLO	You Only Look Once

EXECUTIVE SUMMARY

Extensive efforts have been made to develop countermeasures to protect roadside service and incident response personnel (Alabama Law Enforcement Institute, 2019; U.S. Government Accountability Office, 2021). Research is greatly needed to understand the effectiveness of different countermeasures and responders' compliance (or non-compliance) with safety protocols and their use (or non-use) of safety countermeasures. This study aimed to identify and assess the effectiveness of a select countermeasure intended to protect roadside service and incident response personnel at traffic incident sites. Additionally, though focus groups and surveys, it sought to examine responders' use of or compliance with a variety of countermeasures. This study is structured with four major technical tasks:

- ***Evaluation of Vehicle-Mounted Variable Message Signs***—Field data was gathered to evaluate the effectiveness of variable message signs (VMS) mounted on roadside emergency vehicles as a countermeasure to protect roadside incidents and service personnel. The team worked with the ALDOT's Safety Service Patrol (SSP) program, called Alabama Service Assistance Patrol (ASAP), in the West Central Alabama area to collect video data from their service vehicles. A computer vision, deep learning approach was utilized to detect and track vehicles in traffic scene videos. Movements and behaviors of passing vehicles were examined, including their speed and lane change behaviors. Results showed statistically significant relationships between VMS use and behaviors of passing motorists. When the VMS was active, drivers were more likely to move over (change lanes) and slow down than in the cases when the VMS was not active. The odds of a vehicle moving over were 95% higher when the VMS is used. The modeling outcomes suggest that the use of VMS can be an effective countermeasure to protect roadside incidents and service personnel.
- ***Focus Group Meetings***—Focus group meetings with incident response personnel were used to gather information regarding practices of using countermeasures and safety protocols in traffic incident management. Five focus group meetings were organized, and 18 participants from four fields of incident management (police, Department of Transportation (DOT), emergency medical services (EMS), and towing and roadside service) attended the meetings. The discussions shed light on first responder's practices of adopting specific countermeasures at incident management scenes and on reasons or contributing factors in cases which available countermeasures are not used. Responders also shared their experiences and perceptions about their roadside work safety.
- ***National Responder Survey***—Working with Emergency Responder Safety Institute (ERSI) and the AAA Foundation for Traffic Safety, a national responder safety survey was conducted. A total of 1,757 responses from incident response personnel were received. Through descriptive analysis and statistical modeling of survey data, important insight was gleaned related to incident response personnel's perceptions of adopting countermeasures and their compliance with safety guidelines and use of safety countermeasures. The adoption of countermeasures was

also examined in the context of adverse safety outcomes: struck-by and near-miss incidents.

- ***Text Mining of News Data***—Characteristics of first responder-involved incidents were investigated by mining the narrative text in online news reports. A total of 5,113 news reports were extracted from the respondersafety.com website. The characteristics of three types of responder-involved incidents were compared: near-miss incidents, struck-by incidents, and line-of-duty deaths (LODD).

Overall, the research outcomes offer valuable insights for enhancing the safety of roadside service and incident response personnel. In many cases, training (including raising awareness), practice, increasing access, or implementing policies or mandates might help to encourage and promote the use of available countermeasures. Education regarding the risks and/or the efficacy of certain countermeasures might be one avenue to reducing complacency or correcting perceptions that certain countermeasures are ineffective. Prioritizing safety and promoting a strong organizational safety culture are encouraged, especially as avoiding worker injury can readily match and increase the return on investment for training and appropriate safety equipment.

INTRODUCTION

Roadside service and incident response personnel have a high incidence of severe occupational injury while responding to traffic incidents and providing roadside services. These responders include law enforcement officers, highway safety service patrol operators, firefighters, emergency medical technicians, tow truck operators, and mobile mechanics. According to the National Law Enforcement Officer Memorial Fund (NLEOMF), over the past decade, from 2011 to 2020, there were 131 law enforcement officers killed by a passing vehicle while responding to a traffic incident (National Law Enforcement Officer Memorial Fund, 2021). Unfortunately, other roadside services and incident responders face the same type of unsafe conditions while performing their duties on the road or roadside. AAA has reported that more than 250 people, including stranded motorists and first responders, are killed each year on the road or roadside while attending to traffic incidents or disabled vehicles (Edmonds, 2021). Secondary crashes involving traffic incident responders are among the leading causes of responder injuries and deaths. These secondary crashes generally result from conflicts between the stationary responder vehicles, on-scene personnel, and other approaching or passing motorists (Zhan et al., 2009). These additional crashes make it more difficult for responders to get to and from the scene (Yang et al., 2014).

To reduce and prevent incident responder injuries and fatalities, a number of countermeasures and protocols have been developed (EMC Insurance, 2021). The safety countermeasures or protocols can be grouped into two categories based on traffic incident management: on-duty (during an incident response) and off-duty (occurring outside of an incident response). When the responders are on-duty, they are required to comply with safety protocols and stand to benefit from available safety equipment or features; when the responders are off-duty, they may participate in training and practice in the use of equipment so that they may improve their abilities to manage an incident effectively. Selected on-duty safety countermeasures or safety protocols include the following:

- ***High Conspicuity Markings*:** Emergency response vehicles may use high conspicuity markings to draw the attention of other road users. Contrasting colors (e.g., yellow, and red), fluorescent colors, and retroreflective materials are recommended to make the vehicle stand out, increase daytime visibility, and maximize nighttime visibility. Figure 1 shows examples of responder vehicles with high conspicuity markings (USDOT, 2019).

Figure 1. Examples of responder vehicles with high conspicuity markings. (USDOT, 2019)

- ***High-Visibility Safety Apparel*: **Incident responders may wear high-visibility safety apparel (vests, jackets, overalls/coveralls, etc.) if exposed to traffic, work vehicles, and construction equipment (USDOT, 2019). The safety apparel worn by incident responders should be labeled and meet one of the standards: (a) ANSI/ISEA 107 Performance Class II or III, or (b) ANSI/ISEA 207 Public Safety Vests (see Figure 2). Tuttle et al. (2009) found that different types of approved first-responder safety garments (specifically, NFPA 1971–2007 turnout gear coats and ANSI/ISEA 107 and 207 safety vests) provided equal levels of conspicuity.

Figure 2. Examples of high-visibility safety apparel (from left to right: Class II 107 Vest, Class II 207 Public Safety Vest, Class III 107 Vest) (USDOT, 2019).

- ***Emergency Vehicle Lighting*: **In addition to high conspicuity markings, different configurations of static or flashing emergency vehicle lighting can be used to draw the attention of other approaching motorists. However, there are concerns about the use of too many lights at an incident site (Karczewski & Swain, 2004) since this could be distracting and may confuse approaching road users, especially at night. Moreover, current trends in emergency lighting technology, such as LED lights that are brighter and more intense, have inadvertently created adverse conditions for visibility for drivers of passing vehicles (Bullough et al., 2021). Thus, it is recommended that emergency vehicle lighting be kept to a minimum level at sites where temporary traffic control has been effectively established. It is also recommended that when multiple vehicles are present, only the upstream blocking vehicles use emergency vehicle lighting after placing appropriate traffic control devices. Importantly, headlights and floodlights are not recommended for illumination at night if they are not necessary (USDOT, 2019).

- ***Positioning of Responder Vehicles*:** The positioning of responder vehicles in relation to the incident vehicle(s) can help enhance the safety of responders working on site. It is recommended or typical to position law enforcement, fire, and DOT or safety service patrol vehicles upstream to the site, with EMS and tow truck vehicles positioned downstream along with support units (USDOT, 2019).
- ***Critical Wheel Angle*:** For response vehicles in a blocking position (i.e., parked behind or upstream of the incident vehicle), the angle of the wheels can also be used to increase safety. Specifically, the wheels of the blocking vehicle should be angled so that they are not directed towards the incident space in the event the unit is struck by a passing vehicle approaching from upstream (USDOT, 2019).
- ***Use of Incident Command System (ICS)*:** The National Incident Management System (NIMS) requires the use of the ICS at traffic incident sites. When the incident involves multiple agencies, the unified command enables a coordinated response among various jurisdictions and agencies (Bennett, 2011). Responding agencies need to work together to develop and implement an Incident Action Plan (IAP), whether communicated verbally or in writing (depending on the size and nature of the incident).

Responder Training is an important countermeasure that is relevant outside of an active incident response. The National TIM Responder Training Program was developed to help improve the incident response and increase the safety of incident response personnel and the public (USDOT, 2019). It provides a shared understanding of the requirements for safe, quick clearance of traffic incident scenes; prompt, reliable, and open communication; and motorist and responder safeguards. Implementing the TIM training program has led to strong improvement in traffic safety by contributing to a steady decline in secondary crashes killing or injuring the responders (e.g., from 4.1% to 1.7% in Metropolitan Phoenix and from 1.9% to 1.3% in East Tennessee Region 1 from 2012 to 2015). Since receiving the SHRP2 TIM training, 90% of responders reported that the level of safety when working at traffic incident scenes was improved (National Academies of Sciences, Engineering, and Medicines, 2014). In recognition of the safety effectiveness of the SHRP2 TIM training program, it is highly recommended the state emergency responders participate in such training before responding to traffic incidents.

In addition to training, *Test Runs* or *Mock Drills* and *Action Reviews* are important off-duty safety countermeasures to improve traffic incident responses. These countermeasures may be regarded as part of the TIM training program. The main goals are to constructively critique the procedures used and any decisions made and to help identify areas where future incident management could be improved (FHWA, 2010).

In addition, across the U.S. there are state laws that have been enacted to help increase the safety of the responders. For example, the *Move Over Laws* requires motorists to change lanes and/or slow down when approaching an authorized emergency vehicle parked or otherwise stopped on a roadway. Currently, only Washington D.C. does not have a move over law (Emergency Responder Safety Institute, 2015). *Driver Removal Laws* require motorists involved in minor crashes (where there are no serious injuries and the vehicle can be driven) to move their vehicles out of the travel lanes to the shoulder or to another safe area. Approximately half of all U.S. states have driver removal laws. *Authority Removal Laws* provide authority (and immunity from liability in general) for designated public agencies to remove vehicles and/or spilled cargo from the roadway in order to restore traffic flow (Carson, 2008). These laws provide a foundation for facilitating traffic incidents' safe and expedited resolution.

To study the effectiveness of move over laws, the West Chester (PA) Police Department initiated a comprehensive enforcement program (Daly & Barnes, 2019). The result shows that when deploying a "Move Over – It's the Law" sign, there was a 22.2% increase from the baseline to an overall compliance rate of 87.9%. In many cases, move over laws target emergency responders as opposed to towing or other service operators. Given that tow truck operators have the highest exposure compared to other responders (Chandler & Bunn, 2019), various stakeholders are advocating that states include tow trucks as a first-responder vehicle type in their move over laws and implement public awareness campaigns to protect all incident response personnel, including tow truck operators.

In the scholarly literature, there is a paucity of studies related to responder safety, in part because of challenges associated with data collection. A study by Yu et al. (2013) examined the characteristics and contributing factors of on-duty struck-by crashes. Their findings showed that a large proportion of responder crashes occurred on rural interstate highways and that speeding or driving too fast for conditions was the key factor leading to struck-by crashes. They also found that adverse roadway and weather conditions were the most significant environmental factor and that most emergency responder struck-by crashes occurred when responders were assisting with traffic crashes. Chandler and Bunn (2019) characterized causal factors associated with injuries among commercial tow truck operators engaged in roadside assistance. The results indicated that vehicle loading and unloading, defensive techniques when exposed to traffic on roadways, and proper wheel chocking and braking procedures were important factors, suggesting that the towing industry should provide initial and refresher safety training regarding these procedures. Cattermole-Terzic and Horberry (2020) investigated decisions made by senior officers at the scene of an incident to determine system issues and system support solutions. Results indicated that a team-based *Cognitive Work Analysis* was highly beneficial in determining gaps in team coordination, communication, and structures. Newnam et al. (2020) interviewed incident responders in Australia and found that effective coordination between agencies is critical in managing safety at the scene of an incident and that it was achievable through the high-quality exchange of communication within and between agencies.

Extensive efforts have been made to develop safety countermeasures to protect responders (Durbin, 2021); however, there are cases in which responders do not comply with safety guidelines for multiple reasons. Limited research has been conducted to evaluate the effectiveness of safety countermeasures—a fact that could be related to responder's countermeasure adoption behaviors. Research is greatly needed to better understand the efficacy of countermeasures as well as responders' compliance and non-compliance with safety protocols and their use and non-use of safety countermeasures.

OBJECTIVES

The primary objectives of this study were to (a) identify and evaluate the effectiveness of responder safety countermeasures, (b) examine responders' adoption and use of different countermeasures, and (c) understand the correlations between use and non-use. To facilitate these objectives, a multi-agency partnership was established to provide expertise in incident management and traffic safety. The partnership included the Alabama Transportation Institute (ATI) at The University of Alabama (UA), the Alabama Department of Transportation's (ALDOT) Regional Traffic Management Centers (RTMCs), Alabama Traffic Incident Management (TIM) program, the Emergency Responder Safety Institute (ERSI), and several other departments of transportation from across the U.S.

Four major technical tasks were carried out in this study:

1. ***Evaluation of Vehicle-Mounted Variable Message Signs***—This study evaluated the efficacy of Variable Message Signs (VMS) mounted on emergency vehicles in protecting roadside incident and service personnel. The research team worked with the ALDOT's Safety Service Patrol (SSP) program, called Alabama Service Assistance Patrol (ASAP) in the West Central Alabama area to collect video data from their service vehicles. Computer vision deep learning approaches were utilized to detect and track vehicles in the ASAP videos in order to explore the approaching vehicle movements, such as vehicles speeds and lane change behaviors while passing the ASAP vehicle on the roadside. Statistical models were developed to test whether VMS is an effective safety countermeasure to aid in protecting roadside incident and service personnel.
2. ***Focus Groups***—Focus group discussions were conducted in order to learn from incident response personnel about local practices and experiences regarding safety countermeasures. This study organized five focus group meetings with local traffic incident response agencies, including law enforcement, highway safety patrol service, emergency medical service, towing, and roadside service.
3. ***National Responder Survey***—Working with the Emergency Responder Safety Institute (ERSI), this study conducted a national responder safety survey to gather first responders working experience, training background, and behaviors and opinions regarding the adoption of selected safety countermeasures and safety protocols. These safety countermeasures and protocols included TIM training programs, test runs or mock drills, action reviews, critical wheel angle, non-traffic side operation, safety apparel, emergency vehicle lighting, advanced warning signs, and traffic cones. The objectives of the survey were to: (a) assess compliance and non-compliance with safety protocols and the use and non-use of safety countermeasures; (b) identify factors associated with non-compliance or non-use; and (c) understand past experiences involving incidents or crashes, or near-misses while performing duties on the roads.
4. ***Text Mining of News Data***—This task investigated the characteristics of first responder incidents and crashes reported in recent news reports. This study collected a total of 5,113 responder incident news articles from 2001 to 2020. Through narrative text mining, this study extracted useful information from incident news reports regarding key attributes of the reported incidents.

The following four major sections (referred to as Technical Modules) correspond with these tasks, providing technical details of the work, significant findings, and discussion. A concluding section that distills key information from each module is also provided.

TECHNICAL MODULE 1: Field Evaluation of Vehicle-Mounted Variable Message Signs

Introduction

VMS are frequently used to display a variety of messages to inform motorists of incidents and road conditions and to help manage traffic. VMS have also been referred to as Changeable Message Sign (CMS), Dynamic Message Sign (DMS), and Changeable Electronic Variable Message Sign (CEVMS), among others (New York State Thruway Authority, 2011).

VMS can be deployed in a number of different ways, including in fixed permanent locations, on portable units, and on truck-mounted units, among others (Figure 3). Permanent VMS are typically mounted on overhead structures either spanning the roadway, cantilevered out over a portion of the highway, or adjacent to the highway and are often used to direct or inform motorists for traffic control purposes. Portable VMS are typically trailer mounted, self-powered, easily moveable, and placed near the decision or relevant point on the highway. Truck-mounted VMS are generally small units mounted on the top or rear of a service or work truck.

Figure 3. Permanent VMS, portable VMS, and truck-mounted VMS.
(Sources: commons.wikimedia.org; 4directionssigns.com; and ebovanweel.com)

VMS are primarily used to give motorists real-time traffic conditions, safety, and guidance information regarding planned and unplanned events that significantly impact traffic on the highway system. VMS play a key role in traffic incident management. They notify the motorist about unexpected incidents, including traffic crashes, stalled vehicles, debris in the roadway, spilled loads, emergency roadwork, or other similar conditions. Extensive research has been conducted on the topic of the effectiveness of VMS. Most studies focused on permanent VMS (e.g., Basso et al., 2021; Nygårdhs, 2011; Nygardhs & Helmers, 2007), and a considerable amount of research has concentrated on portable VMS (e.g., Ahmed et al., 2016; Bham & Leu, 2018; Park et al., 2009; Song et al., 2010; Wang & Cao, 2005). However, relatively little research has addressed truck-mounted VMS (e.g., Ullman et al., 2009; Ullman et al., 2011; Ullman et al., 2012). To date, most research has been concerned with how VMS could be used to support traffic management and guide drivers on the road to make the right driving decisions. Limited research has focused on the role of VMS in protecting responders that work on the road or roadside and are exposed to passing traffic. The objective of this study was to evaluate the effectiveness of active VMS mounted on roadside emergency vehicles as a countermeasure to protect roadside service or incident response personnel.

Methodology Overview

This section provides an overview of the experimental and analytical approach to evaluating the effectiveness of vehicle-mounted VMS. The team collected video data from one of the ASAP vehicles, which is equipped with a VMS, in the West Central Alabama area. The data was collected in a naturalistic manner without interrupting ASAP operations. The video data provided continuous recordings of the traffic approaching incident sites where the ASAP vehicle was stopped on the roadside. Data was gathered at all moments during a stop, including when the VMS was active and when it was not. Thus, the treatment of interest for this study was the status of the VMS (active versus inactive) in influencing the safety and behaviors of passing motorists. When active, the VMS in the current study displayed a flashing diamond sign.

This study used deep learning techniques to extract information from the videos to capture the maneuvers of vehicles approaching the ASAP vehicle. Three measures were developed to reflect vehicle maneuvers, including speed, lane change, and distance to the ASAP vehicle when a lane change was made. Whether the VMS was active or inactive, as a key factor to be examined, was also linked to individual passing vehicles. Finally, this study built rigorous statistical models to examine the impact of VMS on passing vehicles' maneuvers (speed, lane change, and distance to ASAP vehicle when a lane change was made). In addition to the status of VMS, a range of other factors, including the characteristics of the vehicles, road, and traffic environment were also examined or controlled for in the modeling. Considering the nested or hierarchical structure of observations (individual passing vehicles nested in incident sites or roadside stops), this study used the hierarchical modeling method (mixed-effects models) to account for unmeasured site-specific variables when estimating model parameters.

Data Collection

With support from the ALDOT's ASAP program in the West Central Alabama area, this study collected video data from one of their service vehicles. ALDOT provides SSP services in the state in five regions (Mobile, Montgomery, Birmingham, Tuscaloosa, and Huntsville). The ASAP program in the Tuscaloosa region provides safety services to interstate traffic on I-20/I-59 between Exit 68 (Joe Mallisham Parkway or Northport/Tuscaloosa Western Bypass) and Exit 89 (Mercedes Drive), as shown in Figure 4. The service area is a 25-mile section of I-20/I-59 with travel lanes in each direction. The speed limit is 70 mph. Annual average daily traffic is between 40,000 and 60,000 per direction, and heavy-duty vehicles account for approximately 30% of traffic.

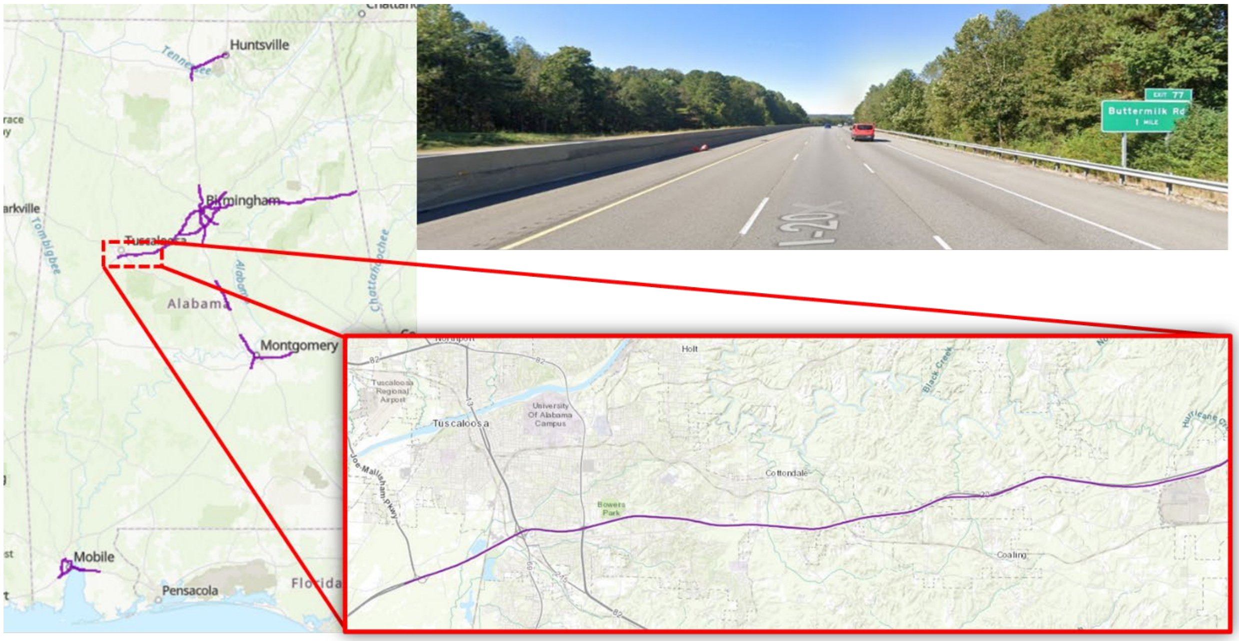

Figure 4. ASAP service area in Tuscaloosa, Alabama, and a typical roadway environment.

Figure 5 shows an ASAP vehicle, a white pick-up truck with ASAP logos placed along the sides of the vehicle, along with amber emergency lights on top. ASAP trucks are outfitted with traffic cones, push bumpers, a mobile weather station, and other special equipment.

Figure 5. ALDOT's ASAP vehicle. (tuscaloosanews.com)

The ASAP truck carries a VMS board mounted over the vehicle's cab. The VMS board is used to inform drivers about the presence of traffic incident responses on the road or roadside. ASAP drivers are trained to activate the VMS board whenever they feel it is needed and when they are comfortable operating it. The built-in messages include flashing diamond signs, arrow signs, and text messages "MERGE" and "SLOW." According to the operational codes, the text message "MERGE" and arrow sign can be used when a travel lane is affected (or closed), which is infrequent. Therefore, such signs/messages are not frequently used by ASAP truck drivers. In daily operation, when attending to incident vehicles on the roadside, the drivers would typically activate the flashing diamond sign on the VMS board to get passing vehicles' attention. The flashing diamond sign is the default display when the VMS board is activated. Figure 6 shows an example of a flashing diamond sign. Given its common use by ASAP vehicles, this study focused on evaluating the effectiveness of flashing diamond signs on a VMS as the countermeasures to protect roadside responders.

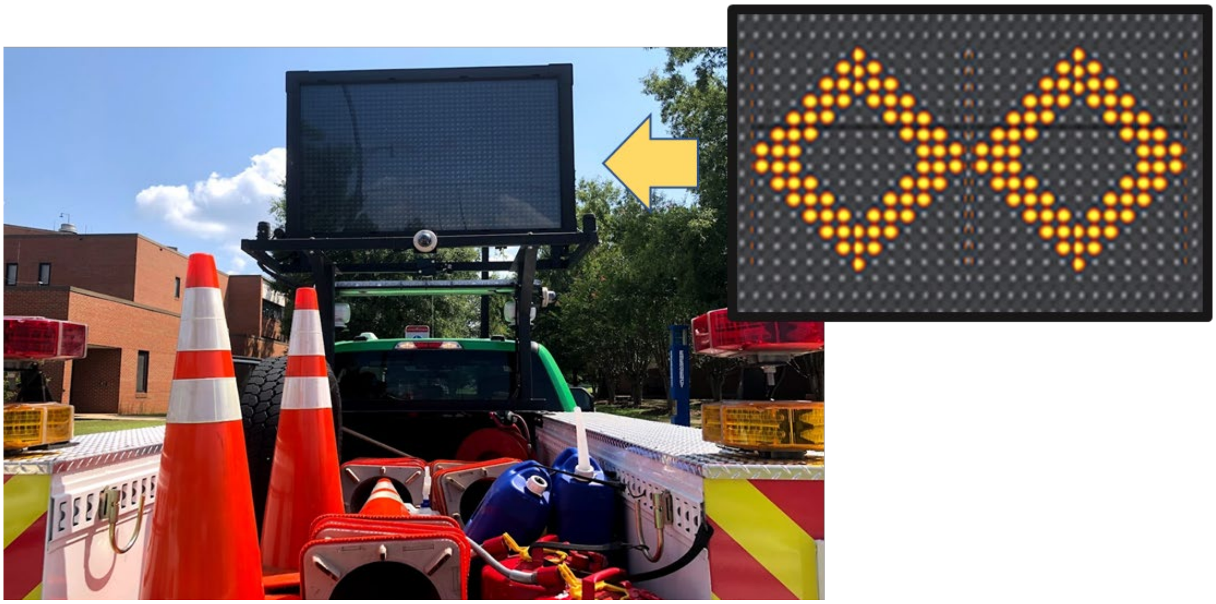

Figure 6. Flashing diamond sign used as a default mode when the VMS board position is activated.

This study collected the video data from ASAP truck-mounted cameras during August to October 2021. Note, ALDOT currently does not typically record or store the truck camera videos; however, in this case provisions were made for the research team to record video. Currently, ASAP only operates on weekdays; this study aimed to collect data on each day when services were available. Over 50 hours of videos were collected and 40 different ASAP vehicle stops at various locations were observed. Given the focus on outcomes related to the behaviors of passing vehicles, the rearview video data were analyzed in this study exclusively. In data pre-processing, the research team manually reviewed the rear-facing videos to identify the segments of video (and corresponding timestamps) when the ASAP vehicle was stopped on the roadside (Figure 7). The video also allowed investigators to identify when the VMS board was activated (Figure 8).

Figure 7. Sample stills from roadside video footage.

Figure 8. Position of the VMS board (left: inactive, right: active).

Data Extraction

To capture motorist behavior and vehicle movements when approaching the ASAP vehicle, this study used deep learning techniques to extract information from the recorded videos. Specifically, the "You Only Look Once" (YOLO) model (Karimi, 2021) was used to detect and track vehicles in the videos (Tan, 2020). Figure 9 shows the major steps of extracting data from ASAP videos using the YOLO model. These include the following:

1. **Parsing videos into frames or image sequences.** The inputs of the YOLO model are individual images parsed from the videos. In ASAP videos, there are approximately 29 frames per second, meaning that every second of a video can be parsed into 29 images. A Frame ID was assigned to each frame. The Frame ID can be used as an index of time.

2. **Detecting objects in each frame.** The target objects are detected in each frame, including cars, trucks, and buses. Each object was assigned an Object ID. Note that the same objects detected in sequential frames are assigned with the same Object ID.
3. **Tracking objects across frames.** Objects are tracked with their respective IDs. When an object is detected, the boundary of its bounding box (i.e., the rectangle that surrounds the pixels inferred to make up the object of interest) is recorded as its position in a frame. The position is noted by using the pixel of grid ID in a frame. The direct outputs of the YOLO model are the positions of object bounding boxes in each frame. The size of detected objects and their bounding boxes increase when approaching the ASAP vehicle in the videos. In this study, the lower right corner (and corresponding pixel coordinates) of a bounding box were taken as the object's position for scenarios that the ASAP vehicle stopped on the right shoulder; whereas the lower-left corner coordinates were taken the position for scenarios where the ASAP vehicle stopped on the left shoulder. Each vehicle is tracked across frames within each video with the different IDs (video file ID, frame ID, and Object ID).

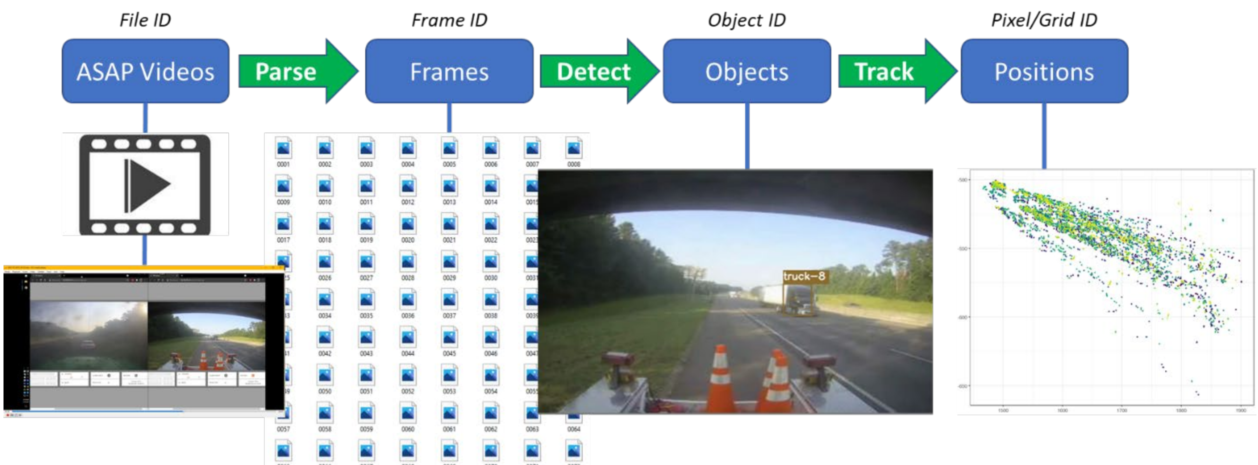

Figure 9. Data Extraction Steps.

Data Post-Processing

The results from the YOLO model are pixel coordinates of detected vehicles in the videos. In total, there were 146,666 data points representing the detectable positions of 11,338 unique detected vehicles relative to the position of the ASAP vehicle. Figure 10 shows the distributions of the vehicle positions.

