Evaluation of Pilot Deployment of Portable Visual Barriers to Reduce Rubbernecking Impact during Freeway Crashes

Project No. BED25-977-02

Final Report

Prepared for

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CUTR
CENTER FOR URBAN TRANSPORTATION RESEARCH

UNIVERSITY of SOUTH FLORIDA

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Prepared for:

Florida Department of Transportation
Megan Arasteh, P.E. (PM)
TSM&O Program Engineer
Florida Department of Transportation District 7, Traffic Operations
Email: megan.arasteh@dot.state.fl.us, Phone: (813) 415-4623

Prepared by:

USF Center for Urban Transportation Research
Pei-Sung Lin, Ph.D., P.E., PTOE, FITE (PI)
Program Director – ITS, Traffic Operations and Safety
Center for Urban Transportation Research (CUTR)
University of South Florida
E-mail: lin@usf.edu, Phone: (813) 974-4910

Achilleas Kourtellis, Ph.D., (Co-PI)
Assistant Program Director, ITS, Traffic Operations and Safety, CUTR

Yaye Keita, Ph.D.,
Research Faculty, CUTR

Shubhankar Shindgikar
Shivaram Reddy Chalamalla
Research Assistants, CUTR

June 2025

Disclaimer

Metric Conversion

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C

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16. Abstract

Rubbernecking—when drivers slow down to view incidents on the opposite side of the road—causes major traffic disruptions and heightens the risk of secondary crashes. Recognizing this threat to safety and mobility, the Florida Department of Transportation (FDOT) partnered with the Center for Urban Transportation Research (CUTR) at the University of South Florida to evaluate the use of portable visual barriers (PVBs) as a countermeasure during freeway crashes.

The study combined a literature review, traffic simulation, a pilot deployment, and the development of implementation guidelines. Simulation modeling revealed that rubbernecking can increase queue lengths by up to 10 miles and significantly delay traffic, especially under high incident durations. Longer delays were also associated with a greater risk of secondary crashes. Simulations showed that deploying PVBs could reduce traffic delays and crash risk by limiting visual distractions.

A pilot deployment of PVBs in Hillsborough County demonstrated their real-world effectiveness. During a fatal motorcycle crash that occurred in December 2024 on I-75, the deployment of visual barriers on the incident side of the freeway reduced congestion on the opposite side due to rubbernecking by approximately 45%, potentially saving over $165,000 in congestion-related costs.

These results support the use of PVBs to reduce rubbernecking and its negative consequences. The project provides actionable deployment guidelines and recommends expanding use across Florida’s highway network, integrating PVBs with traffic management operations, and implementing public education campaigns. Overall, the research confirms that PVBs are a promising and cost-effective tool for improving roadway safety and maintaining traffic flow during incident response.

17. Key Words Traffic safety, Driver behavior, Rubbernecking, Incident Management, Portable Visual Barrier, Driver distraction, Traffic congestion, Secondary crashes, Freeway incidents, Countermeasures, Highway safety, Portable equipment, Traffic crashes.		**18. Distribution Statement**	
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Our gratitude also goes to FDOT Research Center Manager Darryll Dockstader, Research Development Coordinator Jennifer Clark, Performance and Workforce Coordinator Jason Tuck, and Business Systems Coordinator Ta'rika Green for their support and assistance.

Executive Summary

Rubbernecking, also known as gawking, is a prevalent issue on roadways where drivers slow down to observe incidents on the opposite side of the road. This behavior can not only cause significant traffic congestion when traffic is heavy, but also increase the risk of secondary crashes. When drivers divert their attention to look at crashes or other incidents, it leads to a reduction in roadway efficiency and can cause long vehicle queues. According to the National Highway Traffic Safety Administration (NHTSA), 25% of distracted driving crashes are due to events outside the vehicle, and rubbernecking is a major contributor to this statistic.

The Florida Department of Transportation (FDOT) recognizes the critical impact of rubbernecking on traffic flow and safety. To address this issue, FDOT sponsored this project initiated by researchers at the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF) to evaluate the effectiveness of portable visual barriers (PVBs) in mitigating the effects of rubbernecking during freeway crashes. The primary goal of this project is to explore the deployment of PVBs as a countermeasure to reduce traffic congestion caused by drivers' rubbernecking and improve overall roadway safety.

This project involves a comprehensive approach that includes a literature review, pilot deployment of PVBs, data analysis, and the development of implementation guidelines. By understanding the causes and effects of rubbernecking and testing potential solutions, FDOT aims to provide practical recommendations for reducing the negative impacts of rubbernecking on Florida's highways.

Project Objectives

The project had four main objectives:

1. **Literature Review**: Conduct a comprehensive review of existing studies on the impacts of rubbernecking and potential countermeasures.
2. **Pilot Deployment**: Plan, coordinate, and execute a pilot deployment of PVBs via FDOT Road Rangers to reduce rubbernecking during freeway crashes.
3. **Data Analysis**: Perform in-depth analyses to evaluate the effectiveness of PVBs in reducing traffic congestion and secondary crashes.
4. **Implementation Guidelines**: Develop guidelines for the deployment of PVBs, including recommendations for future use in Florida.

Methodology

The project involved two primary activities:

1. **Simulation Modeling**: Develop and use simulation models to assess the impact of rubbernecking on traffic congestion. The simulations considered various scenarios,

including different levels of service (LOS), incident durations, and percentages of drivers exhibiting rubbernecking behavior.

2. **Pilot Deployment**: Conduct a pilot study to deploy selected PVB systems on freeways in Hillsborough County, Florida. The effectiveness of the barriers was evaluated by comparing traffic conditions before and during deployment.

Key Findings

Simulation Analysis:

- **Queue Lengths**: The simulations revealed that rubbernecking significantly increases queue lengths and delays. For example, in scenarios with high levels of rubbernecking, queue lengths increased by up to 10 miles.
- **Vehicle Delays**: Increased rubbernecking percentages correlated with higher vehicle delays. Reducing rubbernecking through PVB deployment showed potential to decrease delays and improve traffic flow.
- **Secondary Crashes**: Longer incident durations and higher rubbernecking percentages increased the likelihood of secondary crashes. Deploying PVBs could reduce these risks by minimizing driver distractions.

Pilot Deployment:

- **Effectiveness of PVBs**: The pilot study demonstrated that PVBs effectively reduced rubbernecking and associated congestion. Visual barriers helped maintain traffic flow and reduced the occurrence of secondary crashes.
- **Congestion Reduction of Deploying PVBs**: It was estimated that the PVB deployment during the fatal motorcycle crash on I-75 northbound which occurred in December 2024, reduced traffic congestion caused by rubbernecking on the southbound side by approximately 45%, potentially saving over $165,000 in congestion-related costs—and even more if secondary crashes were avoided.
- **Deployment Guidelines**: Based on the findings, guidelines were developed for the strategic deployment of PVBs. These include criteria for when and where to deploy barriers, considering factors such as traffic volume, incident severity, and roadway conditions.

Recommendations

The project recommends the following actions to enhance traffic safety and mobility:

1. **Widespread Deployment**: Implement PVBs across Florida's freeways, especially in areas prone to frequent crashes or other incidents and high traffic volumes.

2. **Driver Education**: Educate drivers on the dangers of rubbernecking and promote awareness of PVBs as a safety measure.
3. **Further Research**: Conduct additional studies to refine the deployment strategies and evaluate long-term impacts of PVBs on traffic flow and safety.
4. **Integration with Traffic Management Systems**: Integrate PVB deployment with