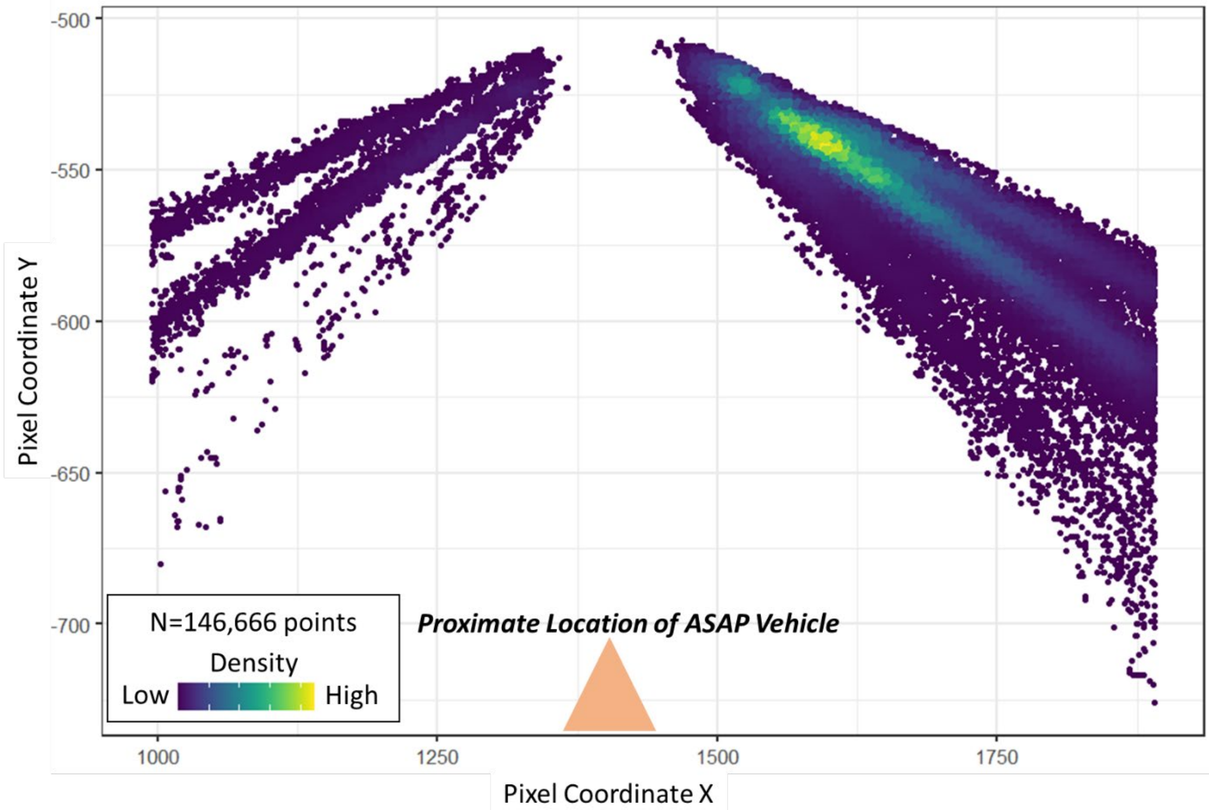

Figure 10. Positions of detected vehicles when passing the ASAP vehicle.

As shown in Figure 11, the detected vehicle positions are in two areas, representing two different types of roadside stops. The ASAP vehicle can stop on either the right or left shoulder depending on the roadside assistance needs.

Figure 11. Left shoulder stop and right shoulder stop

Lane Position

To capture lane change behaviors, the lane boundaries were first manually extracted from the videos. Next, the lane positions were labeled with lane number for every data point.

Figure 12 shows the lane positions labeled for each data point. The lane is labeled according to its position relative to the shoulder.

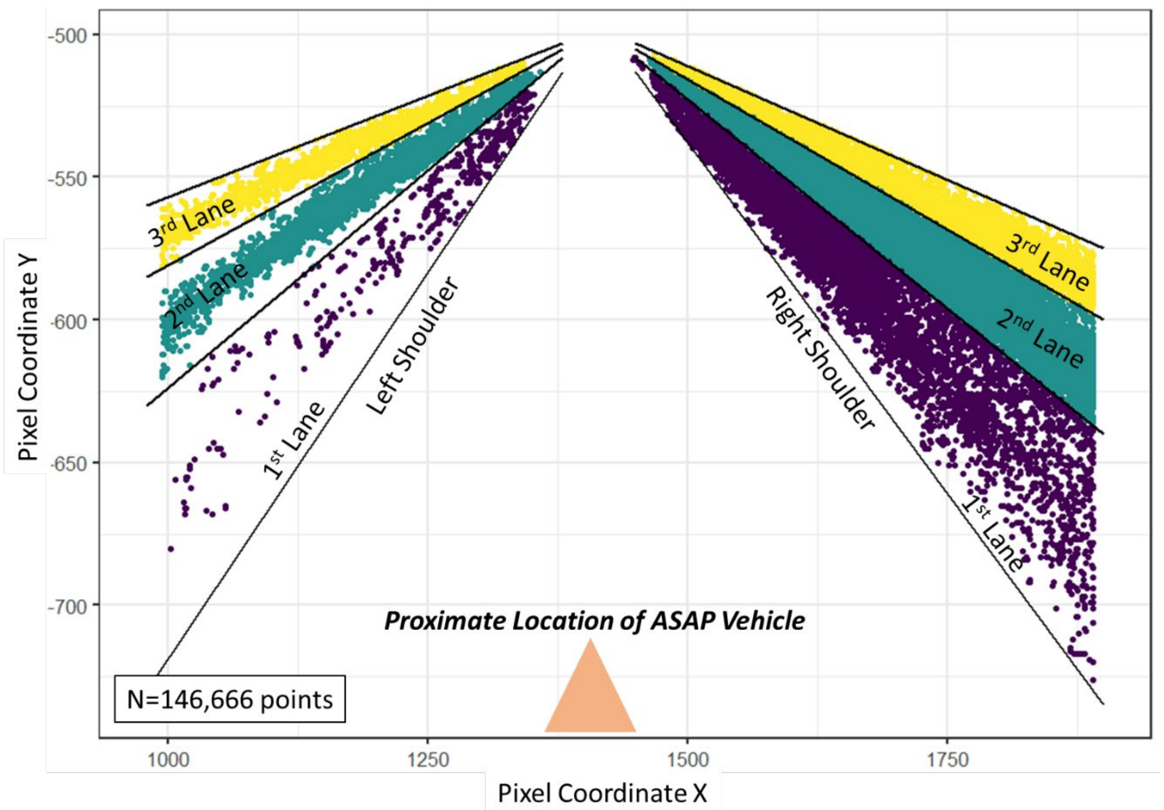

Figure 12. Lane positions of vehicles detected in every frame

Note that, the data were extracted from different vehicles as well as from different ASAP stops where the positioning of the vehicle varied relative to the travel lanes, its angle, etc. The data extraction process utilized the fixed boundaries shown in Figure 12; as a result, the detected lane position and corresponding lane number are subject to some inaccuracies—a known limitation of this approach.

Figures 13 and 14 show the number and percentages of data points across the different lanes. The majority of vehicles were in the 2nd lane; the lane next to the shoulder (the 1st lane) has the fewest data points. It is important to note that some data were collected from stops occurring on two-lane sections of the road. The analysis of speed and lane change behaviors in this study is focused on the 1st lane.

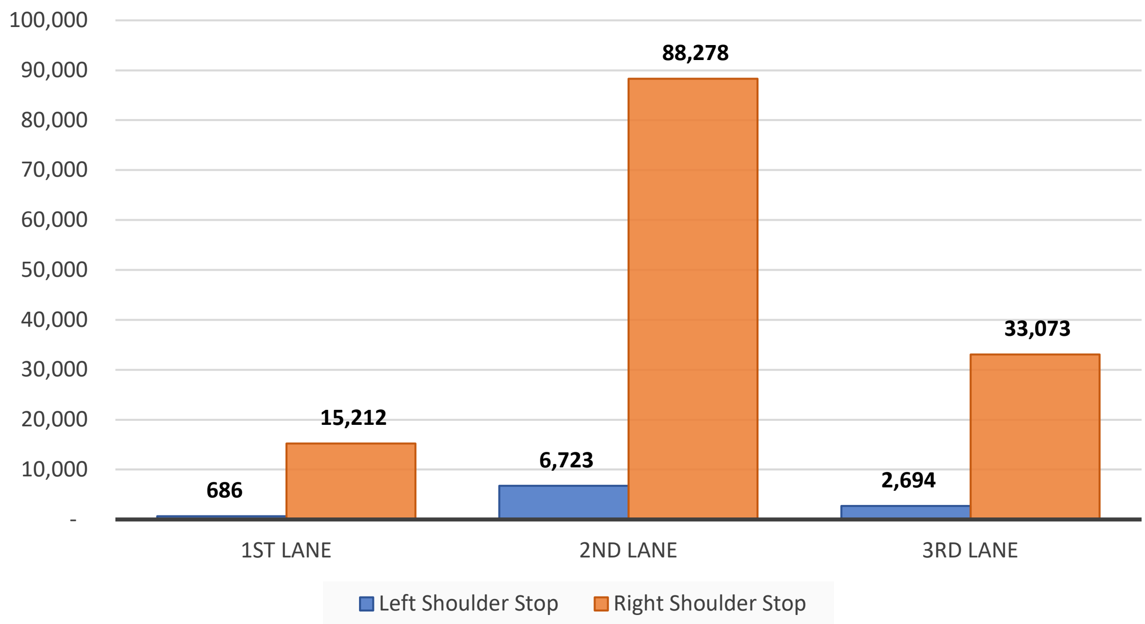

Figure 13. Numbers of data points in different lanes.

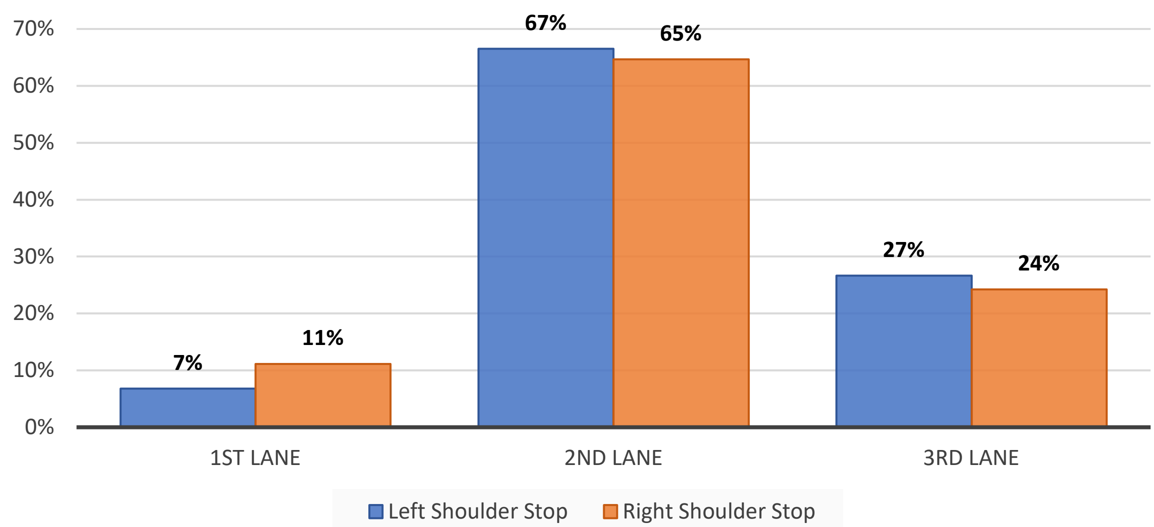

Figure 14. Percentages of data points in different lanes.

Lane Change Behavior

Tracking the lane position for vehicles across frames allowed for the detection of lane change behaviors. Two lane change measures were created for each detected vehicle:

1. ***Lane Change***: This is a binary measure (Yes or No) to indicate whether a vehicle moved from one lane to another lane within the range of detection (from the moment that a vehicle is detectable to the moment that a vehicle leaves the video frame). This study was particularly concerned with lane change behaviors of vehicles in the 1st Lane (next to the shoulder) when entering the detection range. Figure 15 shows three sample

lane change trajectories. Among 11,270 detected vehicles, 156 vehicles changed the lane from the 1st Lane to the 2nd Lane.

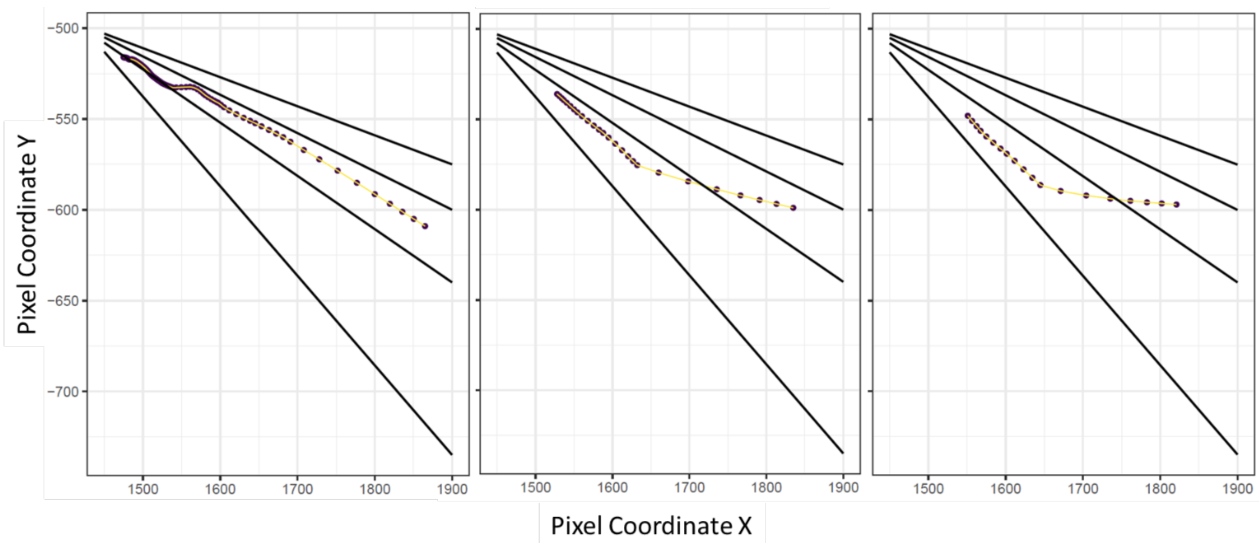

Figure 15. Sample vehicle trajectories where a lane change occurred.

2. Distance to ASAP vehicle: This measure characterizes the location of a vehicle when it moves from the 1st Lane to the 2nd Lane. The distance to the ASAP vehicle is measured by the number of pixels (in the video images) between the lane-changing vehicle and the ASAP vehicle. Figure 16 shows the distribution of (pixel) distances to the ASAP vehicle before the moment that the detected vehicle switched the lane.

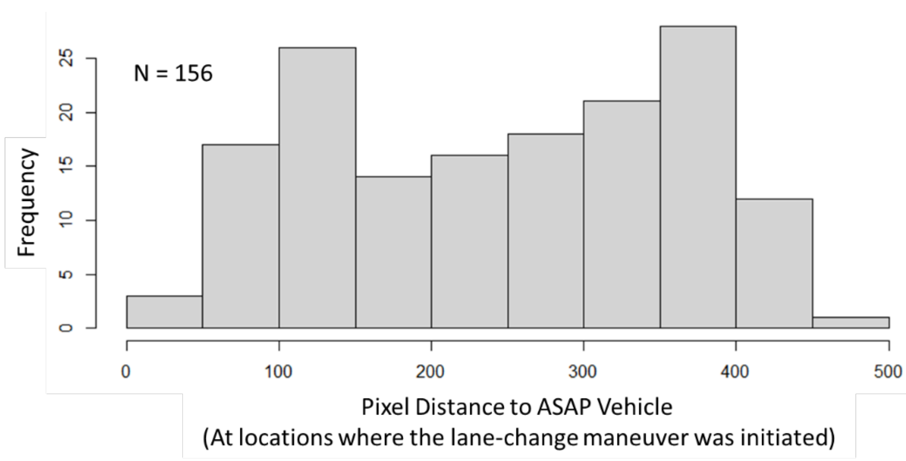

Figure 16. Distribution of distances to ASAP vehicle.

Speed

Another indicator to examine the impact of VMS on driver behavior is the speed of vehicles approaching the ASAP vehicle on the roadside. As the videos collected in this study are not from the same location, it is difficult to calibrate the video background to obtain a reasonable estimate of the vehicle speeds in miles per hour. Thus, the vehicle speeds were calculated in terms of pixels per frame, meaning the number of pixels that a vehicle traverses from one frame to the next (1/29 second). Since the vehicle detection was done for a very high frequency (29 frames per second), vehicle locations may not be accurately captured from one frame to another frame. Therefore, the average speed was calculated for every trajectory (or vehicle). Equation (1) shows the calculation of speed in this study.

$$Speed_i = \frac{\sqrt[2]{\left(x_i^1 - x_i^n\right)^2 + \left(y_i^1 - y_i^n\right)^2}}{n} \tag{1}$$

where, $Speed_i$ is the average speed (pixels per frame) for vehicle trajectory i; x_i^1 is the pixel coordinate x of the i vehicle detected in the 1st frame; x_i^n is the pixel coordinate x of the i vehicle detected in the last frame, n is the total number of frames that a vehicle detected in the video; y_i^1 is the pixel coordinate y of the i vehicle detected in the 1st frame; y_i^n is the pixel coordinate y of the i vehicle detected in the last frame. Figure 17 shows the distributions of average speed and pixels per frame (1/29 second).

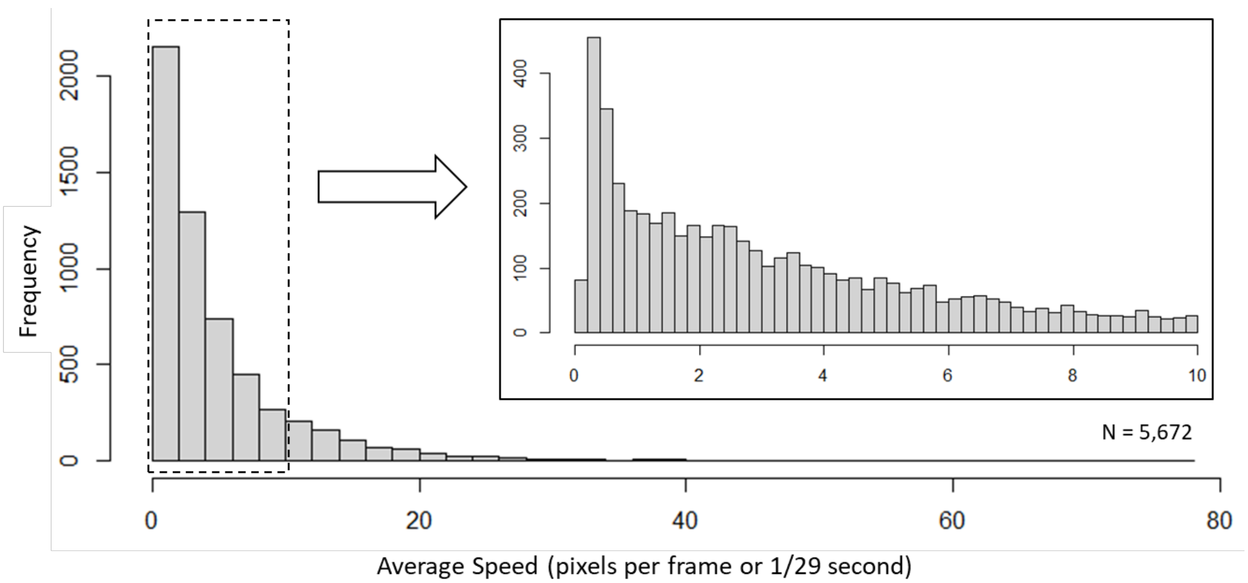

Figure 17. Distribution of average speed at the vehicle trajectory level. The inset figure magnifies the values at lower speeds.

Traffic Density

It is known that driver behaviors are different under various traffic conditions. For example, the speed and lane change behaviors of motorists could be affected by the presence of nearby vehicles. In order to account for other traffic, the number of vehicles within each frame was counted to show the traffic density. Figure 18 shows the distribution of objects counted in 135,946 frames. More than half of the frames have only one vehicle detected, and approximately 30% of frames had two vehicles detected.

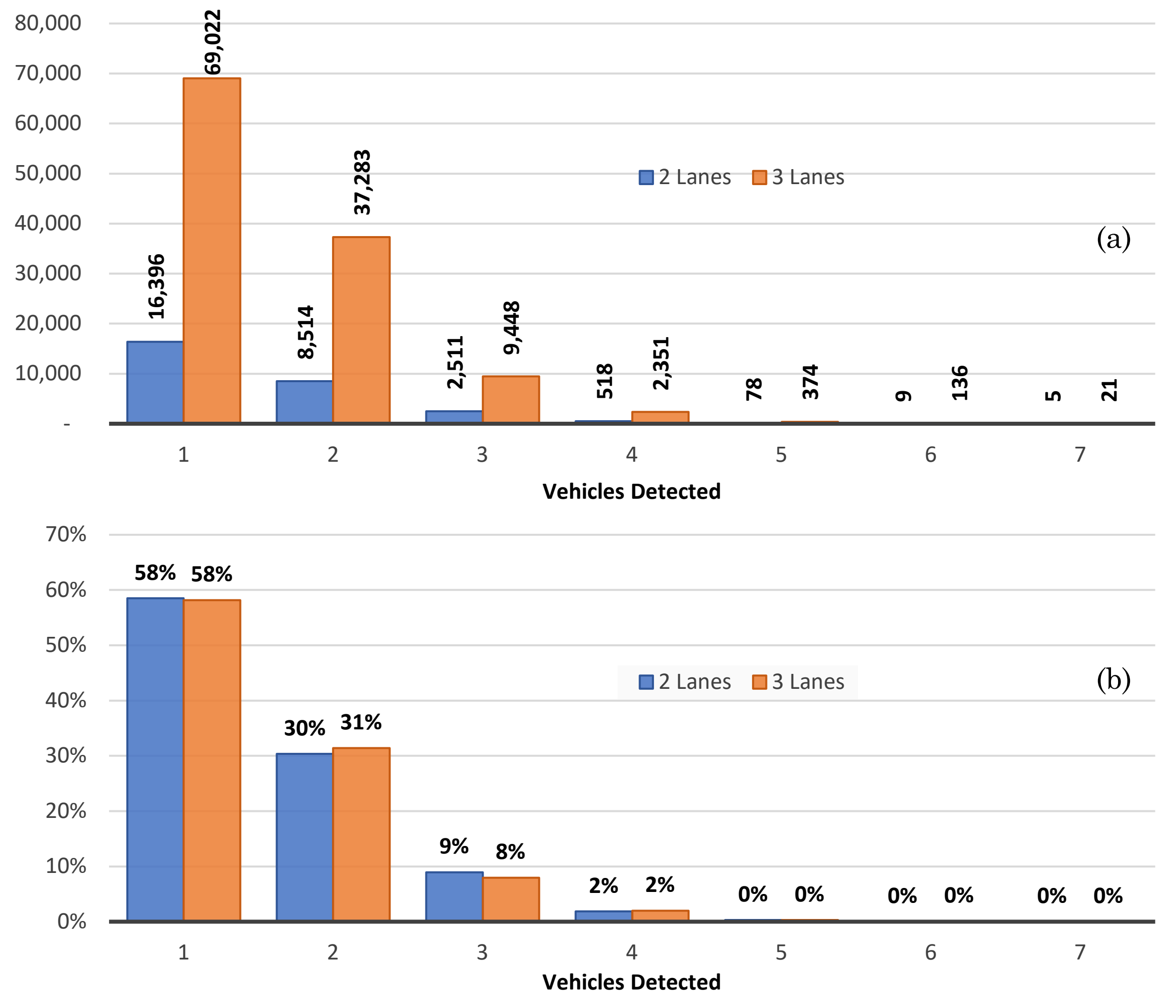

Figure 18. Distribution of the number of detected vehicles (1–7) in each frame by the number of lanes: (a) the raw counts of frames with the corresponding number of vehicles; (b) the percentage of frames with the corresponding number of vehicles.

Statistical Modeling Methods

The goal of the current modeling was to statistically examine the effectiveness of VMS as a countermeasure to protect responders based on the behaviors of passing vehicles. The modeling is at the passing vehicle level. The number of observations is the number of vehicles observed in the 1st or 2nd lane at their first appearance in videos. The explanatory variables included the use of VMS (displaying flashing diamond signs) along with other factors such as vehicle class, time of day, weather condition, roadway geometry, and traffic density. Three separate models were developed for each of the three main response variables:

1. ***Speed Model***—Models the correlates of average speed (pixels per frame) of vehicles in the 1st and the 2nd lane when approaching the ASAP vehicle. This model included 5,672 observations.

2. ***Lane Change Model***—Models the correlates of whether a passing vehicle makes a lane change from the 1st to the 2nd lane (1 or 0). This model included 587 observations where the object was initially detected in the 1st lane.
3. ***Distance to ASAP Model***—Models the correlates of distance (in pixels) to an ASAP vehicle when a vehicle moves from the 1st Lane to the 2nd Lane. The model included 156 observations.

The model for lane change used logistic regression, as the response value is binary: Yes (1) or No (0). The speed and distance models used linear regression. The estimated coefficients represent the quantified relationships between the outcome measures and the VMS countermeasure, as well as with other factors. Other variables are factors related to ASAP operator location (inside or outside the vehicle), presence of other emergency vehicles/flashing lights, weather (clear, cloudy, rainy), time of day, number of other passing vehicles (in the same frame), roadway alignment (straight or curved; see Figure 19), terrain (level or sloped), presence of sun glare, position of the roadside service (left or right shoulder), and presence of bridge. Interaction terms, such as VMS use by vehicle type, are also modeled to provide more insights into the relationships between the VMS use and driver behaviors.

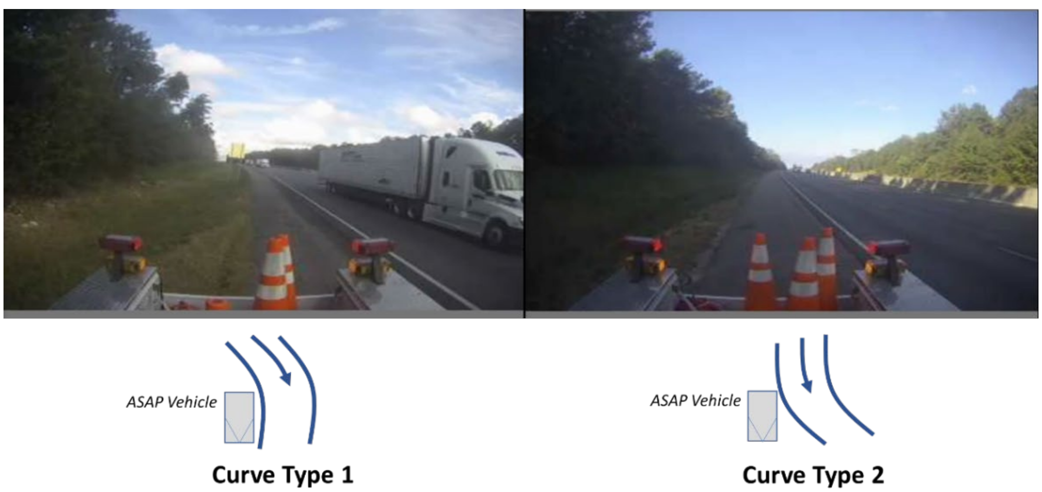

Figure 19. Curve types

Due to the quality of videos (e.g., lighting conditions), the numbers of frames in which the same vehicle was detected differed across observations. Considering that observations with different numbers of frames may unevenly influence the model parameter estimates, this study used the *Weighted Regression* method to estimate the model parameters. Weighted least squares reflect the behavior of the random errors in the model by incorporating weights associated with each data point into the fitting criterion. The size of the weight indicates the amount of information contained in the associated observation. Optimizing the weighted fitting criterion to find the parameter estimates allows the weights to determine the contribution of each observation to the final parameter estimates. In this study, the number of frames detected for each observation is the weighting factor incorporated into the model estimation.

Finally, as noted, the observations were vehicles detected from the ASAP videos gathered at different stops. Thus, these observations are nested within different stops or locations of video recording. That is, a subset of observations was gathered at Stop 1, another set at Stop 2, and so on. In order to account for this, this study used a hierarchical modeling method to build models to capture the potentially unobserved factors for the features of individual stop locations. Specifically, this study developed *Weighted Random Intercept Models* to estimate the relationships between factors.

Modeling Results

Descriptive Statistics

The descriptive statistics for variables included in the Speed Model, Lane Change Model and Distance to ASAP Model are shown in Tables 1, 2, and 3, respectively.

As expected, the VMS was used most of the time (between 89% and 94% in the models). Observations where the VMS was not used typically occurred during the first or last few minutes of a stop. Only 11% of the observations were detected in the 1st Lane (next to the shoulder where the ASAP vehicle stopped). In order to benchmark this, the team leveraged ALGO traffic camera data (https://algotraffic.com) to provide examine the distribution of lane use by vehicles when there was no ASAP vehicle on the roadside. The results showed that the percentage of vehicles using the outer lane range from 19% to 67% under various times. The smaller percentage observed in the current sample could indicate that some motorists may have already switched lanes in response to the ASAP vehicle on the roadside before they could be detected or resolved in the videos.

The majority of detected vehicles were passenger vehicles, accounting for 75% to 83% of the observations in the different models. This approximates the state-reported percentages of trucks on freeways in the Tuscaloosa area (ALDOT, n.d.). The ASAP vehicle operator's location and behavior may also affect the motorist's behaviors. For example, whether the operator was outside the ASAP vehicle versus sitting in the vehicle. Accordingly, researchers reviewed videos and manually labeled the vehicle operator's location. The operators were found to be in the vehicle during 42% to 45% of the observations and working outside of the vehicle (assisting motorists on the roadside) during 55% to 58% of the observations. There were situations where other emergency vehicles were also present at the roadside; 6% to 11% of observations for the different models had other emergency vehicles.

Most observations (97%–98%) occurred during clear or cloudy weather, with a small percentage (2%–3%) occurring in rainy conditions. Regarding time of day, 48% to 58% of observations were obtained from non-peak hours across the different models. The presence of other vehicles within the same frame was extracted from videos. In all cases, observations were collected in free-flow conditions. In 52% to 58% of observations, only one vehicle was detected (the vehicle of interest) and in the remaining observations there were other vehicles present (these were expressed as number of vehicles per lane in the model). Given that objects appear to move faster when closer to the camera (in terms of pixels subtended per unit time), the midpoint location of a vehicle's trajectory (in pixels, along the vertical Y-axis) was included in the Speed Model as a variable to control for the relationship between vehicle pixel speeds and their relative pixel position. This is especially relevant where trajectories span different parts of the video frame (i.e., where the midpoint location falls farther or closer to the camera).

Table 1. Descriptive statistics of variables for Speed Model (No. of Observations = 5,672).

Variable		Frequency	Percent
Y= Average Speed (pixels per frame)		4.9*	5.9*
VMS Use			
	Yes	5314	93.7%
Lane Position			
	1st Lane	648	11.4%
	2nd Lane	5,024	88.6%
Lane Change			
	Yes	312	5.5%
Vehicle Type			
	Truck or Bus	966	17.0%
	Passenger Car	4,706	83.0%
ASAP Operator Location			
	In vehicle	2,560	45.1%
	Outside of vehicle	3,112	54.9%
Other emergency vehicle present			
	Yes	335	5.9%
Weather			
	Clear	4,964	87.5%
	Cloudy	566	10.0%
	Rainy	142	2.5%
Time of Day			
	AM Peak (7 to 9 am)	1,761	31.1%
	PM Peak (4 to 7 pm)	1,192	21.0%
	Mid-Day (9 am to 4 pm)	2,719	48.0%
Number of other vehicles per lane			
	0	3,328	58.7%
	0 ~ 1	2,292	40.4%
	1 ~ 2	52	0.9%
Roadway alignment			
	Straight	4,060	71.6%
	Curve type 2—Towards	1,426	25.1%
	Curve type 1—Away	186	3.3%
Terrain			
	Level	4,964	87.5%
	Downslope	294	5.2%
	Suspect downslope	320	5.6%
	Suspect upslope	94	1.7%
Driving with sun glare			
	No	5,225	92.1%
	Yes	162	2.9%
	Unknown	285	5.0%
Right shoulder stop			
	Yes	5,278	93.0%
Relation to Bridge			
	Over a bridge/narrow shoulder	555	9.8%
	Behind or under a bridge	406	7.2%
	No relation to bridge	4,711	83.1%
Weighting factor		1.0*	0.9*
Midpoint location of vehicle trajectory (pixel coordinate Y)		564.1*	24.8*

Note: *For continuous variables, mean and standard deviation are shown in the table.

Table 2. Descriptive statistics of variables for Lane Change Model (No. of Observations=587).

Variable		Frequency	Percent
Y = Lane Change (Yes)		156	26.6%
VMS Use			
	Yes	523	89.1%
Vehicle Type			
	Truck or Bus	139	23.7%
	Passenger Car	448	76.3%
ASAP Operator Location			
	In vehicle	265	45.1%
	Outside of vehicle	322	54.9%
Other emergency vehicle present			
	Yes	64	10.9%
Weather			
	Clear	539	91.8%
	Cloudy	38	6.5%
	Rainy	10	1.7%
Time of Day			
	AM Peak (7 to 9 am)	117	19.9%
	PM Peak (4 to 7 pm)	156	26.6%
	Mid-Day (9 am to 4 pm)	314	53.5%
Number of other vehicles per lane			
	0	308	52.5%
	0 ~ 1	271	46.2%
	1 ~ 2	8	1.4%
Roadway alignment			
	Straight	336	57.2%
	Curve type 2—Towards	210	35.8%
	Curve type 1—Away	41	7.0%
Terrain			
	Level	535	91.1%
	Downslope	10	1.7%
	Suspect downslope	37	6.3%
	Suspect upslope	5	0.9%
Driving with sun glare			
	No	543	92.5%
	Yes	34	5.8%
	Unknown	10	1.7%
Right shoulder stop			
	Yes	561	95.6%
Relation to Bridge			
	Over a bridge/narrow shoulder	10	1.7%
	Behind or under a bridge	60	10.2%
	No relation to bridge	517	88.1%
Weighting factor		1.0*	0.9*

Note: *For continuous variables, mean and standard deviation are shown in the table.

Table 3. Descriptive statistics of variables for Distance to ASAP Model (N = 156).

Variable		Frequency	Percent
Y = Distance to ASAP Vehicle (pixels)		248.3*	117.6*
VMS Use			
	Yes	140	89.7%
Vehicle Type			
	Truck or Bus	39	25.0%
	Passenger Car	117	75.0%
ASAP Operator Location			
	In vehicle	65	41.7%
	Outside of vehicle	91	58.3%
Other emergency vehicle present			
	Yes	10	6.4%
Weather			
	Clear	141	90.4%
	Cloudy	10	6.4%
	Rainy	5	3.2%
Time of Day			
	AM Peak (7 to 9 am)	34	21.8%
	PM Peak (4 to 7 pm)	31	19.9%
	Mid-Day (9 am to 4 pm)	91	58.3%
Number of other vehicles per lane			
	0	90	57.7%
	0 ~ 1	65	41.7%
	1 ~ 2	1	0.6%
Roadway alignment			
	Straight	89	57.1%
	Curve type 2—Towards	54	34.6%
	Curve type 1—Away	13	8.3%
Terrain			
	Level	145	93.0%
	Downslope	2	1.6%
	Suspect downslope	8	5.1%
	Suspect upslope	1	0.6%
Driving with sun glare			
	No	143	91.7%
	Yes	11	7.1%
	Unknown	2	1.3%
Right shoulder stop			
	Yes	145	93.0%
Relation to Bridge			
	Over a bridge/narrow shoulder	3	1.9%
	Behind or under a bridge	16	10.3%
	No relation to bridge	140	89.7%
Weighting Factor		1.0*	0.8*

Note: *For continuous variables, mean and standard deviation are shown in the table.

Speed Model

Table 4 shows the results of Speed Models without interaction terms. The full model includes all variables. The final model includes only variables that were statistically significant. Most significantly, the modeling results revealed that the use of VMS has a significant association with the speeds of vehicles when approaching the ASAP vehicle on the roadside. A motorist may naturally slow down their vehicle when they see an object (e.g., an abandoned vehicle, or service vehicle) on the shoulder; however, these results show that speeds are further reduced when VMS is active compared to when it is not. The negative coefficient implies that the use of VMS may be an effective countermeasure to protect roadside incident and service personnel.

Results also showed that vehicles in the 1st Lane tended to travel at a relatively lower speeds than vehicles in the 2nd lane. This outcome is logical as the 1st lane is usually occupied by slower moving vehicles. The model also revealed that, when approaching the ASAP vehicle, trucks or buses were found to have a relatively higher speed than passenger cars. In order to better understand these factors, they were also examined in the context of their interaction with VMS use. Tables 5 and 6 show the model results with interaction terms VMS Use × Vehicle Type and VMS Use × Lane Position, respectively. In Tables 5 and 6, only statistically significant estimates were modeled. The model estimates for the interaction term between VMS use and vehicle type reveal that the VMS is more effective for passenger vehicles than trucks. It is possible that the video detection distance was too limited and speed changes by trucks, if present, occurred outside of the detection range. The interaction between VMS use and lane position revealed that the VMS was more effective in slowing down the traffic in the 1st Lane compared to the 2nd Lane.

Other significant correlates in the main model (Table 4) were whether a vehicle was changing lanes and the detection position. Results show that if a vehicle made a lane change, their speeds tended to be lower than those who stayed in a lane. As noted above, objects appear to move faster when closer to the camera, as confirmed by the modeling results pertaining to the trajectory midpoint. Factors such as weather, time of day, and roadway alignment are not discussed as they were not found to be associated with differences in vehicle speeds.

Table 4. Modeling results for Speed Model without interaction terms

Variable		Full Model Coefficient	Full Model P-value	Final Model Coefficient	Final Model P-value
Intercept		−22.80	<0.01	−23.12	<0.01
VMS use					
	No	Base		Base	
	Yes	−0.64	0.03	−0.53	0.05
Lane position					
	1st Lane	−0.57	<0.01	−0.58	<0.01
	2nd Lane	Base		Base	
Vehicle type					
	Truck or bus	1.74	<0.01	1.74	<0.01
	Passenger car	Base		Base	
Lane Change					
	No	Base		Base	
	Yes	−1.50	<0.01	−1.51	<0.01
Midpoint location of vehicle trajectory (pixel coordinate Y)		0.05	<0.01	0.05	<0.01
ASAP operator					
	In vehicle	Base		Base	
	Outside of vehicle	0.02	0.91	−	−
Presence of other emergency vehicles/flashing lights					
	No	Base		Base	
	Yes	0.33	0.83	−	−
Weather					
	Clear	Base		Base	
	Cloudy	−0.22	0.75	−	−
	Rainy	−2.14	0.28	−	−
Time of day					
	AM Peak	−0.44	0.46	−	−
	PM Peak	−0.18	0.81	−	−
	Mid−Day	Base		Base	
Number of other vehicles					
	0	Base		Base	
	0 ~ 1	−0.07	0.54	−	−
	1 ~ 2	0.05	0.94	−	−
Roadway alignment					
	Straight	Base		Base	
	Curve type 2—Towards	−0.10	0.89	−	−
	Curve type 1—Away	0.60	0.73	−	−
Terrain					
	Level	Base		Base	
	Downslope	0.06	0.98	−	−
	Suspect downslope	−0.24	0.82	−	−
	Suspect downslope	−0.94	0.48	−	−
Driving with sun glare					
	No	Base		Base	
	Yes	−0.52	0.80	−	−
	Unknown	2.46	0.36	−	−
Roadside stop					
	Left shoulder	2.21	0.16	−	−
	Right shoulder	Base		Base	

	Full Model		Final Model	
Variable	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Relation to bridge				
Over a bridge/narrow shoulder	0.68	0.56	–	–
Behind or under a bridge	−0.66	0.53	–	–
Other	Base		Base	
Variance of random intercepts	**1.08**		**0.81**	
Summary Statistics				
Number of observations	5,672		5,672	
Number of groups (stops)	32		32	
Log Likelihood	−16860.7		−16876.7	
R^2	0.15		0.13	

Table 5. Modeling results for Speed Model with VMS Use x Vehicle Type interaction

Variable	Coefficient	P-value
Intercept	−23.26	<0.01
VMS use × Vehicle Type		
VMS use (Yes): Passenger Car	−0.93	<0.01
VMS use (Yes): Truck or bus	0.76	0.01
VMS use (No)	Base	
Lane position		
1st Lane	−0.57	<0.01
2nd Lane	Base	
Lane Change		
No	Base	
Yes	−1.50	<0.01
Midpoint location of vehicle trajectory (pixel coordinate Y)	0.05	<0.01
Variance of random intercepts	0.77	
Summary Statistics		
Number of observations	5,672	
Number of groups (stops)	32	
Log Likelihood	−16885.4	
R^2	0.12	

Table 6. Modeling results for Speed Model with VMS Use x Lane Position interaction

Variable		Coefficient	P-value
Intercept		−23.15	<0.01
VMS use × Lane Position			
	VMS use (Yes): 1st Lane	−0.98	<0.01
	VMS use (Yes): 2nd Lane	−0.43	0.12
	VMS use (No)	Base	
Vehicle type			
	Truck or bus	1.74	<0.01
	Passenger car	Base	
Lane Change			
	No	Base	
	Yes	−1.52	<0.01
Midpoint location of vehicle trajectory (pixel coordinate Y)		0.05	<0.01
Variance of random intercepts		0.79	
Summary Statistics			
	Number of observations	5,672	
	Number of groups (stops)	32	
	Log Likelihood	−16879.2	
	R^2	0.13	

Lane Change Model

Table 7 shows the results of Lane Change Models without interaction terms. The full model included all variables and the final model includes only those variables that had significant estimates for at least one of the attribute levels. Table 8 shows the estimates of the Lane Change Model with the interaction term VMS Use × Vehicle Type. The models show the relationships between factors and the likelihood of a vehicle moving over from the 1st Lane to the 2nd Lane with the presence of an ASAP vehicle on the roadside. Positive coefficients show that a vehicle is more likely to move over from the 1st Lane to the 2nd Lane.

The modeling results revealed that the use of VMS significantly impacts lane change behaviors when approaching the ASAP vehicle on the roadside. When the VMS was active, vehicles were more likely to move over than when the VMS was not active, a result that was statistically significant. More specifically, the final model in Table 7 shows that the odds for a vehicle to move over are 95% higher when the VMS was active than when the VMS was not active. This further corroborates the potential for VMS to be an effective countermeasure to protect roadside incident and service personnel in terms of its impacts on lane change behaviors. The model with interaction terms shown in Table 8 further revealed that VMS is associated with a slightly greater odds of moving over for passenger vehicles than for trucks or buses; however, both vehicle types were more likely to move over when the VMS was active compared to when it was not. Again, due to the limited video detection distance, it could be that trucks or buses move over outside of the detection range, as they may see the ASAP vehicle from further down road.

There are a number of other factors that are also statistically related to lane change behaviors. When an operator was working outside the ASAP vehicle on the roadside, approaching vehicles were more likely to move over, compared to the situation where the operator was in the vehicle. When other emergency vehicles were on the roadside, drivers seemed less likely to move over. It is possible that drivers may tend to maintain the lane when facing a complicated situation with multiple agency vehicles. It is also possible that the increased visibility from multiple vehicles may have caused drivers to change lanes earlier (and outside of the detectable range). The relationships between lane change behavior and weather conditions are significant. Cloudy and rainy weather were associated with a smaller odds ratio of moving over than clear weather, implying that roadside incidents and service personnel may face greater risk in unclear weather conditions. Regarding the time of day, drivers seemed to be less likely to move over during morning peak hours from 7 am to 9 am, and more likely to move over during afternoon peak hours from 4 pm to 7 pm.

The presence of other vehicles on the road also had a significant relationship with lane change behaviors, with drivers being less likely to move over compared to situations where no other vehicles were present, possibly because there was no safe space in an adjacent lane for a vehicle to make a lane change. The roadway alignment was also significantly related to lane changes. When the ASAP vehicle stopped on a curve, drivers were more likely to move over, especially for Type 2 curves (as shown in Figure 19). The reason may be related to the visibility of the ASAP vehicle; drivers may be able to see the ASAP vehicle sooner when it stops on the shoulder of a Type 2 curve compared to a Type 1 curve.

Modeling results also showed that when the ASAP vehicle stopped on the left shoulder, passing vehicles were much more likely to move over, from the 1st Lane (inner lane) to 2nd Lane. When the ASAP vehicle was stopped behind or under a bridge, drivers were less likely to move over, potentially because the bridge could block the drivers from seeing the ASAP vehicle on the roadside.

Table 7. Modeling results for Lane Change Model without interaction terms

	Full Model			Final Model		
Variable	**Coefficient**	**P-value**	**OR**	**Coefficient**	**P-value**	**OR**
Intercept	−1.54	<0.01		−1.52	<0.01	
VMS use						
No	Base			Base		
Yes	0.67	<0.01	1.95	0.67	<0.01	1.95
Vehicle type						
Truck or bus	0.07	0.22	1.07			
Passenger car	Base					
ASAP operator						
In vehicle	Base			Base		
Outside of vehicle	0.60	<0.01	1.82	0.60	<0.01	1.82
Presence of other emergency vehicles/flashing lights						
No	Base			Base		
Yes	−3.54	<0.01	0.03	−3.43	<0.01	0.03
Weather						
Clear	Base			Base		
Cloudy	−1.52	0.01	0.22	−1.49	0.01	0.23
Rainy	−1.18	0.42	0.31	−1.09	0.46	0.34
Time of day						
AM Peak (7 to 9 am)	−1.05	0.06	0.35	−1.06	0.06	0.35
PM Peak (4 to 7 pm)	1.07	0.05	2.90	1.05	0.05	2.87
Mid-Day (9 am to 4 pm)	Base			Base		
Number of other vehicles per lane						
0	Base			Base		
0 ~ 1	−0.55	<0.01	0.58	−0.55	<0.01	0.58
1 ~ 2	−0.05	0.73	0.95	−0.06	0.69	0.94
Roadway alignment						
Straight	Base			Base		
Curve type 2—Towards	1.54	0.01	4.68	1.43	0.01	4.20
Curve type 1—Away	1.76	0.17	5.81	1.27	0.07	3.58
Terrain						
Level	Base			Base		
Downslope	−1.14	0.30	0.32	−1.00	0.35	0.37
Suspect downslope	−1.83	0.06	0.16	−1.55	0.03	0.21
Suspect upslope	1.24	0.21	3.46	1.21	0.22	3.36
Driving with sun glare						
No	Base					
Yes	−0.66	0.65	0.51			
Roadside stop						
Left shoulder	2.82	0.02	16.83	2.72	0.02	15.11
Right shoulder	Base			Base		
Relation to Bridge						
Over a bridge/narrow shoulder	1.10	0.19	2.99	1.09	0.19	2.97
Behind or under a bridge	−1.91	0.03	0.15	−1.82	0.03	0.16
No relation to bridge	Base			Base		
Variance of random intercepts	**0.56**			**0.56**		
Summary Statistics						
Number of observations	587			587		
Number of groups (stops)	28			28		
Log Likelihood	−6708.75			−6709.59		
R^2	0.19			0.19		

Table 8. Modeling results for Lane Change Model with VMS Use x Vehicle Type interaction

Variable	Coefficient	P-value	OR
Intercept	−1.53	<0.01	
VMS use × Vehicle Type			
VMS use (Yes): Passenger Car	0.73	<0.01	2.07
VMS use (Yes): Truck or bus	0.56	<0.01	1.76
VMS use (No)	Base		
ASAP operator			
In vehicle	Base		
Outside of vehicle	0.61	<0.01	1.83
Presence of other emergency vehicles/flashing lights			
No	Base		
Yes	−3.42	<0.01	0.03
Weather			
Clear	Base		
Cloudy	−1.51	0.01	0.22
Rainy	−1.08	0.47	0.34
Time of day			
AM Peak (7 to 9 am)	−1.08	0.05	0.34
PM Peak (4 to 7 pm)	1.04	0.06	2.83
Mid−Day (9 am to 4 pm)	Base		
Number of other vehicles per lane			
0	Base		
0 ~ 1	−0.55	<0.01	0.57
1 ~ 2	−0.08	0.60	0.92
Roadway alignment			
Straight	Base		
Curve type 2—Towards	1.42	0.02	4.15
Curve type 1—Away	1.29	0.07	3.62
Terrain			
Level	Base		
Downslope	−0.93	0.39	0.39
Suspect downslope	−1.56	0.03	0.21
Suspect upslope	1.23	0.22	3.41
Roadside stop			
Left shoulder	2.69	0.02	14.75
Right shoulder	Base		
Relation to Bridge			
Over a bridge/narrow shoulder	1.06	0.20	2.89
Behind or under a bridge	−1.83	0.03	0.16
No relation to bridge	Base		
Variance of random intercepts	**0.57**		
Summary Statistics			
Number of observations	587		
Number of groups (stops)	28		
Log Likelihood	−6706.0		
R2	0.19		

Distance to ASAP Model

Table 9 shows the results of Distance to ASAP Model without interaction terms. The response variable is the pixel distance to the ASAP vehicles when a passing vehicle moves over from the 1st Lane to the 2nd Lane. Positive coefficients show that a vehicle would move over sooner. Most variables in the full model did not have a statistically significant estimate or coefficient, including the VMS use, possibly due the small number of observations (N = 156). In the final model, vehicle type, time of day, and roadway alignment are factors that have at least a marginally significant relationship with the response variable. For example, the negative coefficient indicates that trucks or buses were likely to move over at a closer distance to the ASAP vehicle than passenger vehicles. Table 10 shows the final model including the VMS use × Vehicle Type interaction term. The results show that using VMS is strongly related to passenger vehicles' lane change behavior. When the VMS was active, passenger vehicles were likely to move over earlier than in the cases when the VMS was not active.

Table 9. Modeling results for Distance to ASAP Vehicle Model without interaction terms

Variable	Full Model Coefficient	Full Model P−value	Final Model Coefficient	Final Model P−value
Intercept	271.67	<0.01	339.40	<0.01
VMS Use				
No	Base			
Yes	45.29	0.26	−	−
Vehicle Type				
Truck or bus	−78.40	<0.01	−91.84	<0.01
Passenger car	Base		Base	
ASAP Operator				
In vehicle	Base			
Outside of vehicle	40.90	0.15	−	−
Presence of other emergency vehicles/flashing lights				
No	Base			
Yes	−69.18	0.39	−	−
Weather				
Clear	Base			
Cloudy	29.26	0.58	−	−
Rainy	75.03	0.52	−	−
Time of Day				
AM Peak (7 to 9 am)	−108.31	0.19	−75.58	0.07
PM Peak (4 to 7 pm)	−21.21	0.60	−51.83	0.11
Mid-Day (9 am to 4 pm)	Base		Base	
Number of other vehicles per lane				
0	Base			
0 ~ 1	24.48	0.22	−	−
1 ~ 2	90.90	0.20	−	−
Roadway alignment				
Straight	Base		Base	
Curve type 2—Towards	−90.71	0.15	−64.35	0.04
Curve type 1—Away	−9.85	0.95	−30.29	0.53
Terrain				
Level	Base			
Downslope	94.81	0.39	−	−
Suspect downslope	70.67	0.33	−	−
Suspect upslope	−214.40	0.24	−	−
Driving with sun glare				
No	Base			
Yes	−55.23	0.74	−	−
Roadside stop				
Left shoulder	−92.27	0.32	−	−
Right shoulder	Base			
Relation to Bridge				
Over a bridge/narrow shoulder	63.23	0.33	−	−
Behind or under a bridge	−8.58	0.89	−	−
No relation to bridge	Base			
Variance of random intercepts	**344.50**		**1063.00**	
Summary Statistics				
Number of observations	156		156	
Number of groups (stops)	22		22	
Log Likelihood	−870.20		−948.53	
R^2	0.25		0.16	

Table 10. Modeling results for Distance to ASAP Vehicle Model with VMS Use x Vehicle Type interaction

Variable	Coefficient	P−value
Intercept	252.54	<0.01
VMS use × Vehicle Type		
VMS use (Yes): Passenger Car	88.36	0.03
VMS use (Yes): Truck or bus	4.615	0.91
VMS use (No)	Base	
Time of Day		
AM Peak (7 to 9 am)	−78.48	0.06
PM Peak (4 to 7 pm)	−36.08	0.24
Mid−Day (9 am to 4 pm)	Base	
Roadway alignment		
Straight	Base	
Curve type 2—Towards	−72.28	0.02
Curve type 1—Away	−27.87	0.56
Variance of random intercepts	**867.30**	
Summary Statistics		
Number of observations	156	
Number of groups (stops)	22	
Log Likelihood	−944.44	
R^2	0.16	

Conclusions

The objective of this study was to evaluate the effectiveness of VMS mounted on a roadside service vehicle as a countermeasure to protect roadside incident and service personnel. Random intercept weighted models were developed to examine the relationship between passing vehicle movements (speed and lane change) and the use of VMS, among other factors.

Based on the modeling efforts, when the VMS was active, drivers were more likely to move over (change lanes) and slow down than in the cases when the VMS was not active. The odds for a passing vehicle to move over were 95% higher when the VMS is active. Active VMS had a greater impact on speed reductions in vehicle in the near (1st) lane compared to farther lanes (2nd). Within the video detection range, passenger vehicles were more responsive to VMS use than trucks or buses in terms of lane change and speed reduction (although both vehicle types are more likely to move over when VMS is active compared to when not). Passenger cars were also more likely to move over at a greater distance from the ASAP vehicle compared to when the VMS was not active. These outcomes imply that using VMS can positively impact traffic, especially passenger vehicles; therefore, this should be strongly considered as a countermeasure to protect roadside incident and service personnel.

Other noteworthy findings included the following:

- If a vehicle was making a lane change, its speed also tended to be lower than those who stayed in a lane. This could indicate that those drivers that do react to the ASAP vehicle adjust their behavior along multiple dimensions (i.e., borrowing from the slogan, they “slow down” *and* “move over”)

- The presence of service personnel working outside of the vehicle on the roadside tended to increase the likelihood of passing vehicles moving over.
- In the presence of other emergency vehicles, drivers were less likely to move over. It is unclear whether the presence of these vehicles (and possible their emergency lighting) led some drivers to move over in advance of the video detection range.
- Cloudy and rainy weather conditions were associated with smaller odds of moving over than clear weather.
- Vehicles seemed less likely to move over during morning peak hours from 7 am to 9 am and more likely to move over during afternoon peak hours from 4 pm to 7 pm.
- Drivers were less likely or unable to move over when more traffic was present, possibly due to a lack of safe space in an adjacent lane occupied by other vehicles.

These findings could serve as critical information for developing or amending strategies to enhance the safety of roadside incident responders and service personnel. The strategies need to consider the varying extents of conflicts under different situations. Modeling results imply that roadside incident responders and service personnel may face greater conflicts when working in cloudy and rainy weather conditions, during morning peak hours from 7 am to 9 am, in higher traffic scenarios, or in other circumstances.

Due to the limited video detection distance, it remains unclear whether VMS use is less effective for trucks or buses than for passenger vehicles. Truck or bus drivers may see the ASAP vehicle sooner than passenger vehicle drivers because of their height advantage and so they may have already moved over before entering the detection areas. As noted earlier, a comparison with benchmark data from ALGO traffic camera data suggested that the use of the 1st lane in the current sample was lower than normal (non-ASAP situations); this could further corroborate that some vehicles had already vacated the lane before they reached the detectable range. It follows that future research is required to expand the detection range or distance to examine the effectiveness of VMS use on trucks and buses passing an incident scene.

There are a number of limitations inherent in the current approach, relating to the sample and quality of the video data. First, the current exercise was limited in terms of location as well as in the number of stops. Ideally, more data collection efforts can be undertaken in the future to cover a greater number and variety of roadside incidents and service scenes. Second, an improved deep learning method would increase the accuracy of object detection and tracking. More specifically, the measures of vehicle speed and distance to ASAP vehicles need to be improved in order to derive more meaningful values. For example, converting the speed and space in video frames into more practical speed (e.g., feet per second) and distance units (e.g., feet). That said, the derived measures applied in the current setting allowed for comparative analysis of the effectiveness of VMS.

TECHNICAL MODULE 2: Focus Groups

Introduction

Traffic incident responders, including firefighters, law enforcement officers, emergency medical technicians, tow truck operators, mobile mechanics, and safety service patrol operators, face various complex and risky conditions while responding to or managing traffic incidents on roadways. According to the respondersafety.com website, there were 44 responder fatalities in 2019 and 46 fatalities in 2020. In 2021, the number increased to 65. These responders were struck and killed while performing duties (e.g., conducting traffic stops) or assisting motorists or disabled vehicles on roads (Emergency Responder Safety Institute, 2022).

Responder safety is the key to a successful Traffic Incident Management (TIM) program. The National TIM Responder Training Program was developed to help improve the incident response and ensure the safety of incident response personnel and the public (Einstein & Luna, 2018). It provides a shared understanding of the requirements for safe, quick clearance of traffic incident scenes; prompt, reliable, and open communication; and motorist and responder safeguards. Along with training, many countermeasures (e.g., reflective apparel and emergency lighting) and safety protocols (e.g., using critical wheel angle and non-traffic side) have been developed and implemented in TIM practice. However, traffic incident responders still get struck and killed by vehicles every year.

Research is needed to address this issue: why do these deadly responder incidents continue to occur each year despite the efforts and countermeasures that agencies and responders have undertaken? Limited research has been done to answer this question, often due to a lack of relevant data. The current study, described in this technical module, sought to shed some insight by conducting focus groups to learn directly from incident response personnel about practices regarding the use of countermeasures and incident management experiences. Unlike traditional survey studies, a focus group allows researchers to explore issues in greater depth while actively engaging focus group participants (Gibbs, 1997). The main objective was to understand what specific countermeasures are adopted by responders at incident management scenes and, as importantly (if not more), why responders do not use certain countermeasures or comply with safety protocols.

Method

Five focus group meetings were conducted between May and August of 2021. Due to COVID restrictions, meetings were held as online virtual meetings. A total of 18 participants from four fields of incident management (police, DOT, EMS, and towing and roadside service) attended the focus group meetings. In each meeting, a moderator led the meeting, asking prepared questions, and facilitating discussions among meeting participants.

Before joining a focus group meeting, participants were asked to provide informed consent. At the start of the virtual session, the moderator introduced the background and objectives of the research and the goals of the focus group meetings. A PowerPoint presentation was used to augment the verbal information shared by the facilitator and to show the discussion questions. Each meeting lasted approximately 90 minutes and participants were compensated for their time with a $25 gift card delivered via email. In addition to participating in the focus group, the participants were also asked to fill out a short survey to collect their socio-demographic information.

The main discussion topics dealt with the adoption of common countermeasures and safety protocols. These included the following:

- Emergency Vehicle Lighting
- Safety Apparel
- Positioning Responding Vehicle
- Critical Wheel Angle
- Advance Warning Signs
- Traffic Cones
- Vehicle Mounted Variable Message Sign
- Test Runs/Mock Drills & Action Reviews
- Safety Training

The moderator provided a short overview for each countermeasure and allowed participants to share their perspectives. To help participants engage in discussion, they were asked questions such as the following:

- On a scale of 1 to 5, how beneficial is this countermeasure in improving incident response personnel safety (1 = least to 5 = highly)?
- In what way is it beneficial (if applicable)?
- What factors may influence the decision to use this countermeasure?
- Why is it being used, or why is it not being used?
- What will encourage incident response personnel to use this countermeasure?

If time permitted, the moderator invited participants to share their experiences and perceptions about the safety of their practice, as well as additional perspectives and suggestions regarding the use of safety countermeasures and protocols, including those that were missed in previous discussion. Questions included the following:

- Do you know of any incident response personnel (including yourself) who was injured or killed by a passing vehicle while managing traffic incidents?
- What was found to be the leading contributor behind that incident?
- What can be done to reduce incident response personnel injuries or fatalities?
- Can you list any other countermeasures or practices you or your organization currently use?
- Can you name one or two countermeasures that every incident response personnel should adopt?

- Which countermeasure do you think is most effective, and if we can measure one countermeasure's effectiveness, which one should that be?

All meetings were audio-recorded with the permission of the participants. A verbatim transcript of the meeting discussion was created from the recording. The five focus group meeting transcripts were combined and coded for thematic elements. The coding process was an iterative process where transcripts were read multiple times. During the first few passes, two members of the research team documented topic themes that emerged from the discourse. In the next phase, the research team reviewed and collapsed these themes into a smaller subset of codes. In the final phase, the transcript was reviewed to distill information related to each code. A summary of focus group meeting results is presented in the following section.

Results and Discussion

Socio-Demographics of Focus Group Participants

A total of 18 incident response personnel participated in four focus group meetings. All participants were male, most of whom were under 45 years old. Figure 20 shows the age, ethnicity, state of residence, education level, and organization of the participants. Most participants were Caucasian, with three African American responders and one Latino responder.

Only five responders were from outside of Alabama, as three of the four participating agencies were local incident response agencies in Alabama. The meeting participants came from four types of agencies: law enforcement, DOT or public works, paramedics or EMS, and towing and roadside service. There were five responders with a bachelor's degree or higher and ten responders who reported some college education or an associate's degree.

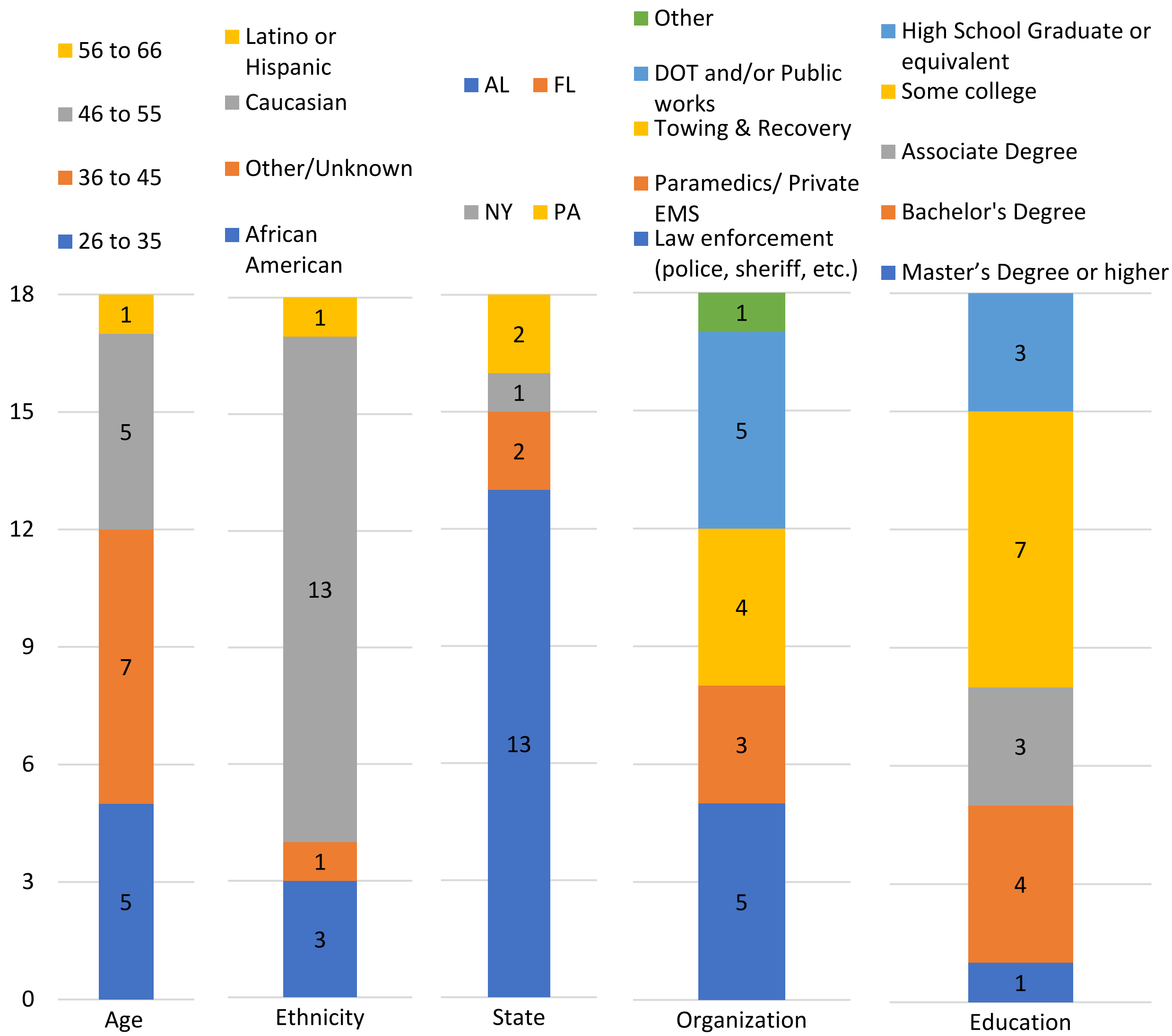

Figure 20. Demographic information for the focus group participants.

Countermeasures

As noted, codes were created for each countermeasure to summarize and organize key findings from the discussion. In the subsections below, summaries for each theme or code are provided, along with some sample statements from the participants (verbatim, in *italics*). The information presented in this section represents participants' views rather than those of the research team**.**

Emergency Vehicle Lighting. Emergency vehicle lighting is an important countermeasure that helps incident response personnel catch the attention of road users before road users enter the incident scene.

Usage. Nearly all participants stated that they use emergency vehicle lighting all of the time. The type of emergency vehicle lighting they use might vary depending on the conditions.

"…our standard operating procedures say you have to use all lighting all of the time when they're on a service call."

"The emergency strobes are a vital part of our work. We require that all our operators, regardless of the time of day and where the operator is located, that they have their strobes on."

Blinding. Almost all focus group participants pointed out that too much light at an incident site could be blinding and confusing to other drivers. Advancement in LED technology (that reduces brightness when not needed) has helped control this issue. Agencies have different strategies for combating blinding caused due to too much lighting, such as turning off the forward-facing lights after the scene stabilizes or using reduced brightness. The participants from EMS agencies mentioned that only a few vehicles have the technology to control vehicle lighting luminance. It was also mentioned that vehicles not using emergency vehicle lighting are considered at fault if involved in a subsequent crash (e.g., when parked on the wrong side of the road).

"They're all so much brighter, they're blinding and confusing especially when you have multiple vehicles with their lights on. That's what people are looking at, trying to figure out what's going on. That's why they're not looking at us."

"What I've taught and told people is that once the scene is stabilized, turn off forward-facing lights so it's not blinding oncoming drivers. And reduce as many lights as possible."

"We have changed and modified our lights to where you can partially turn them off. Such as just flashing to the rear so you're not also affecting cars coming from the other lane."

Night. Participants expressed that the emergency vehicle lighting can help warn drivers, especially during nighttime conditions, but the issue of too much light becomes exacerbated at night. Too much light may create an illusion and make the responders and the roads disappear from the motorist's sight.

"Especially at night they help a lot to get the motorists' attention to let them know there's an accident up ahead."

"It's also an illusion that happens at night when you're in the middle of high beam lights that the roadway disappears like a magic trick."

"The problem is not having too many lights; it's not being able to dim those lights. Brighter lights give you more visibility during the day, but cause issues at night."

Coordination. The issue of too much lighting is also confounded when there are multiple vehicles and/or multiple agencies at the incident site with their lights activated. All the focus group participants acknowledged that they do not coordinate with fellow responding agencies to reduce the effects of too much lighting. The focus group participants from EMS said that they keep their emergency vehicle lighting turned on all the time for insurance purposes.

"Unfortunately, everyone, in that case, has their own rules and policies. Asking the firetruck or ambulance to turn off their lights often results in the response: this is what I'm supposed to do."

"It would be tough for everyone to get it down to one vehicle flashing, because if their car gets hit, their boss will ask why their lights were off."

"A lot of times you run into a liability issue. If you turn off your lights, [you] *might end up being responsible."*

Intoxicated. Some participants mentioned the emergency vehicle lighting may have a different impact on intoxicated drivers, thereby presenting additional risks.

"It seems that people who are intoxicated seem to be drawn to the lights."

Color of Lighting. Different incident responders will have different kinds of lights. For example, police use red and blue lighting while tow truck drivers use yellow/amber flashing lights. Also, different states and regions have different regulations or requirements on the light color(s). The DOT and tow truck operators expressed that drivers do not respect the yellow/amber flashing lights as much as they do the red and blue flashing lights.

"In our society, most drivers don't really pay attention to our lighting. It's great for us, but a lot of people don't treat our lighting the same as the red and blue police lighting."

Decision Factors. The following factors were mentioned as having some influence on the decision to use and not use emergency vehicle lighting:

- Time of the day
- The emergency vehicle is parked in such a way that the drivers have limited visibility of the vehicle
- Traffic behavior
- Policy

Safety Apparel. These are safety clothing made with retroreflective materials, intended to the increase the visibility of the person wearing it in low daytime lighting or in the dark when illuminated by headlights of vehicles (see e.g., Figure 2). Most focus group meeting participants agreed that the safety apparel is beneficial for their safety, while a few disagreed.

Usage. Although the majority of tow truck drivers in the focus group claimed that they always wear safety apparel themselves, they also reported that they often see other contractors not wearing safety vests. Police noted that putting on an entirely different garment will cost some time that may not be available during an emergency. In the EMS group, the participants mentioned that safety apparel is not commonly used as it does not come to mind when stepping out of the vehicle.

"I've seen multiple of our contractors not wearing them. They just go out in jeans and a T-shirt to service calls."

> *"If we could integrate the safety panels into the actual uniform so we didn't have to stop and put on an entirely different garment. May not have enough time to get to it to put it on."*
>
> *"They could make reflective safety panels on the back of the vest; I think that would be a better option because at a traffic stop you don't have time when you get out of your car to put your vest on. The back of the vest has "police" on it, so they could add some reflective panels that say "police." Stopping to put a vest on isn't going to really work on a traffic stop."*

Recommendations. The participants shared their opinions on how to ensure incident response personnel use safety vests all the time. One of the suggestions was to make it state-mandated along with enforcement. Police suggested integrating reflective panels into their uniforms. Another suggestion was to change the training and safety culture to help promote the use of high-visibility safety apparel.

> *"I think it's one of those things that unless it's state-mandated, if you're a small business owner and you have all these overhead costs, insurance being one of them, you're going to try to cut corners where you can. Unless it's state-mandated like here in Pennsylvania, our guys have to wear Class III out on the road, but not everyone follows that. So not only does it have to be mandated, it has to be enforced."*

Decision Factors. The following factors were mentioned to influence the decision to use or not use safety apparel:

- Not remembering to wear it
- Training and safety culture differences
- Perceived utility: it does not matter as drivers are distracted, inattentive, and intoxicated
- The weather is not always conducive to wearing additional clothing
- Complacency or unawareness of risks or safety benefits

Positioning Responding Vehicle. Focus group respondents recommended to position law enforcement, fire, and DOT or safety service patrol vehicles upstream from the incident site. In contrast, EMS and tow truck vehicles should be positioned downstream, along with support units (Figure 21). However, several conditions influence how responders position their vehicle at the incident site. From the discussions, it was echoed that there is no established way of doing things and that the specific placement was highly dependent on the situation.

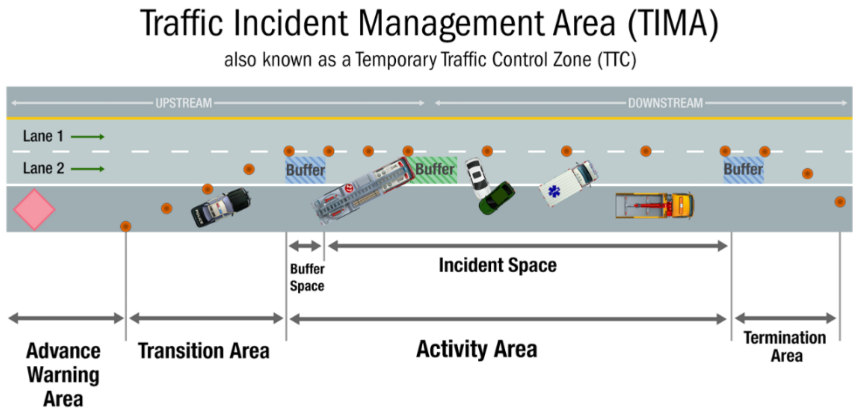

Figure 21. Traffic incident management area (source: respondersafety.com)

Position. Participants indicated that their own DOT service trucks are designed to be behind all other emergency vehicles. The tow truck drivers expressed that their position depends on the situation and condition. The participants from EMS mentioned that they like to park their vehicles downstream if there is additional support from other agencies, to protect their vehicle as it is needed to transport the injured people for treatment. If EMS is the first to arrive at the incident, they have been instructed to move their vehicle downstream as soon as they have additional support from other agencies.

> *"The Alabama Service Assistance Patrol (ASAP) units are designed to be behind all other emergency vehicles. As traffic approaches, the first vehicles would be the ASAP vehicles with their cones and lighting set up."*

> *"I will direct EMS downstream for safety, we position ourselves and the ambulance so that the wreck is in between us and oncoming traffic."*

Blocking. There are different blocking methods for different vehicles. The police respondents indicated that, when they first arrive at the scene, they will place the car at an angle to block lanes if there is a need for lane closures. DOT service trucks will block the lane behind all other emergency vehicles, and they do not use angle blocks. When the incident is at an intersection, the police usually block the lane of traffic coming towards the crash, and they will call for backup if they need more vehicles to block the traffic.

> *"In this case, the fire department will leave when they're done, so we place the police car at an angle that funnels lane 2 traffic into lane 1. We would still probably block off the shoulder because if you give people an opportunity to go around you, they'll take it."*

> *"We usually block the lane of traffic coming towards the accident, especially from across the intersection. So, we want them to be aware if they won't be able to travel through that lane. We also call for backup if we need more cars blocking traffic."*

> *"Service patrols don't use angle blocking because that would be the incorrect position. If you angle block, the message board is not easily visible to oncoming traffic."*

Two-to-Three Car Distance. Some focus group meeting participants recommended the two-to-three car distance in the practice of traffic incident management.

> *"Generally speaking, most service vehicles should give 2–3 car lengths unless we have a reason to move forward closer to the vehicle. Normally the 2–3 car lengths are designed for the safety of the people you're assisting. If someone were to come off the road and hit the service truck, that will absorb most of the blow, so it hopefully won't crash into the vehicle you're behind. Also, if you have the ASAP vehicle too close to the car you're assisting, and someone strikes the ASAP truck, you could be involved with the truck hitting the vehicle you're assisting, so it's really a safety factor to keep the motorists safe and increase the safety of the service vehicle operator."*

Critical Wheel Angle. It is recommended that the driver of the service or response vehicle turn the blocking vehicle's wheel to an angle so that they are not facing the incident space (see e.g., Figure 22). Were the unit to be struck by a passing vehicle approaching from upstream, it would push the service vehicle away from the incident space, not into it.

Figure 22. Critical Wheel Angle (source: highways.dot.gov)

Adoption. The participants said they prefer to park their vehicles with wheels facing away from them. Some admitted to doing it subconsciously while others were more deliberate about the practice. That said, other participants acknowledged that they do not practice it regularly.

> *"It's a normal practice to protect yourself so if you get hit, your vehicle won't veer off and hit someone else."*

> *"If I'm working on a vehicle on the side of the road, I'm going to make sure the wheels are turned away to protect me. We've always been trained to turn them facing the traffic."*

Non-Traffic Side. Working from the non-traffic side of an incident reduces exposure to passing vehicles during the response to the traffic incident.

Adoption. Participants echoed that it is common sense to use the non-traffic side while working at the incident site. But in some instances, they are forced to work from the traffic side, such as fixing a flat tire on the traffic side. In such scenarios, participants said they adopt some strategies to protect themselves, such as calling for extra support.

"We train our guys to work from the side away from traffic as much as possible, and to move to the non-traffic side when able."

"I would still say almost 90% of traffic stops [by law enforcement] *happen at the driver's door."*

"Sometimes there's no option but to work on the traffic side. At that point, you angle your vehicle, turn on lights, and use traffic cones. That's if you don't have enough room between the vehicle and the white line. If you're in a tow truck, tow it to a safer area. Our practice is that we call in a tow truck and take the vehicle and motorist to a safe location."

Policy. Although the agencies have some policies that mandate the responders to work on the non-traffic side, some of them will still violate the rule to save money and time. Participants acknowledged that incident response personnel could get complacent regarding risky situations while on duty, which could make them less likely to adopt safety countermeasures.

"We can set up all the guidelines and give all the tools and safety equipment, but at the end of the day it's going to be the decision of that [tow] *technician that is on the scene."*

One participant said there are no set rules that dictate how an incident must be managed.

"Everything is incident driven, not hard rules of 'you have to do it this way every time.' It's not a cookie-cutter way of looking at it, it's a best practice if the situation allows. It may not be that you can move to the non-traffic side. It is what it is. With the dynamic situations that these incidents lead to, there's no way to say this is how you should do it every time. Unfortunately, people often do things without thinking."

Training and Monitoring. Participants (towers) said that they use training and supervision to help ensure incident response personnel do not get complacent and let their guard down.

"When we hire a new [employee]*, they are in training for at least 60 days with a trainer. They gradually work up to fully leading an incident. We have weekly meetings between supervisors, leads, and trainees. They're told multiple times not to step out into traffic.* [If] *you realize they're not getting the safety aspect of the job, we cut them loose before they get hurt."*

Decision Factors. The following factors were mentioned as having an influence on the decision to work from the non-traffic side or not:

- Lack of education and common sense
- Complacency
- Lack of situational awareness

Advance Warning Signs and Traffic Cones. Advance warning signs and cones can inform drivers of the situation and make them change lanes (see e.g., Figure 23).

Figure 23. Advance Warning Signs and Traffic Cones (source: mcftoa.org)

Usage. While some participants stated they use cones all the time, others said they use them depending on the situation. One participant stated that drivers see cones all the time (e.g., at construction sites), and so they are "numb" to them; thus, they are of questionable effectiveness (though he acknowledged that he uses them). Responders seem more likely to use traffic cones when the shoulder is narrow.

Almost all participants agreed that they rarely use advance warning signs to warn drivers about the incident. The primary reason for the low adoption of this countermeasure is the extra work needed to set up the sign and then collect the sign back from the road, which is usually placed a few hundred feet from the incident site. Participants said they would often call for backup support to serve as advance warning signs at the incident sites. Police said they do not carry this sign in their cars and usually request the local or state DOT to bring them if they see a need for it.

> *"I use my cones every day."*

> *"If an individual is close to moving traffic, they will put up cones to help make a better visual for oncoming traffic that someone's going to be working right on the side of the road close to the lane of travel. It's kind of a judgment basis to determine if you want the extra safety."*

Lighted Cones. A few agencies mentioned using traffic cones with flashing lights on top when traffic is not responding well and during night times.

Traffic Cone Configuration. Participants mentioned that the cones are often set at an angle so the drivers will go around the vehicle.

> *"I'm trying to protect myself and my* [tow truck]. *So, you set up the cones at an angle, so they'll go around the vehicle."*

"I think it would be more likely and they should use traffic cones, in some of our cities on the interstate shoulders are not wide. So, we have some places that are so tight that it would be a good idea to use them."

Decision Factors. Participants mentioned the following factors influencing their decision to use or not use traffic cones or advanced warning signs:

- Drivers are numb to the presence of traffic cones
- No agency policies in place
- Not having them available on the vehicle
- It is cumbersome and risky to use them
- The time it takes to set them up outweighs the benefit

Vehicle Mounted Variable Message Sign. Most participants expressed they have interacted with DOT service vehicles equipped with variable message signs (see e.g., Figure 24). Their experiences were positive; although one incident response personnel thought that the use of text on a VMS could be distracting to drivers as well as to responders.

Figure 24. Vehicle Mounted Variable Message Sign (Source: litesys.com/)

"All he does is drive around the interstate looking for stopped vehicles and tow trucks. It's a godsend to have these guys and I support and thank them. Well worth it, wish we had more."

"I would ask how productive that sign really is. Depending on the size, it may be distracting to drivers. In my opinion I think this would be too distracting for our technicians. I would just go with flashing arrows."

"I've encountered them on the interstate. I think they're a good thing, it gives people more of a warning to shift traffic. It makes it safer for us, giving us more space between oncoming traffic and the incident."

Usage. The DOT service vehicle drivers were trained to use the message boards when closing lanes or during unfavorable conditions such as nighttime, bad weather, etc. At the same time, they were encouraged to use the message sign during all conditions if it made them feel more comfortable.

"I think it's more of an operator comfort aspect rather than a requirement that it's used on the shoulder."

"We also train our guys that even if it's broad daylight and you would feel more comfortable that you have the message board up and all lights on, by all means activate it."

Decision Factors. Responders listed out some factors that they take into consideration regarding when to use overhead VMS.

"Am I in a curve? Am I too close to the traffic because it's a narrow shoulder? What's the traffic doing? Are they close by? You'll see our guys adjust their behavior based what is going on and the environment they're in at that time."

Other factors that influenced the decision of using VMS were similar to the use of emergency vehicle lighting:

- Time of the day
- The emergency vehicle is parked in such a way that the drivers have limited visibility of the vehicle
- Traffic behavior
- Policy

Test Runs, Mock Drills & Action Reviews. Test runs, mock drills, and action reviews are important off-duty countermeasures to improve the traffic incident response practice (see e.g., Figure 25). The main goals are to critique the procedures used and the decision-making process constructively and determine where future incident management could be improved.

Figure 25. Test Runs, Mock Drills & Action Reviews (USDOT, 2019)

Usage. Almost all police officers and DOT service operators indicated that they do not have test runs or action reviews specific to traffic incident management. However, tow truck operators in the focus groups mentioned that they conduct yearly reviews.

Feedback. All participants stated that they have casual discussions with their peers if they experienced specific events on a given day. They said these discussions were not formal, where the details of an incident are covered. They acknowledged that they need more controlled discussion to determine the appropriate approaches.

Decision Factors. The following factors were mentioned to influence the use of this countermeasure:

- Insufficient resources
- Have other important duties to be concerned with than traffic incident management

Safety Training. It is highly recommended that the incident responders have training before performing relevant traffic incident tasks at scenes (see e.g., Figure 26). Almost all participants agreed that safety training is important to protect themselves at incident sites. They suggested that the safety culture within an organization be occasionally reinforced through training. One participant argued that training could not be done for every situation, but it can cover the basics, and safety is mostly commonsense.

Figure 26. Safety training (USDOT, 2019)

> *"We're in all kinds of different situations on the roadway so you couldn't train for half of it because I may be doing something tomorrow that I never thought of, and I've been here 18 years. Basic safety on the road is very important especially with traffic stops. I'd say it is the number one thing. It would be hard to cover everything we may see on the road."*

Police officers stated that they get their basic training before joining the department. However, most agreed that training happens when they are learning from their day-to-day job activities.

Decision Factors. The following factors were mentioned as having an influence on likelihood of getting safety training:

- Not being aware of such programs
- People do not want to spend their personal time attending safety trainings
- Agencies do not have replacements to cover shifts if participants want to attend safety training
- Some believe learning on the job is the best form of training

Experiences

The participants shared numerous experiences in which they or someone they knew got injured while managing traffic incidents. Again, all participants echoed that it was not the responders' fault when incident response personnel incidents happened. Participants believed distracted or inattentive drivers to be the primary cause of most incident response personnel injuries and fatalities ("*Most of our wrecks are caused by people not paying attention. It's a people problem.*"). Even though they use the preventive measures such as wearing reflective clothing, using emergency vehicle lighting, etc., they still get involved in crashes.

Conclusions

To gather practices of using countermeasures and safety protocols in traffic incident management, this study conducted focus group meetings with responders from stakeholder agencies that perform roadside services and incident response. Five focus group meetings were organized, and 18 participants from four fields of incident management (police, DOT, EMS, and towing and roadside service) attended the meetings. The outcomes of these meetings reveal the first responder's practices of adopting specific countermeasures at incident management scenes and also shed some insight into the reasons why responders do not use countermeasures or comply with safety protocols.

This study focused on some specific countermeasures or safety protocols, including emergency vehicle lighting, safety apparel, positioning responding vehicle, critical wheel angle, advance warning signs and traffic cones, vehicle-mounted variable message sign, test runs, mock drills and action reviews, and safety training. Key findings from focus group meetings include the following:

- ***Emergency Vehicle Lighting***—As required by policy, almost all participants always use this countermeasure. While responders expressed that emergency vehicle lighting is effective in protecting them, especially at night, they raised safety concerns if there are too many lights which could blind and confuse motorists. It is critical to coordinate the lighting and control vehicle lighting luminance at an incident management scene when multiple agencies and emergency vehicles are involved. Regarding the color of lighting, the DOT workers and tow truck operators expressed that drivers do not always respect the yellow/amber flashing lights as much as they do the red and blue flashing lights.

- ***Safety Apparel***—Most responders agreed that safety apparel benefits their safety; however, there were significant differences across agencies in terms of its use. Tow truck drivers in the focus groups claimed that they always wear safety apparel, but they frequently see others not wearing it. Police, during an emergency, might not have enough time to put on a reflective vest or jacket and responders from EMS mentioned that safety apparel is not commonly used. Reasons for not wearing safety apparel include not remembering to wear it, limited training, complacency, cultural differences, perceived ineffectiveness due to reckless driving behaviors, and weather not being conducive to wearing additional clothing. To increase the use of safety apparel, responders suggested training and making it mandatory along with enforcement. Work clothes and uniforms with integrated reflective panels may be beneficial for responders.
- ***Positioning Responding Vehicle***—If multiple agencies are involved in an incident management, there are recommended positions for their vehicles on the scene. However, focus group participants expressed that how they position their vehicles largely depends on the situation and conditions, especially for tow trucks. Some participants recommended the two-to-three car distance in the practice of positioning responding vehicles.
- ***Critical Wheel Angle***—The participants said they prefer to park their vehicles with wheels facing away from them. Training and practice can help reinforce this habit and make it more deliberate; some participants acknowledged that they do not practice it regularly.
- ***Non-Traffic Side***—The participants agreed that it is common sense to work from the non-traffic side. In some instances, however, they are forced to work from the traffic side. Although there are policies that mandate responders' use of the non-traffic side, some of them still violate the rule. Reasons for not using the non-traffic side include lack of education and common sense, complacency, and not having adequate situational awareness. Training and supervision were recommended to increase likelihood of using the non-traffic side.
- ***Advance Warning Signs and Traffic Cones***—While some participants stated they use cones all the time, others said they use them depending on the situation. Meeting participants said they rarely use advance warning signs, primarily because of extra work and time needed to place a sign some distance from the incident site. Police participants said they do not have the sign or cones with them, and they usually request local or state DOT to bring them if needed. To increase the effectiveness of traffic cones, responders mentioned that lighted traffic cones (those with flashing lights on top) could be used when traffic is not responding well and at night.
- ***Vehicle Mounted VMS***—Not all agencies have implemented this countermeasure, although most participants are aware that DOT service vehicles have VMS. The DOT service vehicle drivers are trained to use the VMS, and they are told they can use the VMS during all conditions to increase their comfort on the roadside. Regarding the effectiveness of this countermeasure, meeting participants were generally positive; however one responder noted that the text on the VMS could distract drivers.

- ***Test Runs, Mock Drills, and Action Reviews***—Almost all police officers and DOT service operators said they do not have test runs or action reviews specific to traffic incident management. However, the tow truck operators mentioned that they have yearly reviews. All the participants stated that they have discussions with their peers if they experienced specific events, but these were casual rather than formal discussions. Focus group participants mentioned that their agencies might not have sufficient resources to organize test runs, mock drills, or action reviews. Also, they may feel that they have other more important priorities.
- ***Safety Training***—Almost all participants agreed that safety training is important to protect themselves at incident sites. Some suggested that the safety culture be occasionally reinforced through training. Reasons for not having sufficient training were varied. Some participants said that they were not aware of such programs; some do not want to spend their personal time attending safety training; agencies do not have replacements to cover shifts if participants want to attend safety training; and some of them believed that learning on the job is the best form of training.

Meeting participants also shared their experiences and perceptions about the safety of their practice. All of them believed distracted and inattentive driving behaviors are major contributing factors to responder injuries and fatalities in traffic crashes, especially the secondary crashes at incident management scenes. The presence of such reckless driving behaviors was felt to be one reason that the effectiveness of countermeasures was reduced, also impacting the behavior of responders adopting countermeasures and complying with recommended safety protocols.

Limitations

There are several noteworthy limitations of this study and the focus group approach adopted. This study organized five focus group meetings and engaged a small number of participants from four major response organizations, including police, DOT, EMS, and towing and roadside service. The study aimed to include all the five major incident management agencies but in the end was unable to include people from the fire department. Also, the majority of participants were from Alabama; thus, the opinions shared by these participants might be biased and not be an accurate representation of the entire first responder population in the U.S.

During focus group meetings, although all participants were encouraged to express their opinions, not all were equally open to sharing their opinions freely. Thus, the amount and quality of the information provided by each participant is uneven, which may be associated with their years of working experience as well as their duties and ranks within their agency, among other factors. Even though all focus group meetings were scheduled to last for 90 minutes, in some meetings, the moderator had to skip some questions to finish the meeting in time, which could have resulted in an incomplete collection of opinions on a couple of countermeasures for some of the groups.

In spite of these limitations, the focus group exercise yielded some important insights. Continuing efforts are needed to engage more agencies and responders to share their perspectives on using countermeasures and safety protocols in their incident management practice.

TECHNICAL MODULE 3: National Responder Survey

Introduction

Numerous countermeasures and protocols have been designed to enhance traffic incident response personnel safety, through Traffic Incident Management (TIM) training programs and other avenues. However, there is little research examining responders' adoption of countermeasures or their compliance with recommended practices. Compliance with recommended practices and appropriate and consistent use of countermeasures could greatly impact the safety of incident response personnel.

Building on the focus groups conducted in Technical Module 2, the current study utilized a survey approach in order to:

- identify frequently used countermeasures,
- assess use and non-use of countermeasures and compliance and non-compliance with safety protocols,
- identify factors associated with non-use or non-compliance,
- examine previous experience involving incidents or crashes, or near-misses while performing duties on the roads,
- evaluate factors related to non-compliance or non-use of countermeasures, and factors associated with roadside traffic incidents involving incident response personnel.

In collaboration with the Emergency Responder Safety Institute (ERSI), this study conducted a national responder safety survey to gather incident response personnel's working experience, training background, and behaviors, as well as opinions on adopting selected countermeasures and safety protocols. The outcomes provide insight for developing strategies to target the first responder groups or emergency response agencies and current TIM practices for improving the adoption of countermeasures and safety protocols that effectively protect incident response personnel on roadways.

Survey Design

The survey consisted of three sets of questions. The first set of questions collected participants' socio-demographic information such as gender, age, race, education, and agency/organization type (fire, police, paramedics, towing services, etc.). The second set of questions related to responders' past experiences with near-misses or secondary crashes while managing traffic incidents. Participants were also asked about perceived causal factors for responder-involved incidents (e.g., near-miss, struck-by, line-of-duty death [LODD]). Ten causal factors were identified from the literature (U.S. Fire Administration, 2012) and respondents were asked to rate each factor on a scale of 1 to 5 (1 being least likely to cause first responder injury/fatality while five being highly likely to cause injury/fatality to a first responder). These factors included the following:

- Lack of training
- Lack of situation awareness
- Failure to establish a proper temporary traffic control (TTC) zone
- Improper positioning of apparatus
- Inappropriate use of scene lighting
- Failure to use safety equipment
- Careless, inattentive, or impaired drivers
- Reduced vision for driving conditions
- Altered traffic patterns
- Lack of advanced warning devices

The third and the largest set of questions centered on the adoption and use of countermeasures and safety protocols, including:

- Safety training on traffic incident management
- Test runs or mock drills
- Action reviews
- Critical wheel angle
- Non-traffic side
- High visibility clothing or safety uniforms
- Emergency vehicle lighting
- Advance warning signs
- Traffic cones

Respondents were asked how frequently they used each specific countermeasure. In cases of non-use, a follow-up question probed the reasons. Response options for these probe questions were informed in part by the focus group exercises described in Technical Module 2. For example, for the question "Why don't you wear high visibility clothing or safety uniforms more often while managing traffic incidents?" response options included the following:

- I don't think high-visibility clothing is effective
- I don't remember to wear it
- I get complacent sometimes, and as a result, I don't wear it
- It limits me from accessing my gear

- Hot and humid weather prevent me from wearing it
- Other (explain below)

Skip pattern–style questions were employed in the survey. For example, if a participant responded that they always use a specific countermeasure, they were not asked why they do not use that countermeasure. Before the survey rollout, the survey was circulated among students, staff, and faculty at UA to estimate the survey's length and ensure the survey could run smoothly with skip pattern–style questions. The final survey was designed to balance its comprehensiveness and its length (not overly long, causing survey fatigue or dropouts). After finalizing the survey questionnaire, a Qualtrics survey link with the informed consent and survey questions was created to facilitate the survey rollout and data collection. The complete survey can be found in Appendix A.

Data Collection

Distribution of the survey was facilitated by the Emergency Responder Safety Institute (ERSI) and AAA. ERSI has close to 70,000 active members of emergency responders from across the country. ERSI sent an email to its members highlighting the purpose of this study and the importance of their participation, along with the survey link. AAA leveraged its contacts to help distribute the survey to additional respondents, primarily tow truck operators and roadside service providers. A raffle was provided to encourage participation in the survey, with an approximate one-in-ten chance of winning a $50 gift card.

The survey rolled out on October 5, 2021. A total of 1,757 responses were recorded by November 9, 2021. Qualtrics settings were used to prevent multiple submissions from the same IP address.

Data Analysis

The data were cleaned prior to analysis, and records were deleted from the survey data if the participant did not provide informed consent (in such cases, the survey was ended when a participant chose not to give consent) or the participant failed to answer any of the core survey questions (e.g., they stopped after completing the demographic questions). Ultimately, data from 1,621 respondents were included in the data analysis. When analyzing variables of interest, missing data points specific to those variables were filtered out. The results below are organized according to descriptive analyses and regression modeling.

Descriptive Analysis

This study used descriptive statistics, simple graphics, and contingency tables to highlight responses to key survey questions, such as the frequency of using a particular countermeasure. Chi-square tests were conducted to test the significance of associations between variables, e.g., using a countermeasure and the agency or organization type. In certain cases where the contingency table cell count fell below five, categories were grouped. For example, for some statistical tests, responses of “never” and “seldom” were merged, as well as “frequently” and “always.” For a limited number of questions, respondents could provide written information in response to the questions. From the initial analysis of the qualitative/text data, no additional meaningful results were found; therefore, they were not presented in this report.

Regression Modeling

Traditional statistical models were conducted to examine the associations between countermeasure use or non-use and responders' involvement in crashes and near misses. The two dependent variables (Y) were: (a) whether the respondent ever experienced a near-miss event while managing a traffic incident, and (b) whether the respondent was ever struck by a passing vehicle while managing a traffic incident. Both dependent variables are binary (Yes or No); therefore, binary logistic regression models were used to study associations between the dependent and independent variables (countermeasures used).

$$P_i = Pr(Y = 1|X = x_i) \tag{2}$$

$$Log\frac{P_i}{1 - P_i} = logit(P_i) = \beta_0 + \beta_1 x_i \tag{3}$$

$$P_i = \frac{exp(\beta_0 + \beta_1 x_i)}{1 + exp(\beta_0 + \beta_1 x_i)} \tag{4}$$

Equations (2) to (4) formulate the model estimation process, where P_i is the probability that the corresponding $Y = 1$ will be satisfied, meaning the responder experienced a near-miss incident; β_0 is the model intercept and β_1 represents the coefficients of independent variables x_i, such as use of high visibility clothing, TIM responder training, etc. While the coefficients only explain the direction, the odds ratio quantifies the effect of independent variables on the dependent variable. It is defined as the ratio of the probability of an event happening to the probability of the event not happening, e.g., the probability of responders experiencing a near-miss incident vs. the probability of responders not experiencing a near-miss incident.

Descriptive Analysis Results & Discussion

Demographics of Survey Participants

Table 11 summarizes the key demographics of survey participants, including gender, age, education, experience, and agency. Results show that 84% of the respondents were male, more than half of the respondents were older than 45 years old, and nearly all respondents had a high school diploma or higher education. Responders from fire departments were heavily represented in the collected sample. However, most of the analysis were done at the agency level, which eliminates bias caused due to uneven sample sizes.

Table 11. Demographics of Survey Participants (N = 1,621)

Demographics	Frequency	Percentage
Gender		
Female	245	15.1%
Male	1,367	84.3%
Prefer not to answer	9	0.6%
Age		
18 to 20	22	1.4%
21 to 25	66	4.1%
26 to 35	288	17.8%
36 to 45	366	22.6%
46 to 55	365	22.5%
56 to 66	349	21.5%
67 and above	157	9.7%
Prefer not to answer	8	0.5%
Race		
Caucasian/White	1,382	85.3%
Latino or Hispanic	40	2.5%
African American	25	1.6%
Native American	15	0.9%
Other (e.g., Asian, Native Hawaiian, or Multiracial)	76	4.7%
Prefer not to answer	83	5.1%
Education		
Less than a High School Graduate	18	1.1%
High School Graduate or equivalent	219	13.5%
Some college	440	27.2%
Associate Degree	297	18.3%
Bachelor's Degree	462	28.5%
Master's Degree or higher	177	10.9%
Prefer not to answer	8	0.5%
Agency		
DOT and/or public works	99	6.2%
Fire	722	44.9%
Law enforcement (police, sheriff, etc.)	270	16.8%
Paramedics/Private EMS	217	13.5%
Towing & Recovery	144	9.0%
Other (e.g., accident cleanup service)	157	9.8%
Prefer not to answer	12	0.7%

Figure 27 shows the distribution of the survey data by state. The survey had some representation from all 50 states and Washington D.C. Populous states such as California, New York, and Texas had larger samples than North Dakota, South Dakota, Nebraska, and Kansas. This study collected disproportionally more samples from Alabama and Pennsylvania because of the Alabama-based research team and Pennsylvania-based survey facilitator.

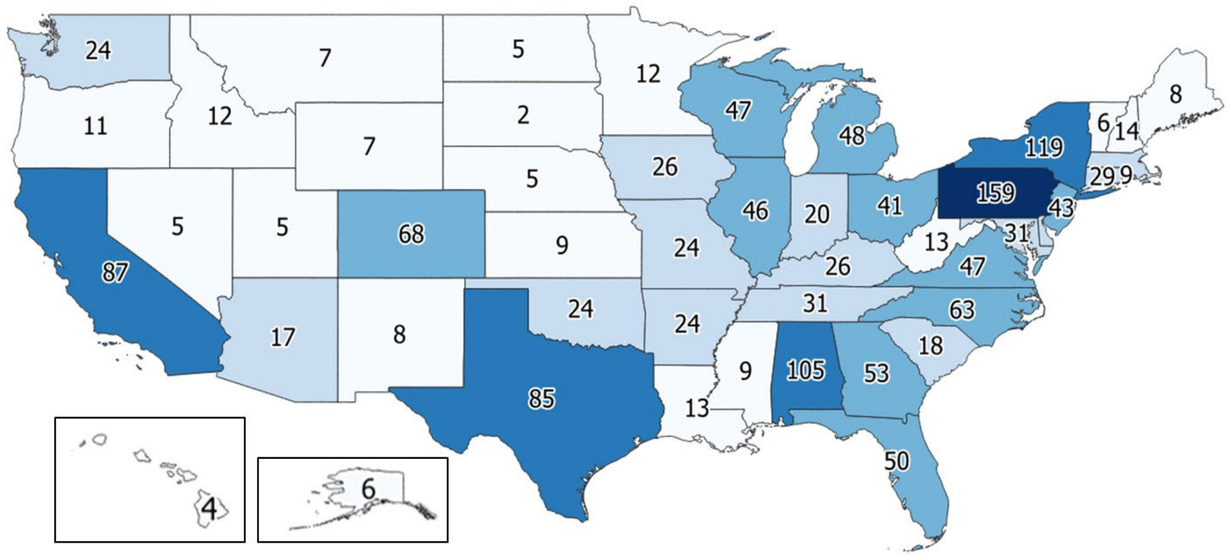

Figure 27. Sample distribution by state (N = 1,621)

The following sections provide descriptive statistics along with discussions on survey participants' responses to questions related to compliance with or use/non-use of the specific countermeasures.

Traffic Incident Management Responder Training

Table 12 shows the responses to survey questions related to TIM Responder Training. Most respondents (88%) said they had attended training on traffic incident management, particularly responder safety. Less than 10% of the respondents said they had not attended any safety training. When asked about the reasons for not attending such programs, the top reasons include not being aware of safety programs and their agency not having sufficient staff (i.e., replacements) if they want to attend training programs.

Responders were also asked how long ago they received TIM responder training. Over 60% of the respondents said they attended the safety training within the past two years.

Table 12. Responses related to TIM Responder Training.

Questions	Responses	Frequency	Percentage
Have you ever attended any TIM training programs? (N = 1,621)			
	Yes	1,425	87.9%
	No	149	9.2%
	I do not remember	40	2.5%
	Prefer not to answer	7	0.4%
Any reasons for not attending training? (N = 147)			
	Not aware	69	46.9%
	Don't want to spend personal time	12	8.2%
	No replacements	20	13.6%
	Believe learning on the job	14	9.5%
	Other	35	23.8%
	Prefer not to answer	6	4.1%
When was the last time you attended the training? (N = 1,425)			
	Within the past year	468	32.8%
	In the past 1 to 2 years	431	30.2%
	In the past 3 to 4 years	273	19.1%
	In the past 5 to 6 years	192	13.4%
	I do not remember	58	4.1%
	Prefer not to answer	3	0.2%

Table 13 shows the breakdown of TIM training by the agency. Odds were estimated at the agency level for not receiving safety training. The odds of a responder not receiving safety training were highest in the towing industry; DOT and/or public works, law enforcement, and paramedics were more likely to receive safety training. Unlike fire and police, tow truck operators and roadside assistance personnel do not have formal training/education specific to incident management. Further, the towing industry is primarily privately owned; in such cases, costs and staffing considerations could hinder the uptake of training within this industry.

Table 13. Safety Training by Agency (N = 1,448).

Agency	Safety training No		Safety training Yes		Odds of not receiving safety training (no/yes)	Odds Ratio
Fire	57	8.7%	600	91.3%	0.10	0.51
Law enforcement	16	6.2%	244	93.8%	0.07	0.35
Paramedics/Private EMS	13	6.7%	182	93.3%	0.07	0.38
Towing & Recovery	18	15.8%	96	84.2%	0.19	1 (reference)
DOT and/or public works	4	4.4%	87	95.6%	0.05	0.25

Test Runs and Mock Drills

Responders were asked how frequently their agency conducted test runs and mock drills to improve safety. Figure 28 shows that 20% of the responders reported never having test runs or mock drills, while 24% stated that they have once every few years. Only 27% reported frequent mock drills and test runs (monthly or quarterly). Only 13% of paramedic responders stated that they never had test runs or mock drills, while 36% of the responders from towing industry said they never had test runs or mock drills. Responders from law enforcement reported the highest percentage of having monthly drills related to incident management. A chi-square test confirmed the statistically significant differences between agencies in terms of the frequency of test runs and mock drills for TIM (Chi-square: 75.2; p-value: <0.01).

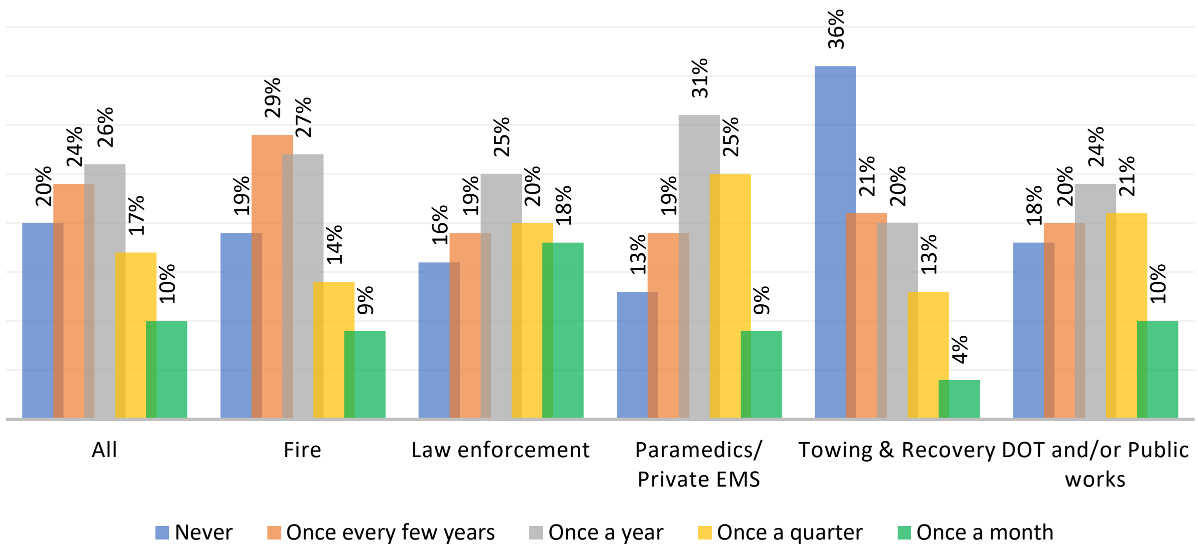

Figure 28. Frequency of test runs and mock drills across agencies (N = 1,586).

Respondents who reported not having frequent mock drills or test runs were asked why their agencies were not adopting this countermeasure, and the results are shown in Figure 29. Note that responders were allowed to choose multiple reasons for the question of why their agencies do not conduct test runs frequently. Each reason is counted as many times as it appears in the responses. However, the percentages were estimated considering the number of respondents rather than the number of responses, therefore, the percentages do not add up to 100 percent.

Over half of the responders indicated that conducting test runs and mock drills requires a lot of resources, such as time, money, staffing, etc., which their agencies might not have. Over 10% of the responders from law enforcement, fire, and EMS said that they have other more significant perils in their job that take precedence. While only 3% of the firefighters said test runs are not effective, 18% of the law enforcement officers felt they are not that effective in improving incident response personnel safety. Agencies could dedicate funds and resources from their annual budget to make sure they conduct test runs. The safety benefits derived from conducting test runs could outweigh the costs associated with adopting this countermeasure overall because of the lives saved or injuries reduced.

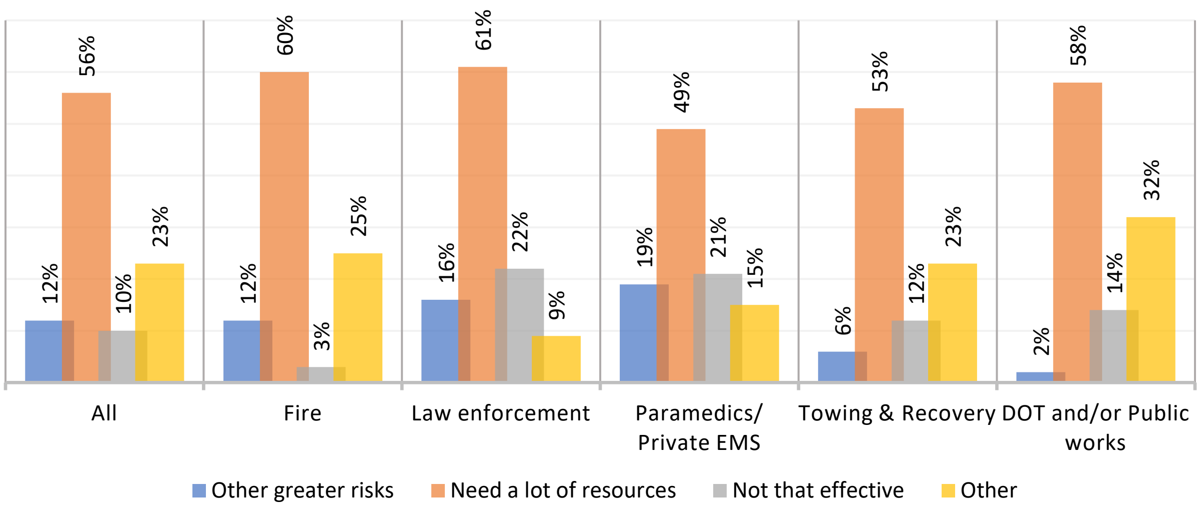

Figure 29. Reasons for not conducting frequent test runs and mock drills by agency (N = 1,076).

Action Reviews

Respondents were asked how frequently their agencies or organizations conduct action reviews to improve safety. Figure 30 shows the frequency of action reviews by the agency. Nearly 30% of the responders reported having monthly action reviews, while 13% reported never having an action review. Responders from paramedics/private EMS reported the lowest percentage of having monthly action reviews, while police, DOT, and towing reported the highest. There was a significant difference across agencies in conducting action reviews (Chi-square: 52.7; p-value: 0.001); some tend to have frequent action reviews compared to others.

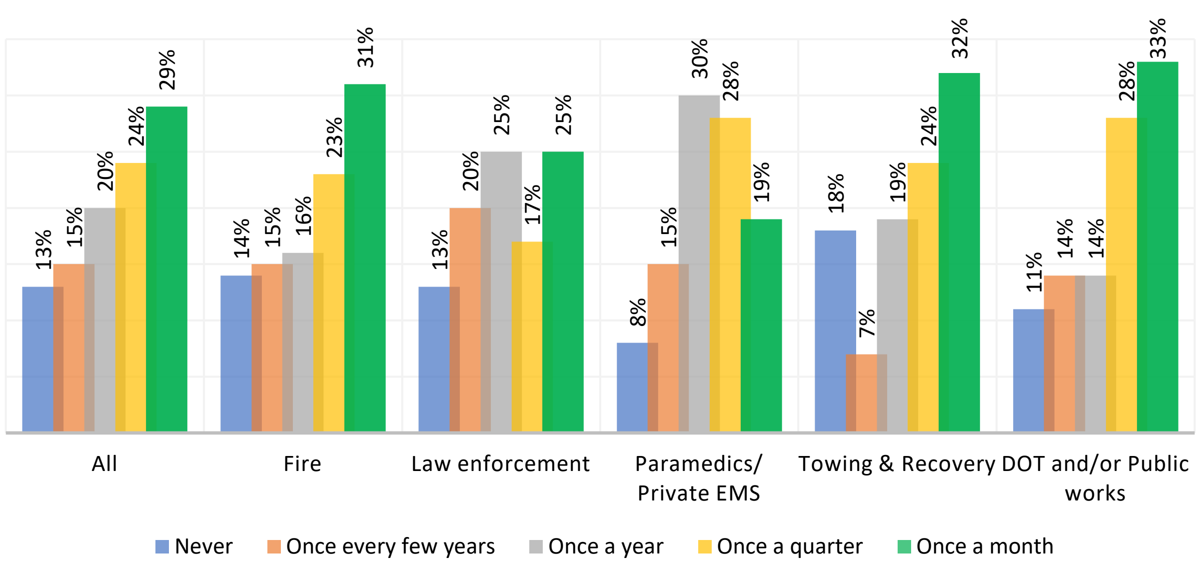

Figure 30. Frequency of action reviews by agency (N = 1,469).

Responders were asked why their agencies do not conduct action reviews frequently in a follow-up question. Responses were summarized and presented in Figure 31. Across all agencies, over 40% of responders reported that action reviews require a lot of resources such as time, money, and staffing, which their respective agency did not have. Around 30% of the law enforcement officers expressed that action reviews are ineffective in improving incident response personnel safety to merit the investment of resources. In contrast, only 6% of the fire responders thought the same.

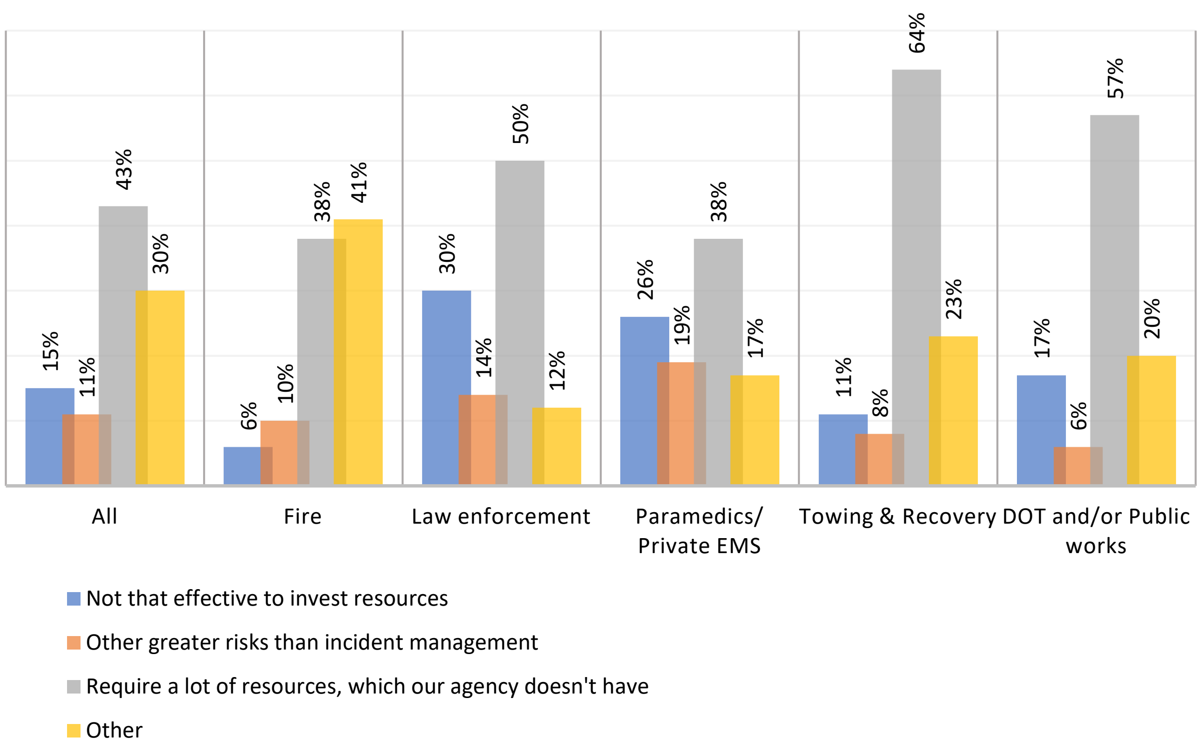

Figure 31. Reasons for not conducting action reviews by agency (N = 697).

Critical Wheel Angle

Responders were asked how frequently they park their service vehicles at the incident site with wheels facing away from the scene, and the results are shown in Figure 32. Half of the responders reported using this countermeasure all the time, while 24% reported frequent use. Only 2% of the responders reported they never use critical wheel angle as an added measure to improve their safety at incident locations. Fire fighters reported the highest percentage of "always" using the critical wheel angle, while paramedics reported the lowest. This could be expected as firefighters are often taught to use their vehicles as "a protection shield" at the incident sites. There were significant differences in the frequency use of critical wheel angle across agency types (Chi-square: 50.2; p-value: <0.0001)

Figure 33 shows the reasons for not using critical wheel angle frequently. Around 30% of the responders from law enforcement thought this was not an effective countermeasure in improving incident response personnel safety. Law enforcement officers undergo formal training/education on traffic incident management; thus, it is surprising that one-third of police officers would feel this countermeasure is not effective. Only 6% of firefighters felt the same way. Following law enforcement, 22%–25% of the responders from DOT and the towing industry felt this was not a sufficiently effective countermeasure. Around 25% of law enforcement and 28% of paramedic responders reported being complacent and not using this countermeasure.

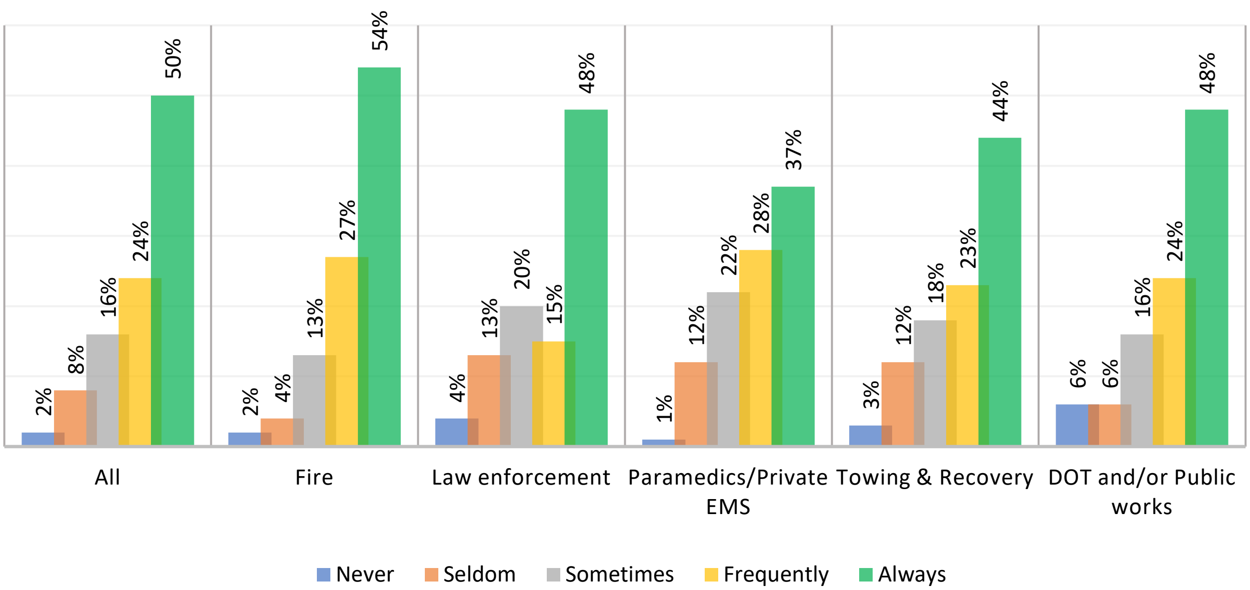

Figure 32. Frequency of critical wheel angle by agency (N = 1,557).

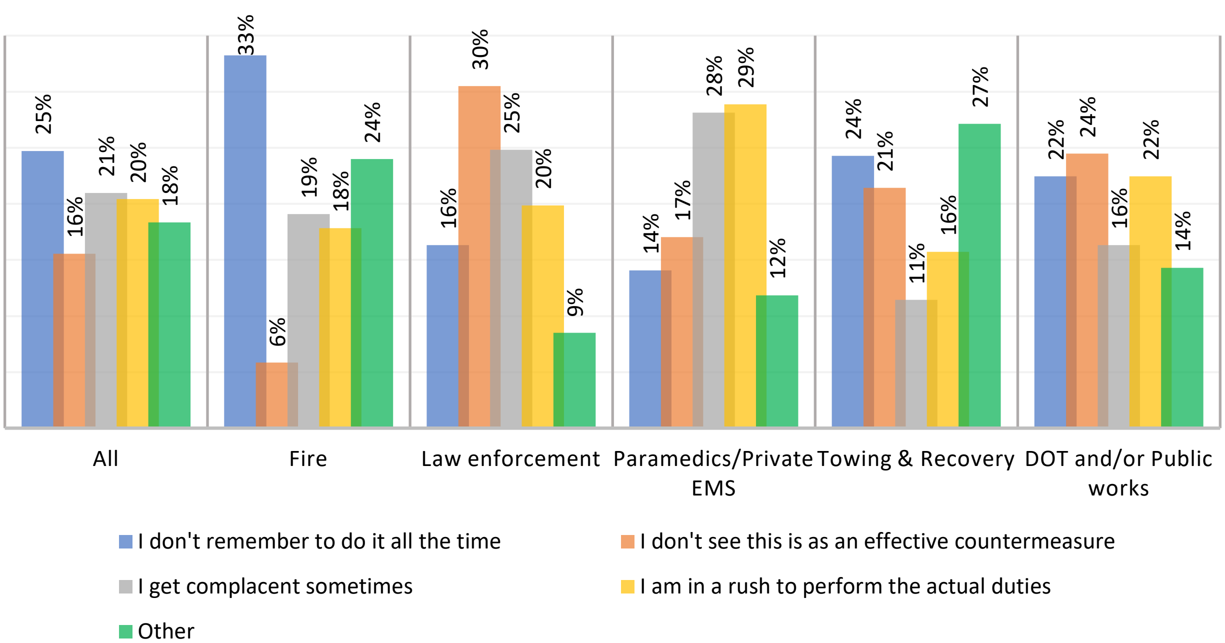

Figure 33. Reasons for not using critical wheel angle (N = 708).

Non-Traffic Side

Responders were asked how frequently they use the non-traffic side at incident sites, and Figure 34 shows their responses by agency. Responders from DOT reported the highest percentage of using the non-traffic side all the time. Because of the volume of responders who said they use the non-traffic side either all the time or sometimes, very few responders answered the question related to why this countermeasure is not being used. There were no significant differences in using this countermeasure across agencies (p-value: 0.23). Table 14 shows the most frequent reasons aggregated across agencies. Perceived ineffectiveness and being rushed were the most common responses.

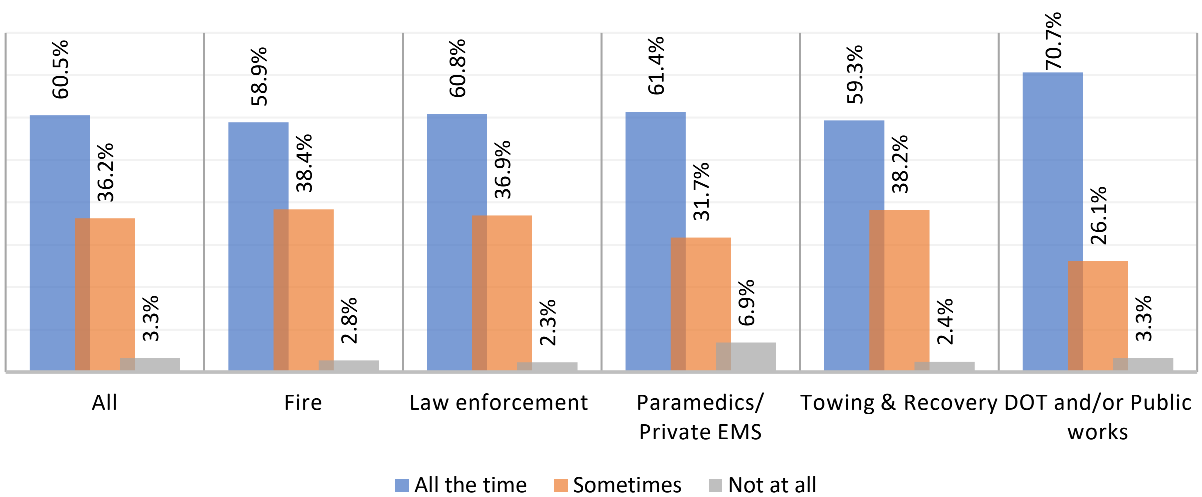

Figure 34. Frequency of use of non-traffic side overall and by agency (N = 1,504).

Table 14. Reasons for not using the non-traffic side at incident sites.

Reason for not using non-traffic side	Frequency	Percentage
I am in a rush to perform the actual duties at the incident site and don't give much attention to this	16	33%
I don't remember it to do it all the time	5	10%
I don't see this as an effective countermeasure to improve safety	21	43%
I get complacent sometimes	6	12%
Prefer not to answer	9	18%
Total	**49**	**100%**

Safety Apparel & High Visibility Apparel

Figure 35 shows the frequency of use of high visibility clothing by agency. In general, 77% of the responders said they always use high-visibility clothing while working at incident sites. Around 85% of the responders from the fire department reported consistently using this countermeasure. Paramedics reported the lowest percentage for "always" using high visibility clothing, followed by law enforcement. There were significant differences among agencies in the use of high-visibility clothing at incident sites (Chi-square: 111.6; p-value: <0.001).

Responders were asked the reasons for not using this countermeasure frequently, and the results are presented in Figure 36. Overall, 36% of the respondents who do not always wear high visibility clothing said they are complacent sometimes. Nearly half of respondents (47%) from DOTs reported being complacent. Only 5% of all the respondents reported this countermeasure not being effective, while 13% of the towing industry responders said it was ineffective. Being complacent or not remembering to wear high visibility clothing accounted for nearly 60% of the responses across all agencies.

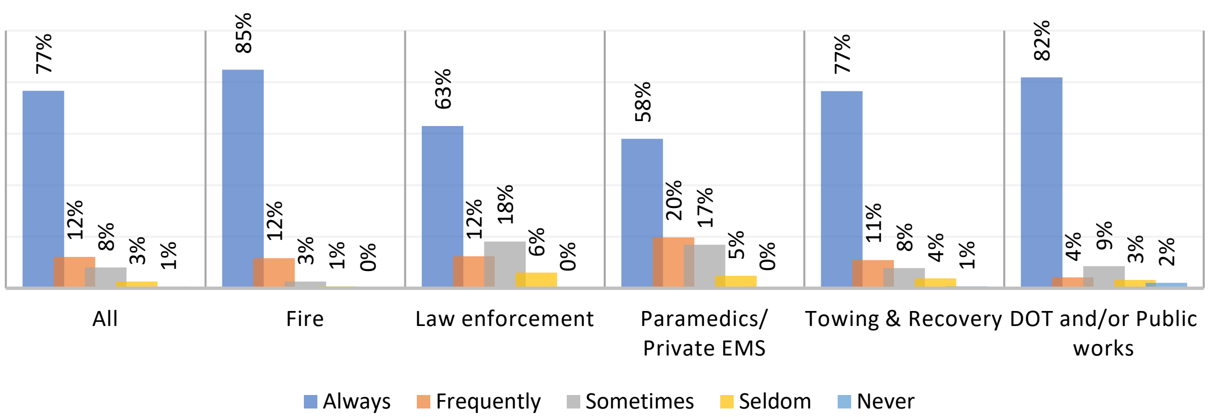

Figure 35. Use of safety apparel by agency (N = 1,519).

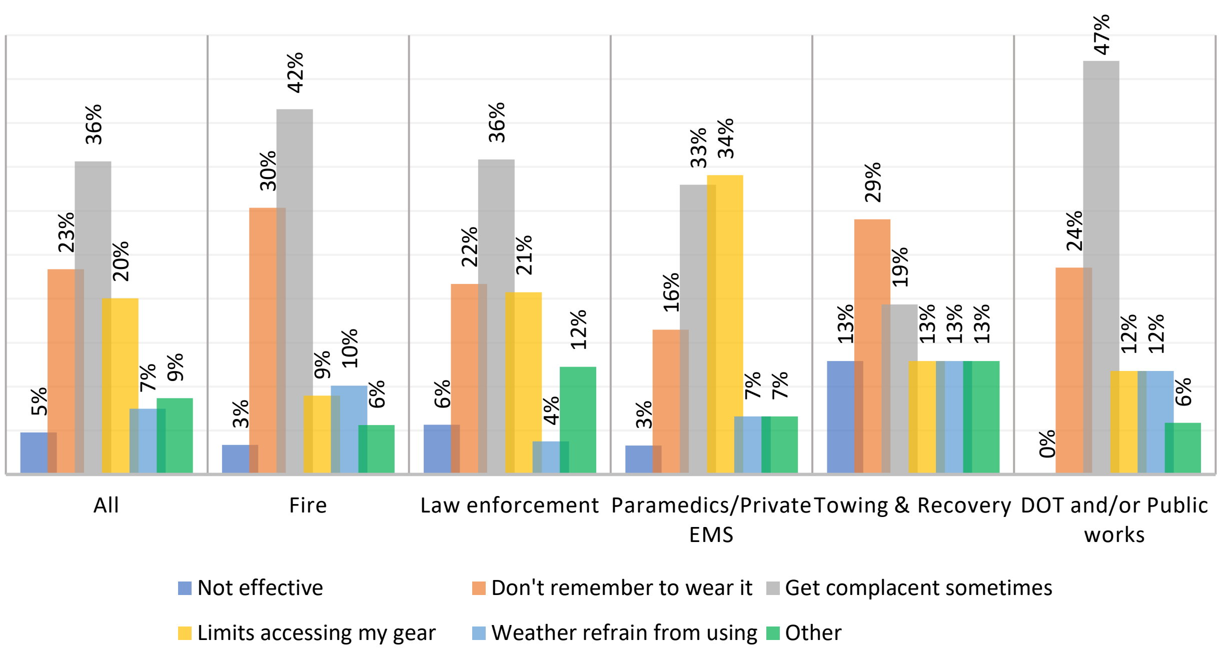

Figure 36. Reasons for not using this countermeasure across agencies (N = 360).

Emergency Vehicle Lighting

Responders were asked how frequently they use emergency vehicle lighting. The results are presented in Figure 37. Over 90% of the responders from fire reported consistently using emergency vehicle lighting, while only 60% of the paramedics reported always using it. Paramedics vehicles are often situated closest to the struck or incident vehicles, oftentimes, other responder vehicles such as police cars, fire trucks, and DOT service vehicles are situated upstream, which act as an additional buffer. In cases where the upstream vehicles are using emergency vehicle lighting, paramedics may be less likely to use lighting. Very few (around 1%) responders reported never using this countermeasure. Some agencies used this countermeasure more than others, and the differences are statistically significant (Chi-square: 118.2; p-value: <0.001).

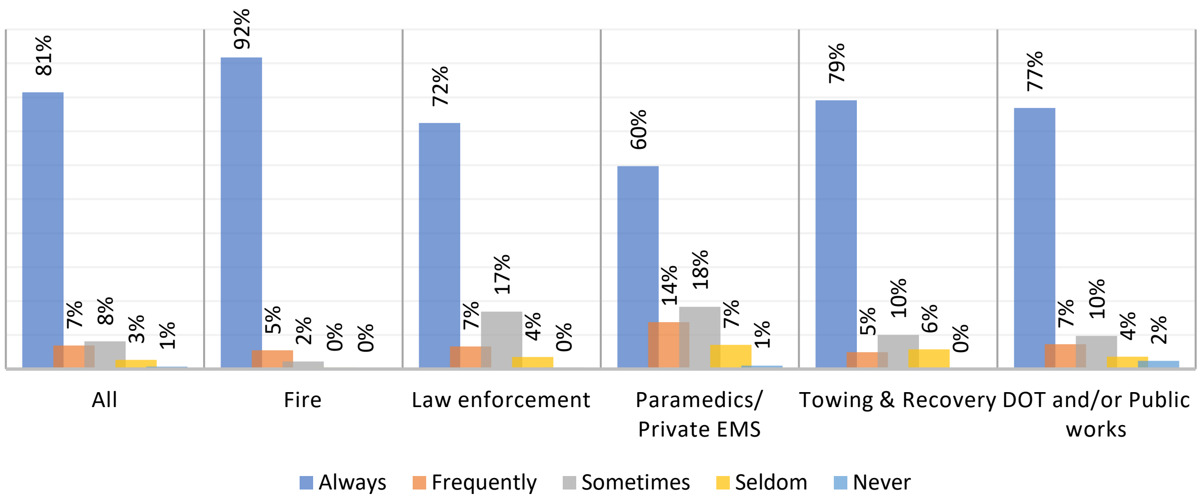

Figure 37. Frequency of emergency vehicle lighting use by agency (N = 1,399)

Approximately 40% of the responders from the towing industry said they do not use emergency vehicle lighting when surrounding lighting condition is sufficient that makes them visible, compared to approximately 20% of responders from fire and law enforcement (Figure 38). For these police and paramedics, the most commonly cited reason for not using emergency vehicle lighting by far was in cases where there was no obstruction in the line of sight.

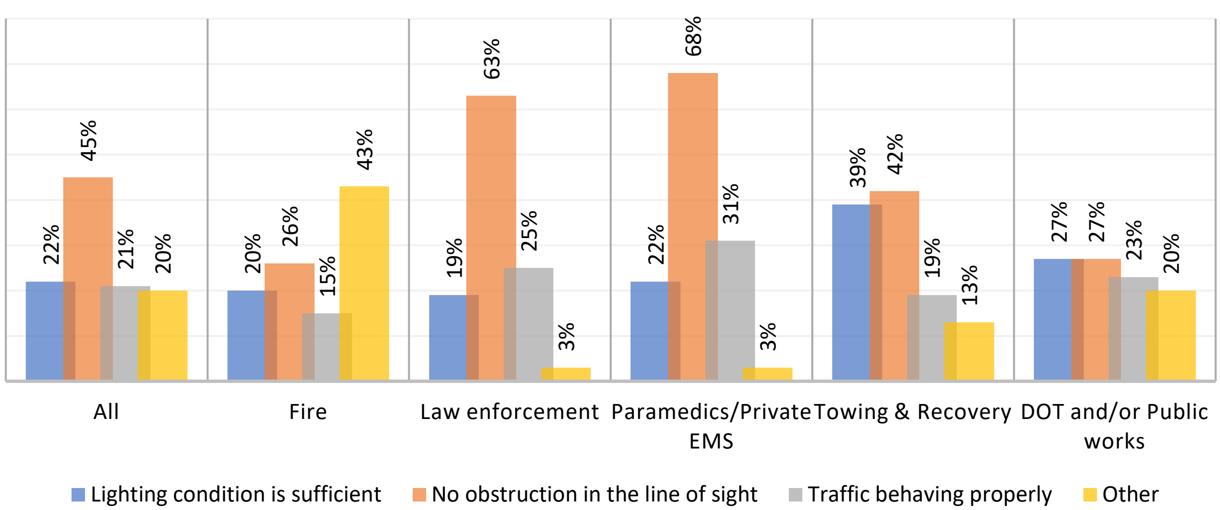

Figure 38. Reasons for not using emergency vehicle lighting (N = 373).

Advance Warning Signs

Figure 39 and Figure 40 show the frequency of advance warning signs and reasons for not using this countermeasure, respectively. This countermeasure was reported to be least used by many responders compared to other countermeasures examined in this study. Nearly 40% of responders reported never using advance warning signs to improve their safety. Towing industry reported the highest percentage of never using this countermeasure, followed by fire. Thirty-five percent of law enforcement officers said they use this countermeasure all the time, whereas only 9% of the firefighters reported using it all the time. There were statistically significant differences in using this countermeasure across agencies (Chi-square: 46.3; p-value: <0.001). The most frequent reason for not using this countermeasure is responders' not carrying them in their vehicles. Many responders said they would prefer to call for an extra support vehicle to park upstream of the incident to serve as an advanced warning than use an advance warning sign. A few responders agreed that placing and collecting these signs is cumbersome, while a small percentage said this countermeasure is ineffective.

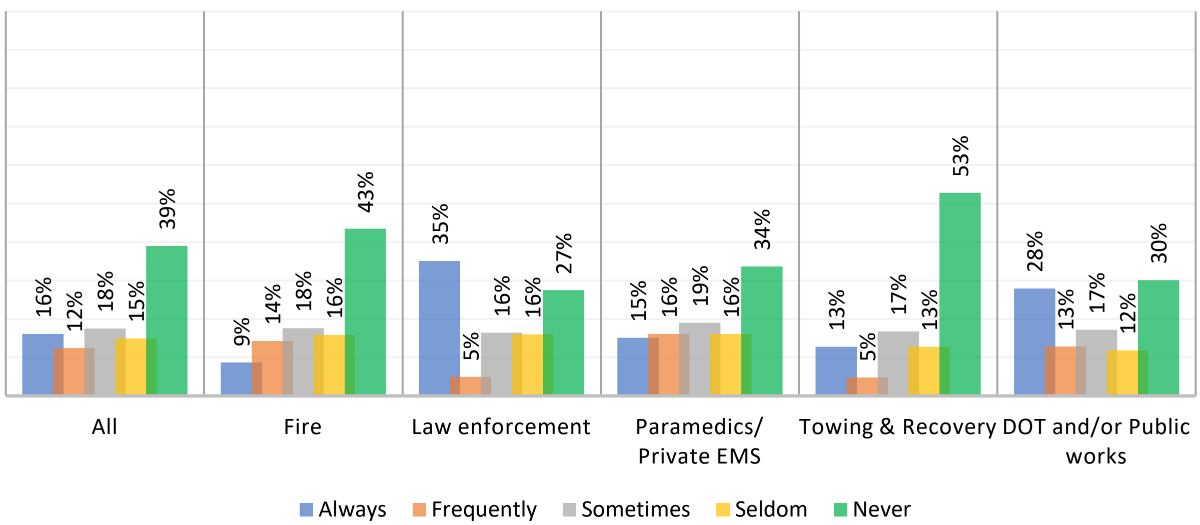

Figure 39. Frequency of use of advance warning signs (N = 1,498).

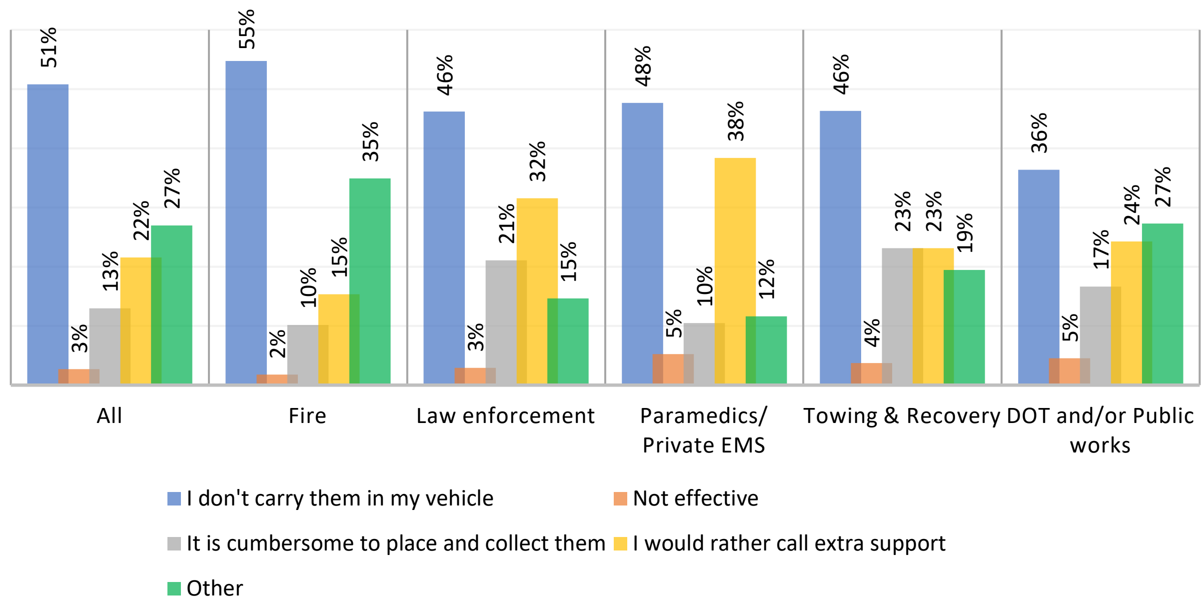

Figure 40. Reasons for not using advance warning signs (N = 1,256)

Traffic Cones

Figure 41 and Figure 42 show the frequency of traffic cone use by an agency and reasons for not using this countermeasure. Overall, 38% of the responders said they use traffic cones all the time, while 8% said they never use them. Responders from towing and EMS departments had the highest percentage of never using traffic cones. There were significant differences across age groups and agencies in the frequency of use of traffic cones (Chi-square: 158.8; p-value: <0.001). Not carrying traffic cones in the service vehicles is the most commonly cited reason for not using them and this reason was especially pronounced in the paramedic and law enforcement agency groups. While 21% of the responders from the towing industry reported it is cumbersome to place and collect traffic cones, only 7% of the DOT responders reported this reason for not using traffic cones.

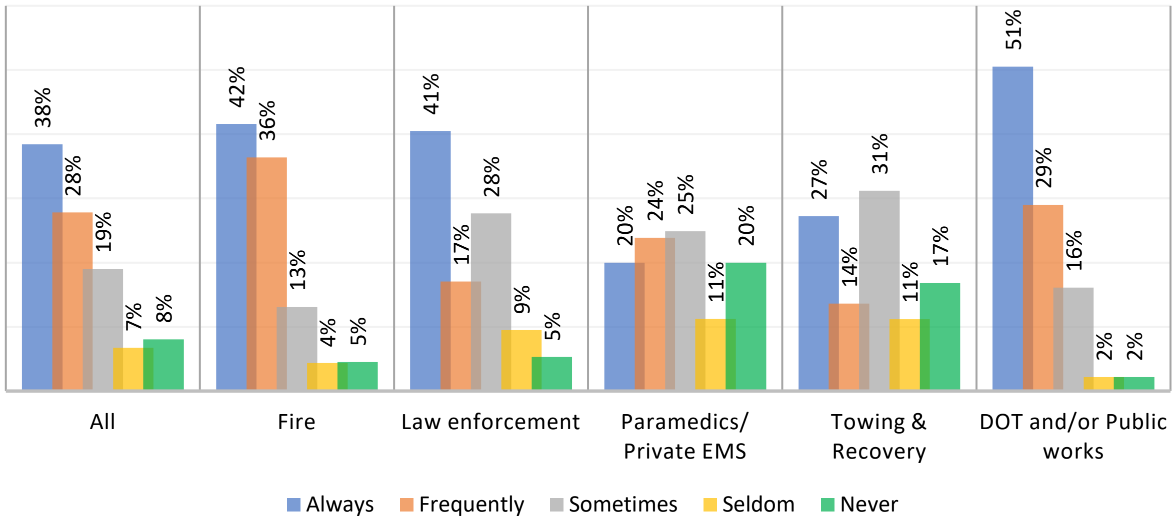

Figure 41. Use of traffic cones by agency (N = 1,500).

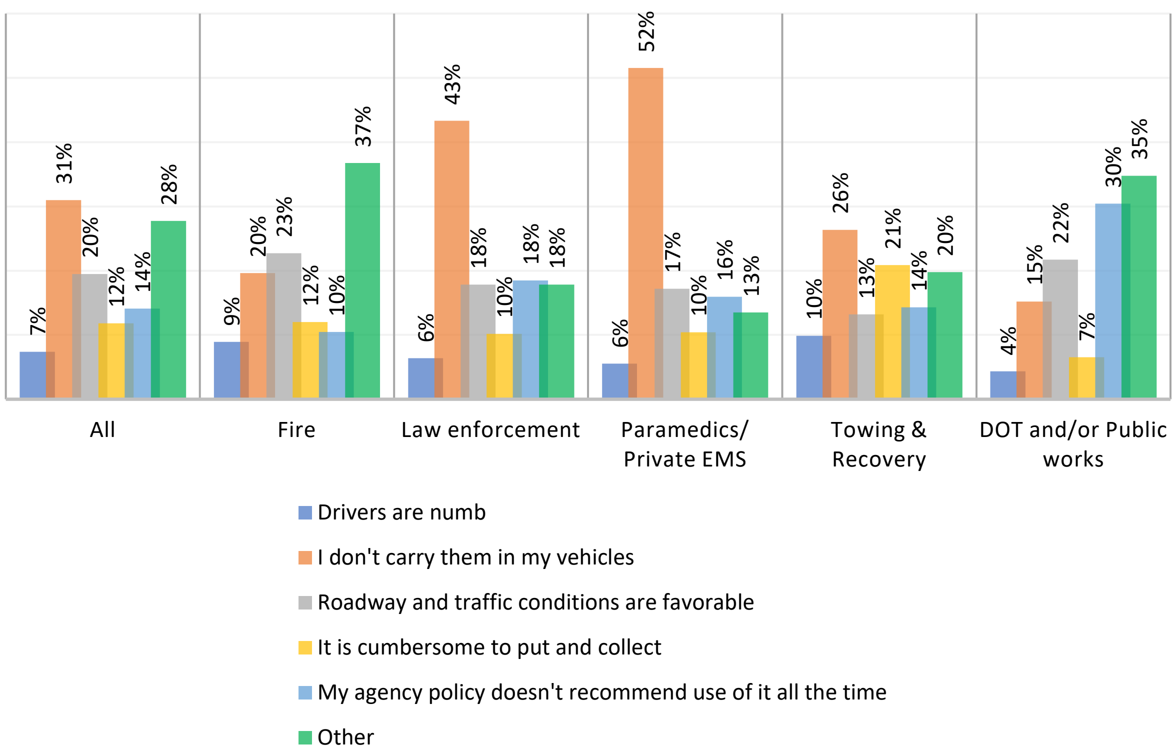

Figure 42. Reasons for not always using traffic cones by agency (N = 923).

Associations Between Training and Use of Countermeasures

An additional analysis was conducted to examine the association between the completion of TIM responder training and the use of specific countermeasures (e.g., critical wheel angle, use of traffic cones, etc.). Table 15 shows the results from the Spearman's correlation test.

While the correlations where generally small, TIM training was positively correlated with the use of advance warning signs, traffic cones, and high visibility clothing.

Table 15. Correlations between TIM responder training and other countermeasures (N = 1,317)

Countermeasure	Spearman's ρ correlation coefficient	p-value
Critical wheel angle	0.021	0.46
Non-traffic side	0.008	0.78
High visibility clothing	0.061	0.03
Emergency vehicle lighting	−0.027	0.33
Advance warning signs	0.143	0.001
Traffic cones	0.102	0.002

Note: Bold implies significance at 95% confidence level.

Safety Experiences

In addition to information regarding the use of different countermeasures, the survey queried respondents regarding their involvement in crashes and near misses while managing traffic incidents. Fifteen percent of survey participants (248 responders) reported being struck while managing traffic incidents. Table 16 shows the distributions of reported injury severities among those struck by traffic. Of these 248 responders, slightly over 50% reported that struck-by experiences caused no or minor injury that did not require treatment. Over 30% reported that they experienced moderate injuries, which required only outpatient treatment, and 13% reported services injuries that required non-ICU hospital admission. Approximately 2% reported severe and critical injuries due to struck-by incidents. Note that the distribution can be biased due to the survivorship bias of survey samples.

Table 16. Injury severity of struck-by experiences reported by survey participants (N = 248).

Injury severity	Frequency	Percentage
No injury sustained	41	16.5%
Minor: no treatment needed	89	35.9%
Moderate: required only outpatient treatment	81	32.7%
Serious: required non-ICU hospital admission	32	12.9%
Severe: required ICU observation and/or basic treatment	3	1.2%
Critical: required intubation, mechanical ventilation, or vasopressors for blood pressure support	2	0.8%

Responders were also asked if they ever experienced a near-miss incident (i.e., almost getting hit by a passing vehicle) while managing traffic incidents. Slightly less than 60% of survey participants (N = 971) reported experiencing near-misses. Those who said they experienced a near-miss incident were asked how frequently they experienced near-misses and when was the last time they experienced such an incident. Table 17 shows the distribution of the responses to these questions. Of 964 responders (7 did not answer these questions), over 12% reported that they frequently or always experience near-misses, and approximately 31% reported that they sometimes experience near-misses. Note that responders may have uneven perceptions regarding the frequency of experiencing near-misses as well as what constitutes a near miss. Thus, the responses to this survey question shed insight into the perceptions of near-miss experiences but should not be considered objectively characteristic of the safety of the working environment. Among 964 responders, 18% reported they experienced a near-miss within the last three months, and slightly less than 50% reported that it was over a year ago.

Table 17. Responses to near-miss questions (N = 964).

Near-miss experience question	Frequency	Percentage
How often do you experience a near-miss?		
Always	22	2.3%
Frequently	94	9.8%
Sometimes	297	31.2%
Seldom	538	56.6%
When was the last time you experienced a near-miss?		
In the past 3 months	176	18.3%
In the past 4 to 6 months	141	14.6%
In the past 6 to 12 months	188	19.5%
Over a year ago	458	47.5%
No answer	1	0.1%

Responders' Perceptions of Causal Factors

Participants were also asked to provide their perceptions regarding causal factors contributing to responder injuries and fatalities. Responders rated each factor on a 5-point scale (1 being least likely to cause first responder injury/fatality while five being highly likely). Figure 43 shows the responders' ratings. Careless, inattentive, or impaired drivers were considered to be the highest likely cause of injuries or fatalities to incident response personnel (61% of respondents indicated "highly likely"). The second most significant factor was lack of situation awareness, with 46% of respondents rating it highly likely to injure or kill a first responder. Other factors were rated more modestly in terms of their perceived contributions to responder injuries and fatalities.

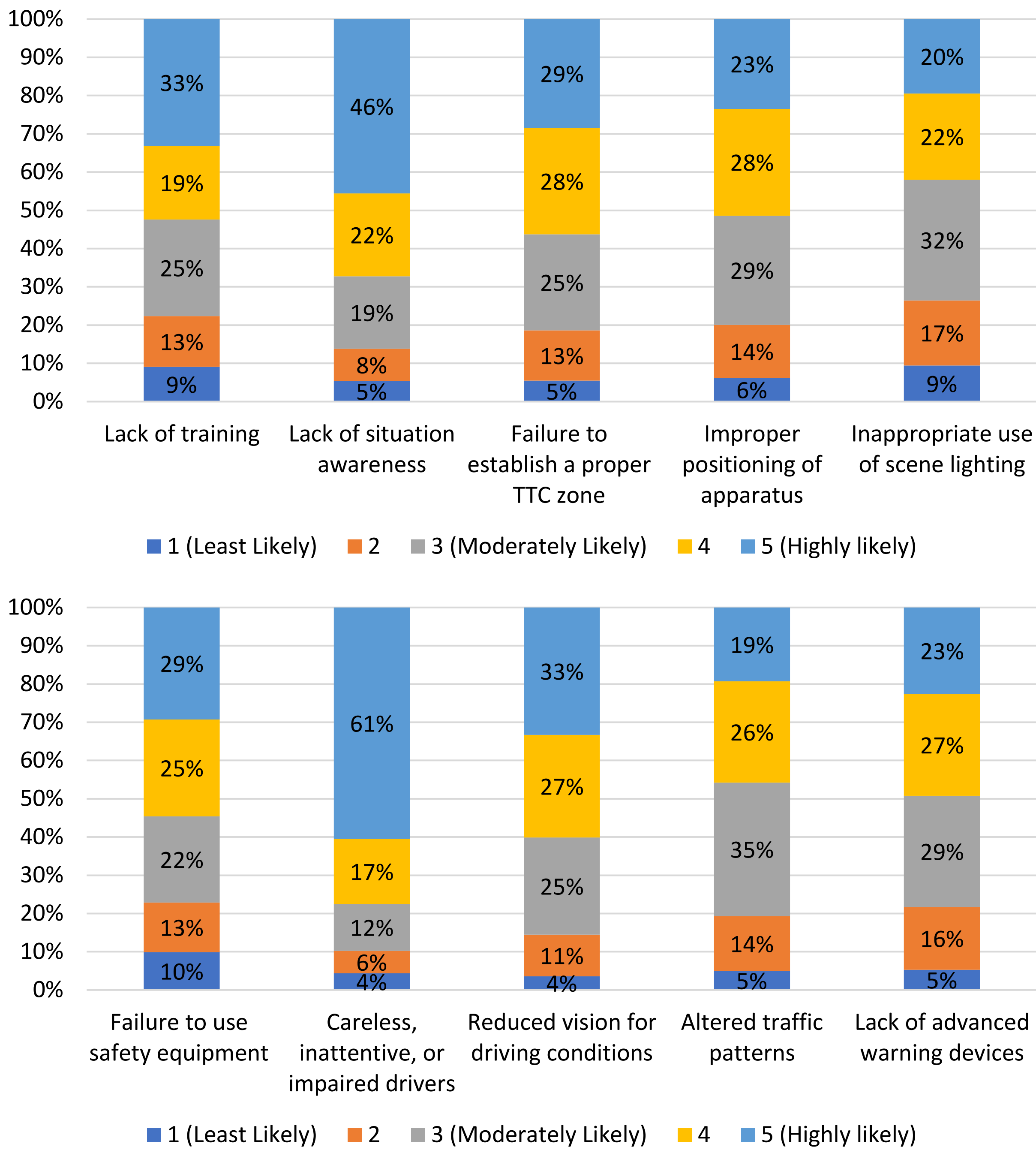

Figure 43. Respondents' ratings of causal factors related to responder-involved incidents

Modeling Results & Discussion

Responder safety can be influenced by a combination of factors, which requires modeling to systematically examine the co-existing relationships between safety and such factors. In this analysis, two models were developed to quantify the correlates of the self-reported experiences of struck-by and near-miss events. The outcome measure for each model, responder safety, was based on corresponding responses to two questions: (a) "whether you have ever been struck by a passing vehicle while managing a traffic incident?” and (b) “whether you have experienced a near miss incident from a passing vehicle while managing traffic incidents?” Since the dependent variables (having been struck and experiencing near-misses) are dichotomous (yes or no), binary logistic regression models were used to examine the relationships between responder safety and an array of independent variables of interest, including sociodemographic characteristics, work duties/agency types, training experiences, and their behaviors or responses regarding different countermeasures or safety protocols. The models estimate the odds of having been struck or experiencing near-misses for responders given a set of independent factors.

Leveraging the complete survey, the initial models included all available variables. Variables such as education and race were later removed from the final model as they showed no association at any sub-category level. Variables of interest and importance were retained in the model. Table 18 shows the descriptive statistics of variables included in the final models. Observations with missing information for these variables were removed, and a total of 1,263 observations with complete information were used for modeling.

Table 18. Descriptive statistics of modeling variables (N = 1,263).

Variables		Frequency	Percentage
Having been struck		225	17.8%
Experiencing Near-miss		831	65.8%
Gender			
	Female	171	13.5%
	Male	1,092	86.5%
Age			
	18–20	14	1.1%
	21–25	45	3.6%
	26–35	242	19.2%
	36–45	302	23.9%
	46–55	282	22.3%
	56–66	264	20.9%
	67 and above	114	9.0%
Agency			
	Towing & Recovery	99	7.8%
	Fire	581	46.0%
	DOT and/or Public works	75	5.9%
	Law enforcement (police, sheriff, etc.)	238	18.8%
	Paramedics/Private EMS	177	14.0%
	Other	93	7.4%
Training			
	Ever Attended Training (Yes)	1,137	90.0%
	Agency providing safety information (Yes)	1,066	84.4%
Safety priority			
	Essential priority	358	28.4%
	High priority	558	44.2%
	Moderate priority	276	21.9%
	Low priority	59	4.7%
	Not a priority	12	1.0%
Test runs			
	Once a month	137	10.9%
	Once a quarter	231	18.3%
	Once a year	344	27.2%
	Once every few years	312	24.7%
	Never	239	18.9%
Action review			
	Once a month	362	28.7%
	Once a quarter	298	23.6%
	Once a year	255	20.2%
	Once every few years	195	15.4%
	Never	153	12.1%
Critical wheel angle			
	Frequently/Always	932	73.8%
	Sometimes	198	15.7%
	Seldom/Never	133	10.5%
Non-traffic side			
	Frequently/Always	765	60.6%
	Sometimes	458	36.3%
	Seldom/Never	40	3.2%

Variables		Frequency	Percentage
Safety apparel			
	Frequently/Always	1,114	88.2%
	Sometimes	110	8.7%
	Seldom/Never	39	3.1%
Emergency lighting			
	Frequently/Always	1,120	88.7%
	Sometimes	101	8.0%
	Seldom/Never	42	3.3%
Emergency signs			
	Frequently/Always	371	29.4%
	Sometimes	224	17.7%
	Seldom/Never	668	52.9%
Traffic cones			
	Frequently/Always	849	67.2%
	Sometimes	234	18.5%
	Seldom/Never	180	14.3%

Struck-By Incidents

Table 19 shows the modeling results for struck-by incidents. Odds ratios are estimated to show the effect of independent variables on the dependent variable. An odds ratio greater than 1 implies a higher chance of a being struck compared to the reference (base) variable. For example, the odds of getting struck for responders between 26 and 35 years was 4.3 times compared to responders of age 67 and above. Young respondents are more likely to provide roadside service compared to senior/experienced respondents, who may be more likely to serve in manager roles; therefore, their exposures are different, which could explain in part the higher odds among young respondents. Responders from law enforcement were only half as likely to get struck by a passing vehicle compared with responders from towing industry. This was also true other agencies as well (with the exception of fire): responders from towing industry have significantly higher odds of getting struck than other responders. These industry differences may be due to a number of factors, including different operational and response-related factors as well as differences across agencies in terms of the availability and adoption of different protective countermeasures.

Based on the modeling efforts, training alone did not have an impact on the incidence of struck-by events, suggesting that existing training programs have room for improvement. Earlier in this module, it was noted that training did not significantly impact compliance with many countermeasures (see Table 15) and the results from the focus groups and survey highlighted the variability and inconsistencies in adoption and use of safety countermeasures. If training can positively impact compliance or use of countermeasures, it will likely reduce struck-by incidents among responders. Responders from agencies that do not provide safety information to their responders were 1.5 times more likely to get struck compared to responders from agencies that provide safety information to their employees, a result which was marginally significant. Responders from agencies that do not conduct frequent test runs were more likely to get struck than responders from agencies that conduct monthly test runs.

Responders who seldom or never use safety apparel were 2.9 times more likely to get struck than those who frequently or always use this countermeasure. Such outcomes could be useful in conveying information regarding risk to educate responders who believe high visibility clothing is ineffective. Similarly, responders who reported using emergency vehicle lighting only sometimes was more likely to get struck than those who frequently or always use this countermeasure. Some countermeasures did not yield any significant impact on the incidence of struck-by events in this sample, including working from the non-traffic side and use of the critical wheel angle. It was also shown that responders who always use advance warning signs had higher odds of getting struck compared to those that only sometimes use this countermeasure. It is plausible that, while placing advance warning signs on roads, responder exposure to traffic is increased. For every one-year increase in experience, the odds of being struck decreased by 8 percent, i.e., experienced responders were less likely to experience getting struck on the side of the roads.

The model also produced some counterintuitive outcomes as well, including those pertaining to action reviews where less frequent reviews were associated with fewer struck-by incidents. It is possible that having more struck-by events in practice would lead to more action reviews by an agency. Action reviews may also be likely to be conducted by large agencies that are exposed to more struck-by conflicts. It follows that these are likely endogenous variables, which may require a different modeling approach to reveal the directional relationship with the response variable.

Table 19. Logistic regression model for struck-by incidents.

Variable	Coef.	p-value	OR
Intercept	−0.18	0.48	
Gender (Base: Female)			
Male	1.00	0.13	2.73
Age (Base: 67 and above)			
18−25	1.16	0.03	3.19
26−35	1.46	<0.01	4.31
36−45	0.38	0.42	1.46
46−55	−0.04	0.92	0.96
56−66	−2.11	<0.01	0.12
Agency (Base: Towing & Recovery)			
Fire	−0.04	0.92	0.97
DOT and/or Public works	−1.01	<0.01	0.37
Law enforcement	−0.61	0.05	0.54
Paramedics/ Private EMS	−1.66	<0.01	0.19
Other	−0.55	0.11	0.58
Training (Base: Yes)			
No	0.00	0.99	1.00
Agency information (Base: Yes)			
No	0.42	0.06	1.52
Safety priority (Base: Essential priority)			
High	0.67	0.02	1.96
Moderate	1.02	0.02	2.78
Low	0.89	0.27	2.44
Test mock (Base: Once a month)			
Not a priority	1.45	<0.01	4.27
Once a quarter	0.81	0.04	2.24
Once a year	0.99	0.01	2.69
Once every few years	1.01	0.02	2.74
Never	−0.09	0.72	0.92
Action review (Base: Once a month)			
Once a quarter	−0.55	0.05	0.58
Once a year	−0.45	0.15	0.64
Once every few years	−0.62	0.10	0.54
Never	−0.45	0.03	0.64
Non-traffic side (Base: Always)			
Sometimes	−0.62	0.23	0.54
Never	−0.29	0.26	0.75
Critical wheel angle (Base: Always/Frequently)			
Sometimes	−0.90	0.77	0.92
Seldom/Never	0.35	0.27	1.42
Safety apparel (Base: Always/Frequently)			
Sometimes	0.66	0.17	1.92
Seldom/Never	1.07	<0.01	2.92
Emergency lighting (Base: Always/Frequently)			
Sometimes	1.21	0.01	3.37
Seldom/Never	−0.07	0.78	0.93
Advance signs (Base: Always/Frequently)			
Sometimes	−0.54	0.02	0.59
Seldom/Never	0.03	0.89	1.03

Variable		Coef.	p-value	OR
Traffic cones (Base: Always/Frequently)				
	Sometimes	−0.17	0.56	0.84
	Seldom/Never	0.04	<0.01	1.04
Work experience (number of years)		−2.52	<0.01	0.08
Summary Statistics				
	Number of observations	1,263		
	Pseudo R-square	0.22		
	Log-likelihood	−459.17		
	AIC	996.34		

Note. AIC = Akaike Information Criterion.

Near-Miss Events

Table 20 shows the modeling results for near-miss events. Middle-aged responders (36–45 years) were twice as likely to experience near-miss incidents as responders aged 67 and above. Similar to the struck-by outcomes, responders from DOT/Public works and law enforcement had lower odds of experiencing near misses than responders from the towing industry. Responders from agencies that do not conduct frequent test runs were more likely to experience near misses while working at incident sites. Responders who seldom/never use emergency vehicle lighting were 1.6 times more likely to experience near-miss incidents than those who frequently/always use it. Responders who frequently use advance warning signs and traffic cones have lower odds of experiencing near misses.

Table 20. Logistic Regression Model for Near Misses Events.

Variable		Coef.	P-value	OR
Intercept		0.35	0.08	
Gender (Base: Female)				
	Male	0.50	0.22	1.65
Age (Base: 67 and above)				
	18−25	0.17	0.60	1.18
	26−35	0.44	0.13	1.56
	36−45	0.74	0.01	2.09*
	46−55	−0.17	0.56	0.85
	56−66	−0.80	0.01	0.46*
Agency (Base: Towing & Recovery)				
	Fire	0.24	0.56	1.27
	DOT and/or Public works	−1.48	0.00	0.23*
	Law enforcement	−1.15	0.00	0.32*
	Paramedics/ Private EMS	−0.43	0.26	0.66
	Other	−0.38	0.09	0.68
Training (Base: Yes)				
	No	−0.37	0.08	0.69
Agency information (Base: Yes)				
	No	0.01	0.97	1.01
Safety priority (Base: Essential priority)				
	High	0.27	0.23	1.30
	Moderate	0.22	0.55	1.24
	Low	−0.03	0.97	0.97
	Not a priority	0.37	0.15	1.44

Variable	Coef.	P-value	OR
Test Runs (Base: Once a month)			
Once a quarter	0.62	0.01	1.85*
Once a year	0.85	0.00	2.33*
Once every few years	0.66	0.03	1.93*
Never	−0.05	0.80	0.95
Action review (Base: Once a month)			
Once a quarter	−0.38	0.08	0.69
Once a year	−0.19	0.44	0.83
Once every few years	0.11	0.70	1.12
Never	−0.14	0.36	0.87
Non-traffic side (Base: Always)			
Sometimes	−0.33	0.39	0.72
Never	−0.15	0.45	0.86
Critical wheel angle (Base: Always/Frequently)			
Sometimes	−0.32	0.18	0.73
Seldom/Never	−0.41	0.15	0.67
Safety apparel (Base: Always/Frequently)			
Sometimes	−0.10	0.82	0.90
Seldom/Never	0.18	0.53	1.20
Emergency lighting (Base: Always/Frequently)			
Sometimes	0.28	0.51	1.32
Seldom/Never	0.49	0.02	1.62*
Emergency signs (Base: Always/Frequently)			
Sometimes	0.63	0.00	1.88*
Seldom/Never	0.43	0.04	1.53*
Traffic cones (Base: Always/Frequently)			
Sometimes	0.41	0.08	1.51
Seldom/Never	0.04	0.00	1.04*
Work experience (number of years)	**−0.65**	**0.52**	
Summary Statistics			
Number of observations	1,263		
Pseudo R-square	0.16		
Log-likelihood	−679.94		
AIC	1437.89		

Note. AIC = Akaike Information Criterion.

Conclusions

This study conducted a national responder safety survey to gather incident response personnel's perceptions of adopting countermeasures and safety protocols in their TIM practices. Through descriptive analysis and modeling of survey data, this study generated important insight related to the compliance with or use of different countermeasures. Through modeling approaches, this study identified how use of countermeasures related to different safety outcomes, such as getting struck by passing vehicles and experiencing near misses.

For most of the countermeasures examined, there were significant differences among agencies in their frequency of use. Some of the key countermeasure-specific findings include the following:

- ***Traffic Incident Management Responder Training***—A majority (88%) of the responders reported that they received TIM training. Among those that did not receive training, not being aware of the existence of training programs was a prominent reason (47%). Responders from towing and recovery industry were less likely to receive training than responders from other agencies. While the correlations when small, TIM training was positively correlated with the use of some of the other countermeasures, such as advance warning signs, traffic cones, and high-visibility clothing.
- ***Non-Traffic Side***—Many responders indicated that they use the non-traffic side either all the time or sometimes. Those that did not use this countermeasure frequently did not perceive the countermeasure to be effective and/or indicated that they were often in a rush to perform other tasks.
- ***Critical Wheel Angle***—Half of the responders said they always use critical wheel angle countermeasures. Paramedic responders reported the lowest percentage of always using this countermeasure and cited complacency and time pressure as reasons for not using this countermeasure.
- ***Test Runs, Mock Drills, and Action Reviews***—Only 20% of the responders reported never having test runs or mock drills, while 27% reported having action reviews every month or quarterly. For action reviews, 30% of the responders reported having monthly action reviews, while 13% reported never having an action review. A common reason that agencies do not frequently use these countermeasures was that they require a lot of resources such as time, money, effort, and staffing, which agencies might not have.
- ***Safety Apparel/High-Visibility Apparel and Emergency Vehicle Lighting***—High visibility apparel and emergency vehicle lighting were the two most frequently used countermeasures by the responders. Complacency was the most common reason cited for not always using high-visibility clothing. While over 90% of the responders from the fire department reported always using emergency lighting, only 60% of the responders from paramedics reported always using emergency vehicle lighting.
- ***Advance Warning Signs***—Advance warning signs were the least used countermeasure among all the responders. The most common reason for their non-use was not carrying advance warning signs in the service vehicles. In many cases, responders preferred calling for an additional service vehicle to park downstream to serve as advance warning to passing motorists.
- ***Traffic Cones***—Around 38% of the responders reported always using traffic cones. Responders from paramedics reported the highest percentage of “never” using this countermeasure, followed by towing and recovery with 17%. Not carrying traffic cones in the service vehicles was the most common cause of not using this countermeasure.

Regarding the safety experiences of respondents, roughly 15% of the responders reported involvement in a struck-by incident. Additionally, approximately 60% of the responders reported experiencing near-miss incidents. Based on the modeling exercise, responders from towing and recovery had the highest odds of experiencing struck-by incidents compared to any other agency group except for fire departments, which was equivalent. Responders who do not always or frequently use safety apparel, emergency lighting, and traffic cones had higher odds of getting struck than those who frequently use these countermeasures.

Responders trained in TIM did not experience lower odds of being involved in struck-by or near miss incidents than responders without training. This could be due in part to the fact that responders who receive training did not necessarily have higher compliance or use rates for the various countermeasures (with a few exceptions) than those without training.

A common reason that responders are not trained is not being aware of the existence of TIM responder training programs. Advertisements targeting specific population groups about the existence/availability of resources could help increase awareness. Training should also be designed to increase the compliance of countermeasures. Some responders expressed that their agency does not have sufficient staffing to allow for replacements to cover their shifts if individuals wanted to complete training. To overcome this issue, other training approaches could be considered, such as interactive online training programs that could reduce the time commitment. Further, compartmentalizing the training into smaller sections could help responders attend the training at their own pace and time availability. Lastly, mandating training or certification for responders from different agencies could increase the uptake of training.

Locating equipment on the service vehicle's passenger side could help boost the degree that responders work from the non-traffic side at incident sites. Also, reminders via stickers on the dashboard or service vehicle to use this countermeasure could help promote the adoption. At the agency or organizational level, changing the safety culture could positively influence responders from the towing industry to embrace different countermeasures. This could be done by educating them about the increased risks associated with not complying with or using different countermeasures, such as high-visibility clothing.

Given that the use of advance warning signs increased the odds of getting struck in the current sample, continuing efforts are needed to understand the relative benefits and risks associated with this countermeasure. Advanced modeling techniques such as random parameter models and machine learning may need to be considered to uncover hidden or high-dimensional patterns in the survey data.

Limitations

Although the survey offered many important insights, there are a few noteworthy limitations. First, the survey is limited to a small number of countermeasures. Other important countermeasures or safety protocols were not examined in this survey. Second, as with all surveys, there is the possibility of biased, incomplete, or false answers by individuals in their completion of the survey. Not unrelated, the sampling procedure may not have yielded a representative sample of response personnel nationwide. For example, firefighters were heavily represented in the current sample. That said, many of the results are broken out at the agency level, which can help reduce bias caused by over-representation. Third, it is also possible that responders may have differed in their understanding or interpretation of some survey questions. Lastly, the survey participants were limited to incident response personnel. Other motorists play an important role and may have different perspectives on the effectiveness of countermeasures and the general traffic incident management from incident response personnel. It would also be advisable to gather more information about the frequency of training to supplement some of the current results. Future research can help address some of the limitations of this study.

TECHNICAL MODULE 4: Text Mining of News Data

Introduction

Researchers and safety experts primarily rely on quantitative data analysis to identify countermeasures (e.g., Banerjee and Khadem, 2019; Tefft, 2016). However, meaningful and high-quality data concerning the safety of incident response personnel is not easy to obtain. For example, traditional crash data cannot be filtered to clearly identify crashes involving incident response personnel. Therefore, researchers must rely on secondary data sources such as surveys, focus groups, etc., to conduct qualitative data analysis. An additional source is publicly available news data regarding the responder-involved incidents and the environment and circumstances in which these incidents occurred. For instance, some news reports reveal the road environments, weather, and causes of the incidents. However, news data tends to be unstructured, thereby creating challenges for quantitative analysis. To address this issue, this study applied text mining technology to extract useful information from news data and create a structured dataset for analysis. More specifically, the goal of this module is to leverage news reports to provide insights regarding contributing factors of the responder-involved incidents, which are valuable information for developing potential countermeasures that protect roadside service and incident response personnel.

This study aimed to investigate the first responder–involved incidents reported in the news in recent years. This study collected a total of 5,113 responder-involved incident news reports. Through text mining, this study identified key attributes of these news-reported incidents and examined these attributes in relation to different incident outcomes, i.e., injury severity of the responder involved in the struck-by incident.

Data Collection

The team pulled news reports from the website, https://www.respondersafety.com/, managed by the Emergency Responder Safety Institute (ERSI). The respondersafety.com website collects, re-posts, and re-distributes first responder news from various news media. The website groups news into three types of responder-involved incidents: near-miss incidents, struck-by incidents, and line-of-duty deaths (LODD). According to the Occupational Safety and Health Administration (OSHA), a near miss is an incident in which no property was damaged and no personal injury was sustained, but where damage or injury could have occurred given a slight shift in timing or position. Near misses also may be referred to as near accidents, accident precursors, injury-free events, and, in the case of moving objects, near-collisions (Keith, 2021). Struck-by incidents occur when a responder comes into forcible contact with other road users (most often a passing vehicle). On the respondersafety.com website, the LODD incidents refer to events that killed on-duty first responders from any agency, including fire, police, emergency medical service, and towing service. Figure 44 shows example news reports from the respondersafety.com website and the original news from source media.

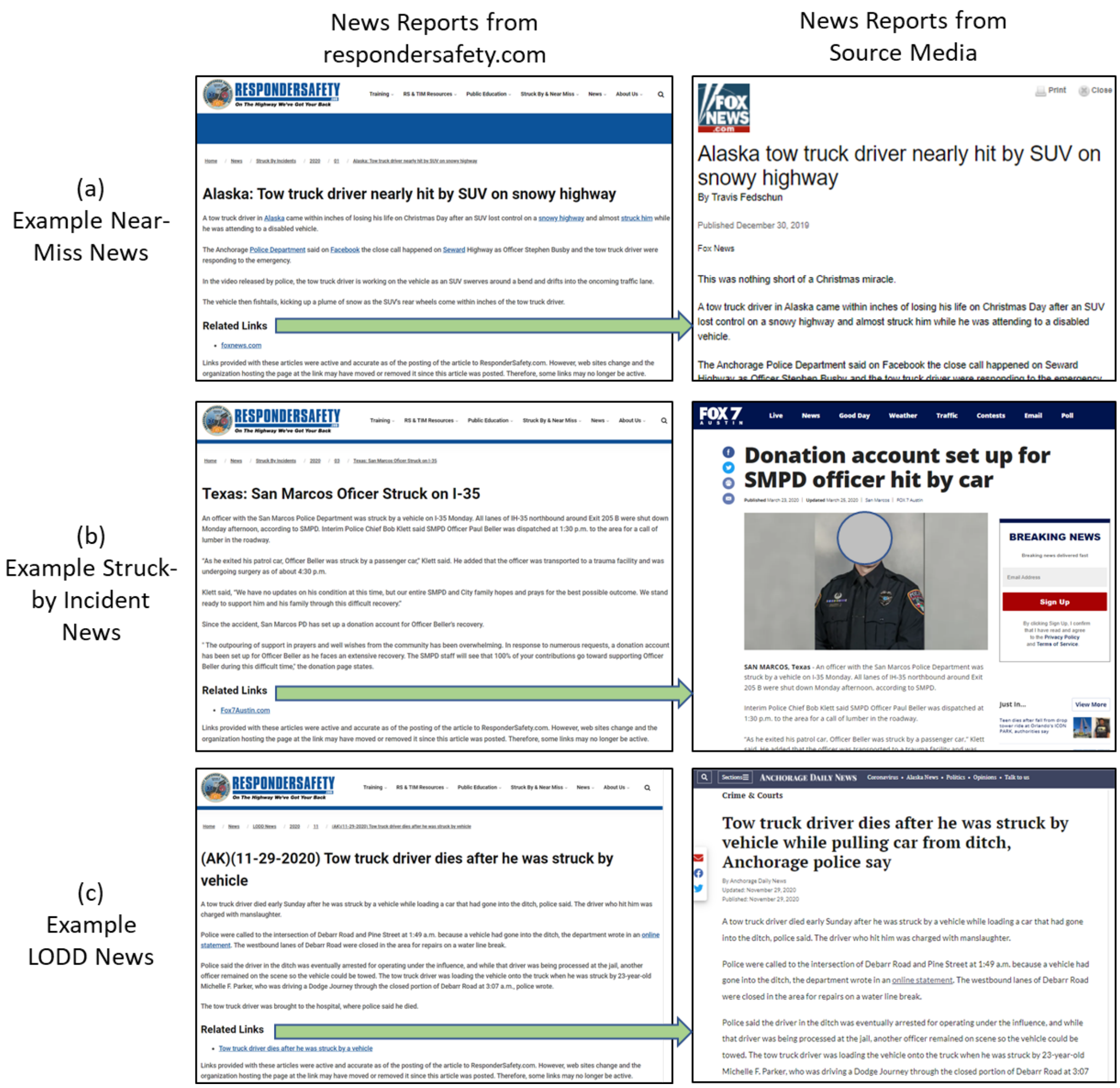

Figure 44. Example news reports from the respondersafety.com website and the original news from media sources: (a) near-miss, (b) struck-by, and (c) LODD.

The news data are textual and can be readily tabulated in an Excel file using the respondersafety.com website data management system. The dataset has the following columns: incident type (three categories), agency type (fire, police, tow, and EMS), news reporting date (year, month, and day), incident day of the week, and the body of news text. The website management team manually coded the information. Another advantage of using news data from the ERSI website is that there is no duplication of news for the same incidents.

This study collected news reports dated between July 11, 2001, and December 6, 2020. News reports related to 5,113 responder-involved incidents were obtained from the respondersafety.com website. As shown in Table 21, nearly 90% of sampled news reports are for struck-by incidents, 7.5% are LODD incidents, and only 2.7% are for near-miss incidents. Note that the proportions do not reflect the distributions of these events in the real world. According to the Safety Pyramid developed by Heinrich (1941), minor events such as near-miss incidents are more likely to be underreported than severe incidents that cause factual damages and injuries (Davis and Company, Inc., 2015).

Table 221. Proportions of responder-involved incident types in sampled news reports

Incident Type	Count	Percentage
Near-miss	139	2.7%
Struck-by-incident	4,590	89.8%
Line-of-duty-deaths (LODD)	384	7.5%
Total	5,113	100%

Figure 45 shows the distribution news reports across the 50 states in the US. For the majority of near-miss reports that were identified, state information was missing and so these data are excluded from the figure. Not surprisingly, the numbers shown in the figure are associated with state populations, with California, Texas, Florida, Ohio, Maryland, Pennsylvania and New York accounting for a large proportion of the news reports regarding struck-by and LODD incidents.

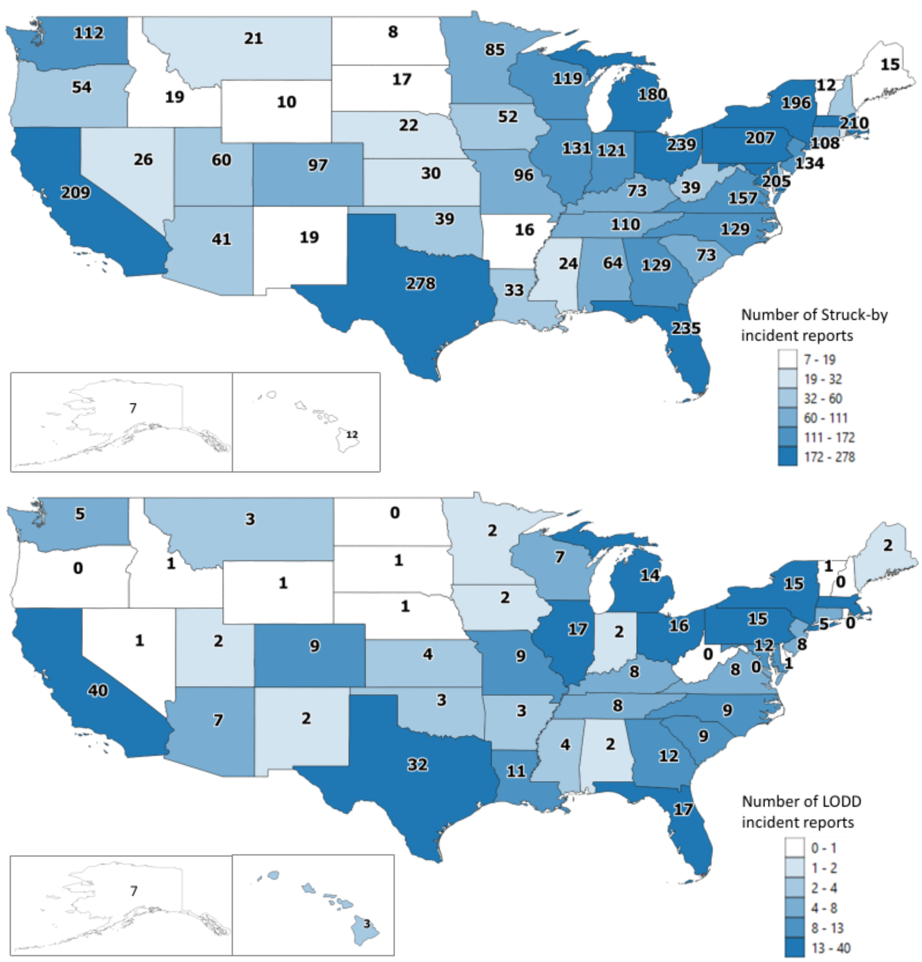

Figure 45. State-level numbers of news reports for Struck-by (top panel) and LODD (bottom panel) incidents.

Text Mining Method

Term Frequency–Inverse Document Frequency

Term Frequency–Inverse Document Frequency (TF-IDF) is a popular term weighting scheme that can reflect the importance of a word in a document within a collection or corpus (Aizawa, 2003). TF-IDF is widely used in text-based data analysis research; a survey conducted in 2015 showed that 83% of text-based recommender systems in digital libraries applied TF-IDF (Beel et al., 2016). Instead of measuring the frequency of a word that appears in the whole document, TF-IDF considers both the word frequency in a single document and the frequency of documents that contain the word across the entire collection. In other words, TF-IDF can be offset by the number of documents within a corpus that contain the word, which helps to adjust because some words appear more frequently in general.

TF-IDF is constructed in two parts—Term Frequency (TF) and Inverse Document Frequency (IDF). TF can be summarized as the weight of a term that occurs in a document. There are several ways to calculate this frequency (Manning et al., 2008). Equation 5 shows the calculation method of TF used in this study.

$$tf(t,d) = \frac{f_{t,d}}{\sum_{t' \in d} f_{t',d}} \tag{5}$$

where $f_{t,d}$ is the raw count of a term in a document, i.e., the number of times that term t occurs in document d. $f_{t',d}$ is the total number of words in a document.

In the second part, an inverse document frequency factor is incorporated, which diminishes the weight of terms that occur very frequently in the document set D and increases the weight of terms that rarely occur (Robertson, 2004). In other words, the IDF of a word is the number of documents in a corpus separated by the frequency of the text that contains the word. Equation 6 shows the calculation methods of IDF based on all the documents and TF-IDF is calculated as Equation 7.

$$idf(t,D) = log(\frac{N}{|\{d \in D, t \in d\}|}) \tag{6}$$

$$tfidf(t,d,D) = tf(t,d) \cdot idf(t,D) \tag{7}$$

Information Extraction

Text mining is the process of transforming unstructured textual information into a structured format for text analysis. This study used text mining approaches to convert each news report to a list of TF-IDF determined keywords that contain useful information for further analysis. Additional keywords of interest relevant for this study (e.g., clearing the road, conducting a traffic stop, etc.) were manually added to the list. Key information was extracted from news reports to provide insight into the following questions:

- Agency: What agency responded to the incident?
- Time: When did the incident occur?
- Operation: What were the responders doing prior to the incident?
- Primary Contributing Factor: What caused the incident?
- Weather: What was the weather at the time of the incident?
- Location: Where did the incident happen?
- Countermeasure: What countermeasure was used at the scene to protect responders?

These questions relate to different attributes of these incidents, and the answers to these questions represent values or labels for a particular attribute. In a tabular dataset, the questions are column names, and the answers are values at different rows under each column. The process is similar to filtering keywords of interest from a news report. Some keywords that have the same or similar meaning may be phrased differently. For instance, three different keywords, "traffic stop", "stop traffic", and "pull over," have the same meaning; they refer to the temporary detention of a driver of a vehicle by police to investigate a possible crime or minor violation of the law (LaFave, 2004). To capture keywords in various phrases, tenses, or forms, this study employed a text mining python package called Spacy (https://spacy.io/). Some of the key steps and terminologies are as follows:

- Tokenization: Segmenting text into words, punctuation marks, etc.
- Part-of-Speech (POS) Tagging: Assigning word types for tokens, like verb or noun.
- Dependency Parsing (DEP): Assigning syntactic dependency labels, describing the relations between individual tokens, like subject or object.
- Lemmatization: Assigning the base forms of words. For example, the lemma of "was" is "be," and the lemma of "rats" is "rat."
- Sentence Boundary Detection (SBD): Finding and segmenting individual sentences.
- Named Entity Recognition (NER): Labelling named "real-world" objects, like persons, companies, or locations.

Spacy contains time entity annotations, making it particularly adept at extracting the time information from news reports. However, the extracted time information might not refer to the time of the incident. Other times such as report time, funeral time, etc., could also be extracted. To eliminate the non-incident time information, the following steps were performed:

1. Merge the noun chunks (e.g., "7", "a.m." → "7 a.m.").
2. Use NER to label the "time" entities (e.g., "Monday afternoon," "early morning").
3. Check the DEP of the time entities and identify the events related to the time entities.
4. Remove the time entities that are not related to the incident.

Unlike time entities, other information such as operation and primary contributing factor has no corresponding entity annotations or labels in the Spacy package, so it is necessary to set the entity annotations for specific information. Table 22 shows the entity annotations for Operation, Primary Contributing Factor, Weather, Location, and Countermeasure. With entity annotations and keywords, the answers to seven questions can be extracted thoroughly from news reports. Key text mining steps are as follows:

1. Separate the sentences
2. Extract the sentences according to the subject that is related to the keywords (e.g., operation: the subject is agency; primary contribution factors: the subject is perpetrators)
3. Check the token; lemma in each sentence to see if it matches the keywords list
4. Generate the information by joining the neighbor tokens according to different keywords (Style 1: token, keyword, token; Style 2: token, token, keyword;)
5. Manually check if the information is extracted correctly

Table 222. Entity annotations and relevant keywords

Attributes	Entity annotations	Relevant keywords (After lemmatization)		
Operation				
	Assistant	Assist	Help	Rescue
	Conducting traffic stop	Traffic stop	Stop traffic	Pullover
	Directing traffic	Direct traffic	Traffic control	Control traffic
	Enter accident scene	Enter		
	Leave accident scene	Leave		
	On the accident scene	On the scene	At the scene	Investigate
	Patrolling	Patrol		
	Road cleaning	Debris	Clean	Remove
	Respond to an accident	Respond		
Primary Contributing Factor				
	Distraction/inattention	Distract	Inattention	Fatigue
	DUI/DWI	DUI, DWI	Intoxicated	Alcohol
	Lost control	Lost control	Out of control	
	Speeding	Speeding		
Weather				
	Rain	Thunderstorm	Rainstorm	Rain
	Snow	Snowstorm	Ice	Snow
	Fog	Fog		
Location				
	Median	Median	Middle	
	In lane	On the road		
	Roadside	Sides	Shoulder	
Countermeasure				
	Emergency lights	Emergency		
	Traffic cones	Cones		
	Advanced warning signs	Warning signs		

Note: "Agency" entity annotations include ambulance, deputy, DOT, DOT truck, DPS, EMS, Firefighter, Officer, Patrol, Police, Sheriff, Tow truck driver, Trooper, Worker, and other. "Time" entity annotations include early morning, morning, afternoon, evening, and night. Their relevant keywords (after lemmatization) are not available.

Results

Overview of Extracted Information

Table 23 provides an overview of the extracted information, showing the counts and percentages of news reports from which specific attributes were extracted. Note that the agency information was already coded in the data downloaded from the website; therefore, the agency attributes are identified in 100% of news reports. Some attributes could not be detected or gleaned from the text; therefore, the attributes are not accounted for in those instances. This is based on the text mining outcomes; the true extent of information loss is unknown as that would require manual identification of the attributes of each incident reported by the news. Results show that the time attribute, showing the time of the incident, can be detected in over 60% of sampled news reports. The operation-related attribute can be detected in 43% of news reports. Among 24% of sampled news reports, the primary contributing factor can be found. In about 20% of news reports, information was found about the incident location. Information about weather was found in less than 4% of news reports, and mentions of countermeasures used by responders to manage traffic incidents, such as emergency lighting, were found in 7% of reports. It is important to note that, in most cases, percentages and distributions presented in the Results section only represent the news reports where a particular attribute was identified. For those attributes that appeared only in a small percentage (< 25%), only summary tables are provided.

Table 223. Summary of extracted information (N = 5,113 news reports total)

Attributes	Number of news reports with identifiable attribute	Percentage
Agency	5,113	100%
Time	3,130	61.2%
Operation	2,193	42.9%
Primary Contributing Factor	1,226	24.0%
Weather	189	3.7%
Location	1,063	20.3%
Countermeasure	366	7.2%

Agency

Agencies coded in the news report data include ambulance, EMS, DOT, DPS, public worker, tow truck driver, firefighter, law enforcement, and other. Table 24 shows the agency attributes and the distributions across three incident types (near-miss, struck-by, LODD; see also Figure 46). Note that the agency information labeled in the news report data indicates which agency's responders were struck or killed in those events and not the agencies that participated in the incident management. Law enforcement agencies were represented in the largest proportion of struck-by and LODD incidents reported by the news (over 78% of struck-by incidents and nearly 60% of LODD). Compared to other agencies, responders from law enforcement agencies may be exposed to more risks while working on the road; they may also receive greater media attention and be more likely to be reported by the news. Nearly 20% of reported LODD incidents involved tow truck drivers; however, interestingly, this group only accounted for roughly 3% of news coverage related to struck-by incidents. Firefighters were represented in 13% of LODD news reports and

11.7% of reported struck-by incidents. They were also disproportionately represented in near miss reports, accounting for over 90% of those reports (again noting that this was a small incident category).

Table 224. Agency representation across incident type, sample of U.S. news reports, 2001–2020.

Agency	Near-miss		Struck-by		LODD		All Incidents	
Ambulance/EMS	4	2.9%	130	2.8%	10	2.6%	114	2.8%
DOT/DPS/Public Worker	0	0.0%	65	1.4%	8	2.1%	73	1.4%
Firefighter	131	94.2%	539	11.7%	51	13.3%	721	14.1%
Law enforcement	2	1.4%	3,595	78.3%	218	58.8%	3,821	74.7%
Tow truck driver	2	1.4%	149	3.2%	76	19.8%	227	4.4%
Other	0	0.0%	112	2.4%	15	3.9%	127	2.5%
Overall	**139**	**100%**	**4,590**	**100%**	**384**	**100%**	**5,113**	**100%**

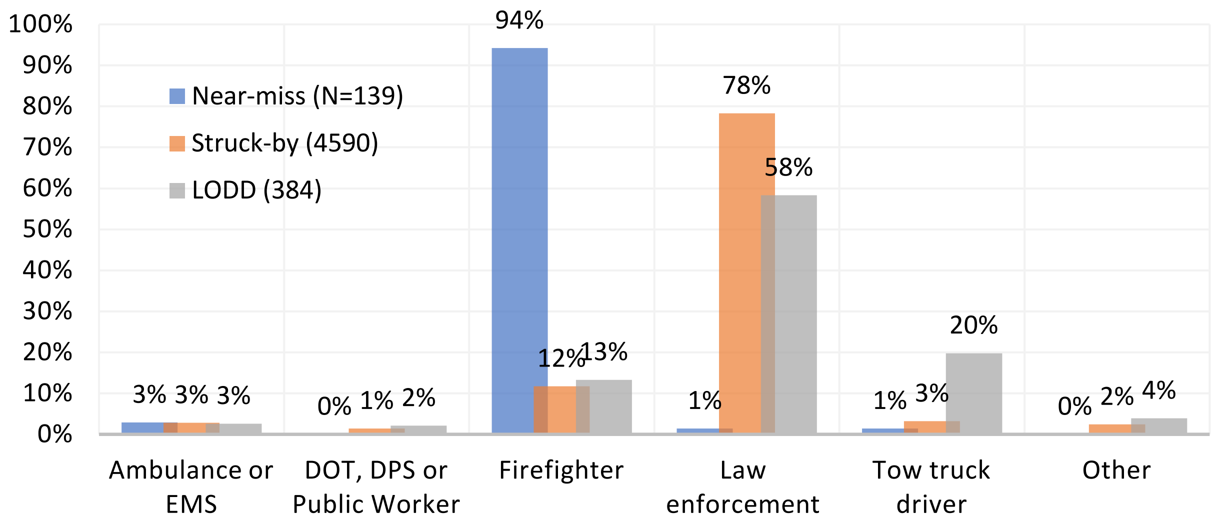

Figure 46. Comparison of agencies across incident type, sample of U.S. news reports, 2001–2020.

Time

Table 25 shows the time attributes identified for incidents reported in the sampled news reports. Five values (early morning, morning, afternoon, evening, and night) were identified for the three types of incidents; the time attributes were either converted from the reported time of an incident or directly extracted from news reports. If a specific time was reported, it was classified according to: early morning (5:00 am to 7:59 am), morning (8:00 am to 11:59 am), afternoon (12:00 pm to 5:59 pm), evening (6:00 pm to 8:59 pm), or night (9:00 pm to 4:59 am).

Nighttime incidents were the largest group reported across the three incident types; in total 20% of incidents are labeled as nighttime, followed closely by incidents occurring in the morning (19%). Afternoon incidents accounted for roughly 10% of the news reports. The relative distribution may be related to both the traffic exposure and the higher occurrence of incidents during certain time periods. For example, traffic is often lighter in the early morning compared to other periods and so fewer early morning responder-involved incidents might be expected. Conversely, nighttime may be associated with a higher occurrence of responder incidents due to visibility or other risk factors; therefore, a sizable portion of reported incidents occur at night even though traffic is lower during this time.

Table 225. Time of day of across incident type identified by text mining, sample of U.S. news reports, 2001–2020.

Time	Near-miss		Struck-by		LODD		All Incidents	
Early morning	3	2.2%	238	5.2%	32	8.3%	273	5.3%
Morning	4	2.9%	889	19.4%	83	21.6%	976	19.1%
Afternoon	2	1.4%	481	10.5%	48	12.5%	531	10.4%
Evening	1	0.7%	273	5.9%	28	7.3%	302	5.9%
Night	18	12.9%	939	20.5%	90	23.4%	1,047	20.5%
No identified value	111	79.9%	1,770	38.6%	103	26.8%	1,984	38.8%
Overall	**139**	**100%**	**4,590**	**100%**	**384**	**100%**	**5,113**	**100%**

Figure 47 compares the reported time across the three types of incidents after removing the reports for which the time attribute was not present or discernable. The relative percentages of struck-by and LODD incidents were fairly consistent across time windows; near-miss event, in contrast, where disproportionately reflected in the night category (although again, this was a small set relative to the other incident types). For those reports where time information was available, 33% of struck-by incidents and 32% of LODD incidents occurred at night, and about 32% of struck-by and 30% of LODD incidents happened in the morning. Seventeen percent of struck-by and LODD incidents were labeled with afternoon time, and 10% labeled with evening for both incident types.

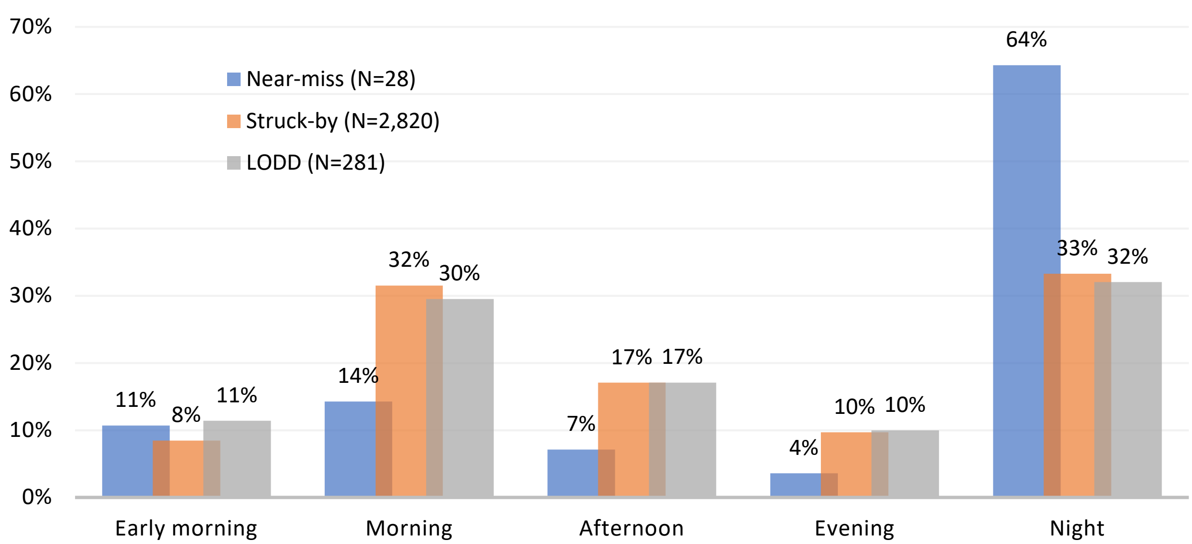

Figure 47. Comparison of time across incident type, among reported incidents for which time was identified, sample of U.S. news reports, 2001–2020.

Operation

Table 26 shows the operation being undertaken by responders in the news reports across incident type. Ten different operations (conducting a traffic stop, directing traffic, etc.) were identified from the news reports. Among these, "staying at the scene," where incident response personnel remain at a site waiting for other responders to come or to finish their work, was the most frequent operation reported in the news reports. In total, "staying at the scene" was identified in 14.5% of all incidents. This was followed by "responding to an accident," "conducting a traffic stop," and "directing traffic," which had similar proportions between 6.2% and 6.9% of all sampled incidents.

Figure 48 compares the selected operation attributes across three types of reported incidents. The percentages were calculated after removing the observations without the identified attribute. A sizable portion of near-miss events seemed to occur during a response to an accident. The operation of "staying at the scene" is frequently reported in three types of incidents, having a relatively large portion compared to other identified operation attributes. The results suggest that responders who stay at the scene are exposed to a greater risk of struck-by incidents and crashes resulting in death.

Table 226. Operation across incident type identified by text mining, sample of U.S. news reports, 2001–2020.

Operation	Near-miss		Struck-by		LODD		All Incidents	
Assisting	6	4.3%	176	3.9%	26	6.8%	208	4.1%
Conducting a traffic stop	0	0.0%	322	7.0%	19	5.0%	341	6.7%
Directing traffic	3	2.2%	294	6.4%	19	5.0%	316	6.2%
Entering the scene	0	0.0%	6	0.1%	1	0.3%	7	0.1%
Leaving the scene	0	0.0%	0	0.0%	2	0.5%	2	0.0%
Staying at the scene	22	15.8%	644	14.1%	72	18.8%	738	14.5%
Patrolling	1	0.7%	21	0.5%	1	0.3%	23	0.5%
Pulling over	1	0.7%	118	2.6%	10	2.6%	129	2.5%
Removing debris	1	0.7%	23	0.5%	2	0.5%	26	0.5%
Responding to an accident	30	21.6%	300	6.6%	21	5.5%	351	6.9%
No identified value	75	54.0%	2,672	58.4%	211	55.0%	2,958	58.0%
Overall	**139**	**100%**	**4,576**	**100%**	**384**	**100%**	**5,099**	**100%**

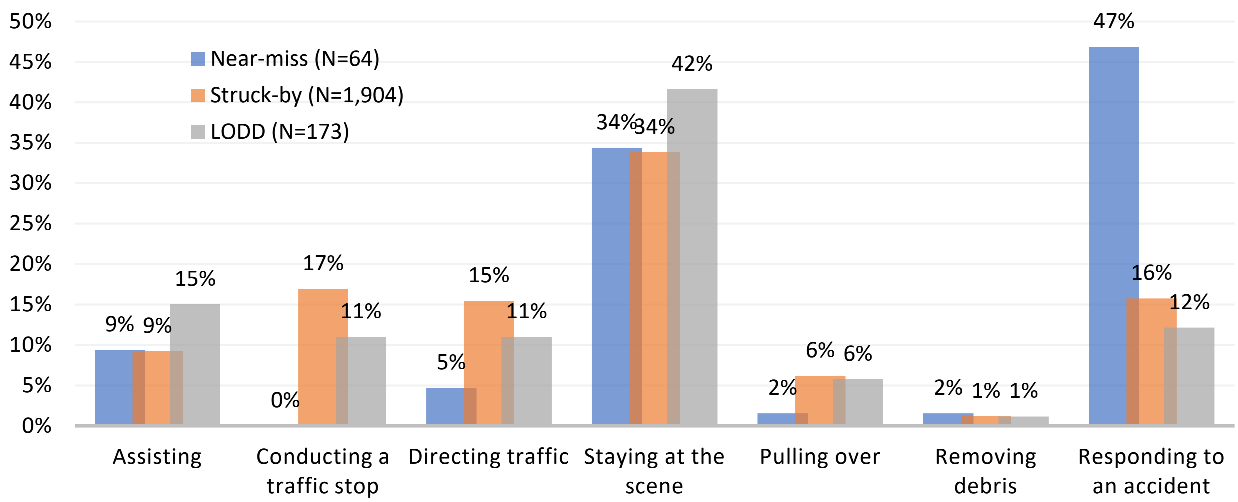

Figure 48. Comparison of operation across incident type, among reported incidents for which operation was identified, sample of U.S. news reports, 2001–2020.

Primary Contributing Factor

Unlike other data sources, such as police crash reports, news reports provided limited information on primary contributing factors, as reflected by the values in Table 27. Nevertheless, information regarding contributing factors could be gleaned from some news reports, including driving under the influence (DUI) or driving while intoxicated (DWI), distraction or inattention, vehicle lost control, and speeding. Table 27 shows the frequencies and percentages of these four primary contributing factors across three types of incidents. DUI or DWI was the most frequent one mentioned in news reports (roughly 15%), followed by lost control, which was identified in 4.5% of news reports, both with some variation across incident type.

Table 227. Primary contributing factor across in incident type identified by text mining, sample of U.S. news reports, 2001–2020.

Primary Contributing Factor	Near-miss		Struck-by		LODD		All Incidents	
Distraction/inattention	7	5.0%	57	1.2%	5	1.3%	69	1.4%
DUI/DWI	11	7.9%	743	16.2%	34	8.9%	788	15.4%
Lost control	8	5.8%	199	4.3%	23	6.0%	230	4.5%
Speeding	2	1.4%	119	2.6%	8	2.1%	129	2.5%
No identified value	111	79.9%	3,470	75.6%	313	81.7%	3,894	76.2%
Overall	**139**	**100%**	**4,588**	**100%**	**383**	**100%**	**5,110**	**100%**

Location

Table 28 shows the location attributes identified across the three types of incidents. News reports specified five different locations in relation to the roadway: in-the-lane, median, shoulder, overpass, and underpass. In general, news reports did not often include location details. For those that did, the results show that incidents were more likely to occur in a travel lane (over 13% of all incidents), followed by the shoulder (5%).

Table 228. Location across incident type identified by text mining, sample of U.S. news reports, 2001–2020.

Location	Near-miss		Struck-by		LODD		All Incidents	
In the lane	25	18.0%	605	13.2%	51	13.3%	681	13.3%
Median	1	0.7%	79	1.7%	12	3.1%	92	1.8%
Shoulder	14	10.1%	227	5.0%	24	6.3%	265	5.2%
Overpass	0	0.0%	21	0.5%	2	0.5%	23	0.5%
Underpass	0	0.0%	0	0.0%	1	0.3%	1	0.0%
No identified value	99	71.2%	3,658	79.7%	294	76.6%	4,051	79.2%
Overall	**139**	**100%**	**4,590**	**100%**	**384**	**100%**	**5,113**	**100%**

Weather

In only a very small number of news reports was information identified on the weather at the time of a responder-involved incident. It is possible that news reporters are inclined to report weather condition only when it is deemed to be a contributing factor (e.g., other than clear or overcast). Table 29 shows those weather attributes that were identified in the news reports. Snow is the most frequent weather among news reports with weather information, followed by rain.

Table 229. Weather across incident type identified by text mining, sample of U.S. news reports, 2001–2020.

Attribute-weather	Near-miss		Struck-by		LODD		All Incidents	
Rain	11	7.9%	34	0.7%	2	0.5%	47	0.9%
Snow	15	10.8%	120	2.6%	5	1.3%	140	2.8%
Fog	0	0.0%	1	<0.01%	0	0.0%	1	<0.01%
No identified value	113	81.3%	4,435	96.7%	377	98.2%	4,925	96.3%
Overall	**139**	**100%**	**4,590**	**100%**	**384**	**100%**	**5,113**	**100%**

Countermeasure

Table 30 shows the summary of selected countermeasures identified in news reports. Responders use these safety countermeasures at traffic scenes for protection; unfortunately, as for weather, only a small number of news reports mentioned the use of countermeasures. Of those that did, the use of emergency lights had the largest percentage followed by advanced warning signs and traffic cones.

Table 30. Countermeasure across incident type identified by text mining, sample of U.S. news reports, 2001–2020.

Countermeasure	Near-miss		Struck-by		LODD		All Incidents	
Emergency lights	8	5.8%	206	4.5%	13	3.4%	227	4.4%
Traffic cones	17	12.2%	42	0.9%	2	0.5%	61	1.2%
Advanced warning signs	11	7.9%	64	1.4%	2	0.5%	77	1.5%
No identified value	103	74.1%	4,278	93.2%	367	95.6%	4,748	92.9%
Overall	**139**	**100%**	**4,590**	**100%**	**384**	**100%**	**5,113**	**100%**

Summary

This study investigated the characteristics of first responder-involved incidents by text mining of narrative news data. A total of 5,113 news reports were extracted from the respondersafety.com website. These reports were originally from various media, covering incidents from 2001 to 2020. Through text mining, this study identified the key attributes of these incidents in aspects including the agencies involved, time and location of an incident, weather conditions, responders' actions or operations prior to the occurrence of an incident, primary contributing factor, and safety countermeasures used to protect responders. As categorized by the respondersafety.com website, the results were presented in terms of three types of responder-involved incidents: near-miss, struck-by, and LODD incidents. These results are not intended to be representative of all such incidents involving responders.

The results showed that the law enforcement agencies are associated with well over half of struck-by and LODD incidents reported by the news. Nearly 20% of reported LODD incidents involved tow truck drivers, which is the second-largest portion among the agencies. In terms of the time of day, morning and night incidents are frequently reported in the news. Among the primary contributing factors, DUI or DWI was the most frequently reported, followed by loss of control of a vehicle.

The current results offer potential insights on understanding the characteristics and possible reasons for first responder-involved incidents, so potential countermeasures can be considered or developed to improve responder safety. The current approach is largely limited by the news data used for analysis and the text mining techniques employed by this study. Regarding the data, the news reports from the website may not convey critical information, whether due to space constraints, availability of information, different "working definitions" for critical attributes, or other factors. Also, there are inherent biases with respect to what incidents are likely to be picked up and promoted through media channels. This is especially salient when considering the distribution of attributes that were not found in most of the news reports and the frequency of reported near miss incidents relative to other more severe outcomes.

With respect to text mining, this is a very effective–albeit imperfect–tool in analyzing large amounts of narrative data for patterns and consistencies. However, following from points above, the outcomes generated are greatly impacted by the quality and comprehensiveness of information being fed into the text mining algorithms. Based on these constraints, it is important to underscore that the outcomes described above are not implied to characterize all roadside incidents occurring on U.S. roads. Rather, they reflect a supplementary source of information that can complement other available data concerning the safety of incident response personnel. Future work should focus on improving the text mining method and expanding the news data (potentially searching for more high-quality news reports with more relevant information to uncover the incident attributes).

CONCLUSIONS & KEY TAKEAWAYS

The fundamental goals of this study were to identify and assess the effectiveness of countermeasures and protocols intended to protect roadside service and incident response personnel at traffic incident sites. There were four major technical tasks:

1. Collecting field data to evaluate the effectiveness of variable message signs (VMS) mounted on service vehicles as a countermeasure to protect roadside incident and service personnel
2. Conducting focus group meetings to learn from incident response personnel regarding their practices and adoption and use of different countermeasures
3. Conducting a national responder survey to gather incident response personnel's perceptions and behaviors regarding countermeasures and safety protocols
4. Text mining of news data to investigate the characteristics of first responder incidents and crashes

Findings are intended to provide insights for enhancing the safety of roadside service and incident response personnel.

This project focused on countermeasures that aim to enhance responder safety. One countermeasure, the vehicle-mounted VMS, was evaluated by analyzing video data collected from an ASAP vehicle providing roadside services in the West Central Alabama area. The study revealed that the use of VMS had a positive impact on the behaviors of passing motorist. More specifically, when the VMS was active, approaching vehicles were more likely to change lanes (to increase safety buffer) and more likely to travel at reduced speeds. The impact of VMS was stronger for passenger vehicles than for heavy-duty vehicles, at least in the current data. Collectively, the results imply that the use of VMS can have a positive impact on traffic, especially passenger vehicles, and that vehicle-mounted VMS should be considered an effective countermeasure to protect roadside incidents and service personnel.

The focus group discussion and national survey revealed many differences across agencies regarding the use or adherence to different countermeasures. In many cases, training (including raising the awareness of), practice, or implementing policies or mandates might help to encourage and promote the use of available countermeasures. Respondents from the towing industry reported the lowest rates of training, representing a potential growth or impact area. In other cases, access was a potentially important barrier. For example, not having cones on one's vehicle was a commonly cited reason for non-use. A variety of barriers were provided with respect to high visibility apparel, including complacency or forgetfulness, lack of training, weather-related issues, and perceptions that this apparel is not effective. Increasing access, mandates, and enforcement are suggested to increase the use of safety apparel. Additionally, it is possible that reflective materials could be better integrated into regular uniforms or work clothes in order to offset weather and comfort concerns as well as the effort to don additional layers while at a response site. Education regarding the risks and/or the efficacy of certain countermeasures might be one avenue to reducing complacency or correcting perceptions that certain countermeasures are ineffective. Lastly, inadequate resources, time, or support for some countermeasures was noted. Prioritizing safety and promoting a strong organizational safety culture are encouraged, especially as avoiding worker injury can readily match and increase the return on investment for training and appropriate safety equipment.

In the survey, a significant proportion of survey respondents reported experiencing struck-by (15%) or near-miss (60%) incidents. In examining factors that are associated with these incidents, in general responders were more likely to have experienced a struck-by or near-miss incident if they reported not always using safety apparel, traffic cones, or emergency lighting. Based on the modeling efforts, training alone did not have an impact on the occurrence of struck-by and near-miss events, suggesting that the relationship between training and safety experience can be complex. Law enforcement officers, for example, receive a significant amount of training, but they still frequently experience struck-by incidents because they may face more unsafe situations on the road than responders from other agencies. Moreover, agencies or individuals that experience such incidents might receive remedial training in response. The outcomes might also indicate that existing training programs have room for improvement. For one, it was found that training did not significantly impact compliance with many countermeasures (Table 15).

The features of responder incidents were also examined. Through text mining of news data, this study revealed that a large proportion of reported struck-by and LODD incidents occurred during the morning and night, implying that incident response personnel face greater risks during these times than at other times. The time of day was also significantly related to the behaviors of passing vehicles in the VMS field study, where the video analysis showed that vehicles were less likely to move over during morning times from 7 am to 9 am. Additional data needs to be collected to cover the night times in order to explain the reported nighttime incidents. In terms of incident locations, a relatively larger portion of LODD incidents occurred at roadway medians than other incidents. When an emergency vehicle or responder stops in the median, they are likely on the left shoulder of a road adjacent to the inner travel lane with higher speeds than the outer lane next to the right shoulder. Though vehicles tend to slow down when seeing an emergency vehicle on the shoulder, the video data modeling results showed that the ASAP vehicle stopping on the left shoulder encountered higher-speed vehicles from the lane adjacent to the incident scene (i.e., the inner lane) than the vehicle stopping on the right shoulder. Results also suggested that roadside incidents and service personnel might face greater conflicts when working in cloudy and rainy weather conditions, and in non-free flow conditions.

Although extensive efforts have been made to develop safety countermeasures to protect roadside responders, there has been limited research regarding the efficacy of these countermeasures as well as reasons why certain approaches are not adopted or used consistently by workers. The current project and the tasks described in each of the technical modules offers different bits of information that hopefully can help to better understand and address some of the prevailing challenges in this safety-critical area.

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APPENDIX A: National Responder Survey

Informed Consent

Please read this informed consent carefully before you decide to participate in the survey.

Consent Form Key Information:

- We are asking for your participation in a 10-minute survey about incident response personnel's use of safety practices.
- A raffle will be conducted at the end of the survey. Only the first 800 participants have a chance to win in the raffle. There will be a 1 in 10 chance of winning a $50 gift card.
- There are no foreseeable risks in participating in this survey.

Purpose of the research study: The purpose of the study is to identify effective countermeasures to protect roadway incident response personnel.

What you will do in the study: If you agree to participate in this study, you will complete a short online survey on a computer or smartphone.

Time required: The study will require about 10 minutes of your time.

Risks: There are no anticipated risks for this study.

Benefits: There are no direct benefits to you for participating in this research study. The study may help improve the safety of incident response personnel while they are managing incidents.

Confidentiality: All responses are recorded anonymously and will remain confidential.

Data not linked to identifying information: The information that you give in the raffle will be collected separately from your survey response. Your email or phone number is only used to communicate the raffle results.

Voluntary participation: Your participation in the study is completely voluntary.

Right to withdraw from the study: You have the right to withdraw from the study at any time without penalty. Simply close your web browser and the study will end. There is no penalty for withdrawing.

Compensation/Reimbursement: There is a 1 in 10 chance of winning a $50 gift card. A total of 80 gift cards will be issued to participants.

If you have questions about the study or need to report a study-related issue please contact, Praveena Penmetsa, Associate Research Engineer, University of Alabama. Email address: ppenmetsa@ua.edu. If you have questions about your rights as a participant in a research study, would like to make suggestions or file complaints and concerns about the research study, please contact: Ms. Tanta Myles, the University of Alabama Research Compliance Officer at (205)-348-8461 or toll-free at 1-877-820- 3066. You may also ask questions, make suggestions, or file complaints and concerns through the IRB Outreach Website at http://ovpred.ua.edu/research-compliance/prco/. You may email the Office for Research Compliance at rscompliance@research.ua.edu.

Agreement:

- I agree to participate in the research study
- I do not want to participate in the study

Are you sure you do not want to participate in the study?

- Yes, I do not want to participate in the study
- No, I accidentally clicked it. I agree to participate in the study

Personal information

What gender do you identify as?

- Male
- Female
- Prefer not to answer

What is your age?

- 18 to 20
- 21 to 25
- 26 to 35
- 36 to 45
- 46 to 55
- 56 to 66
- 67 and above
- Prefer not to answer

What is your ethnicity? (Select all those that apply)

- Caucasian
- African American
- Latino or Hispanic
- Asian
- Native American
- Native Hawaiian or Pacific Islander
- Other/Unknown
- Prefer not to answer

What is your state of residence?

Select a state

What is the highest degree or level of education you have completed?

- Less than a High School Graduate
- High School Graduate or equivalent

- Some college
- Associate Degree
- Bachelor's Degree
- Master’s Degree or higher
- Prefer not to answer

In which type of organization are you employed?

- Law enforcement (police, sheriff, etc.)
- Paramedics/Private EMS
- Fire
- Towing & Recovery
- DOT and/or Public works
- Other (please detail it in the box below)

Incident response personnel refers to law enforcement officers, paramedics/EMS personnel, firefighters, tow truck drivers, and others who regularly engage in managing crashes/accidents and other traffic incidents (vehicles with a flat tire, etc.). Incident response personnel are often exposed to ongoing traffic, putting them at risk. In 2019, vehicles struck and killed 44 incident response personnel performing various activities while managing traffic incidents. Numerous countermeasures and practices are recommended to improve the safety of incident response personnel. This survey is designed to understand incident response personnel perceptions, experiences, and practices and to improve safety in the field.

How many years of experience do you have working as an incident response personnel?

Training

Have you ever attended any safety training programs on traffic incident management particularly focusing on responder safety (e.g., National Traffic Incident Management Responder Training Program)?

- Yes
- No
- I do not remember
- Prefer not to answer

Why didn't you attend any safety training programs on traffic incident management particularly focusing on responder safety? (select all those that apply)

- I am not aware of such programs
- I don't want to spend my personal time attending safety training
- My agency doesn't have replacements to cover my shifts to attend safety training
- I believe in learning on the job
- Other (explain below)
- Prefer not to answer

How long ago did you receive traffic incident management responder safety training?

- Within the past year
- In the past 1 to 2 years
- In the past 3 to 4 years
- In the past 5 to 6 years
- I do not remember
- Prefer not to answer

Does your agency provide you information regarding strategies and safe practices that promote incident response personnel safety at roadway incident scenes?

- Yes
- No
- Prefer not to answer

How much does your agency prioritize your safety in your day-to-day work?

- Not a priority
- Low priority
- Moderate Priority
- High priority
- Essential priority
- Prefer not to answer

How frequently does your agency conduct test runs or mock drills with other first responder agencies to increase coordination during incident management?

- Never
- Once every few years
- Once a year
- Once a quarter
- Once a month
- Prefer not to answer

Why doesn't your agency conduct test runs or mock drills that frequently to increase coordination during incident management? (select all those that apply)

- It requires a lot of resources such as time, manpower, effort, and money, which our agency doesn't have.
- Test runs and mock drills are not that effective in improving incident response personnel safety to justify investing resources.
- In my job, there are other greater risks for my safety that take precedence over traffic incidents such as active shooter, fire, patient care, etc.
- Other (explain below)

- Prefer not to answer

How frequently does your agency facilitate action reviews such as round table discussions to identify areas of improvement or best practices?

- Never
- Once every few years
- Once a year
- Once a quarter
- Once a month
- Prefer not to answer

Why doesn't your agency conduct action reviews such as round table discussions to identify areas of improvement or best practices?

- It requires a lot of resources such as time, manpower, effort, and money, which our agency doesn't have.
- Action reviews are not that effective in improving incident response personnel safety to justify investing resources.
- In my job, there are other greater risks for my safety that take precedence over traffic incidents such as active shooter, fire, patient care, etc.
- Other (explain below)
- Prefer not to answer

Practices

How frequently do you park the response/service vehicle you drive with front wheels facing away from the incident scene? (response/service vehicles include emergency vehicles and other vehicles that are used for traffic incident management)

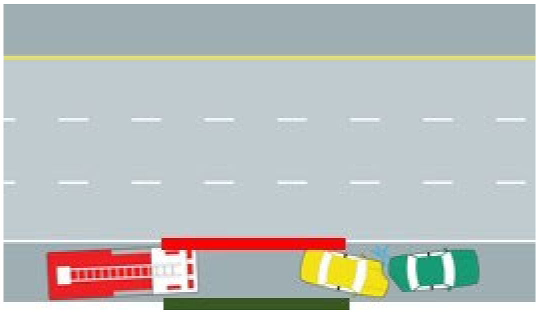
- o Never
- o Seldom
- o Sometimes
- o Frequently
- o Always
- o I do not drive a response/service vehicle
- o I do not pay attention to which direction the wheels are facing when parking a response/service vehicle
- o Prefer not to answer

What are the reasons for you not always park the service vehicle you drive with the front wheels facing away from the incident scene? (select all those that apply)

- o I don't remember it to do it all the time
- o I don't see this as an effective countermeasure to improving safety
- o I get complacent sometimes
- o I am in a rush to perform the actual duties at the incident site and don't give much attention to this
- o Other: Please explain below

- o Prefer not to answer

Do you make a point to use the non-traffic side at the incident site? (in the figure here, the red box is the traffic side, and the green box is the non-traffic side)



- Yes, all the time
- Yes, sometimes
- No
- Prefer not to answer

What are the reasons for not using the non-traffic side at the incident site? (select all those that apply)

- I don’t remember it to do it all the time
- I don’t see this as an effective countermeasure to improving safety
- I get complacent sometimes
- I am in a rush to perform the actual duties at the incident site and don’t give much attention to this
- Prefer not to answer

How frequently do you wear high-visibility clothing or safety uniforms while managing traffic incidents?

- Never
- Seldom
- Sometimes
- Frequently
- Always
- Prefer not to answer

Why don’t you wear high-visibility clothing or safety uniforms more often while managing traffic incidents? (select all those that apply)

- I don’t think high-visibility clothing is effective
- I don’t remember wearing it
- I get complacent sometimes, so I don’t wear it

- It limits me from accessing my gear
- Hot and humid weather refrain me from wearing it
- Other (explain below)

- Prefer not to answer

How frequently do you use the vehicle's emergency lights while you are managing an incident during the day?

- Never
- Seldom
- Sometimes
- Frequently
- Always
- Prefer not to answer

Under which of these scenarios do you not use the vehicle's emergency lights while managing a traffic incident during the day (select all those that apply)?

- The lighting condition is sufficient, and drivers can see me from farther distances
- There are no obstructions in the line of sight (such as curves, buildings, etc.) and drivers can see me from farther distances
- The traffic is behaving properly and giving me adequate space to work
- Other (explain below)

- Prefer not to answer

How frequently do you use signs such as the one shown below to notify drivers about the incident ahead?

- Never
- Seldom
- Sometimes
- Frequently
- Always
- Prefer not to answer

Why don’t you use the signs such as the one shown below to notify drivers about the incident ahead? (select all those that apply)

- I don’t carry them with me in my vehicle
- It is cumbersome and risky to put the sign and collect it
- It is easier to call for extra support and use that extra vehicle as early notification to drivers than using this sign
- I don’t think it is effective to improve safety Other (explain below)

- Prefer not to answer

How frequently do you use traffic cones at incident sites?

- Never
- Seldom
- Sometimes
- Frequently
- Always
- Prefer not to answer

Why don't you use traffic cones more frequently at incident sites? (select all those that apply)

- Drivers are numb to traffic cones, which makes them ineffective
- My agency policy doesn't recommend the use of traffic cones all the time
- I don't carry them with me in my vehicle
- Roadway (good light and visibility) and traffic conditions are not favorable
- It is cumbersome and risky to put the cones and collect them afterward
- Other (explain below)
- Prefer not to answer

Experiences

How often do you observe a conflict among first responders when managing incidents?

- Never
- Seldom
- Sometimes
- Frequently
- Always
- Prefer not to answer

How many traffic incidents do you work on a typical day?

- Zero
- One
- Two
- Three
- More than three

How many traffic incidents do you work in a typical week?

Have you ever been struck by a passing vehicle while you were managing a traffic incident?

- Yes
- No
- Prefer not to answer

What level of injury severity did you sustain when you were struck by a passing vehicle?

- No injury sustained
- Minor: no treatment needed.
- Moderate: required only outpatient treatment.
- Serious: required non-ICU hospital admission.
- Severe: required ICU observation and/or basic treatment.
- Critical: required intubation, mechanical ventilation, or vasopressors for blood pressure support.

In a couple of sentences, can you explain why you were struck by a passing vehicle while managing a traffic incident?

Have you ever experienced a near-miss incident (almost got hit) from a passing vehicle while managing traffic incidents?

- Yes
- No
- Prefer not to answer

When was the last time you experienced a near-miss incident from a passing vehicle while managing a traffic incident?

- In the past 3 months
- In the past 4 to 6 months
- In the past 6 to 12 months
- Over a year ago
- Prefer not to answer

How often do you typically experience a near miss incident from a passing vehicle while managing traffic incidents?

- Never
- Seldom
- Sometimes
- Frequently
- Always
- Prefer not to answer

Below are possible causal factors for first responders' fatalities and injuries. Rate each factor on a scale 1 to 5. (1 being **least likely** to cause first responder injury/fatality while 5 being **highly likely** to cause injury/fatality to a first responder.)

	1 (Least Likely)	2	3 (Moderately Likely)	4	5 (Highly likely)
Lack of training	○	○	○	○	○
Lack of situational awareness	○	○	○	○	○
Failure to establish a proper temporary traffic control (TTC) zone	○	○	○	○	○
Improper positioning of equipment	○	○	○	○	○
Inappropriate use of scene lighting	○	○	○	○	○
Failure to use safety equipment	○	○	○	○	○
Careless, inattentive, or impaired drivers	○	○	○	○	○
Reduced visibility for driving	○	○	○	○	○
Altered traffic patterns	○	○	○	○	○
Lack of advanced warning devices	○	○	○	○	○

Please share any personal experiences and/or countermeasures regarding incident response personnel safety.

We thank you for your time spent taking this survey.

Your response has been recorded.

If you are willing to participate in a raffle, click on the link at the end of the survey. Only the first 800 participants have chances to win in the raffle. There is a one in 10 chance of winning a $50 gift card. We plan to provide a total of 80 gift cards via raffle. We will be requiring either an email id or phone number to reach out and communicate the raffle results. None of the personal information (such as email id or phone number) you provide can be linked to your responses. The personal information collected will be strictly confidential and will be only used to communicate raffle results.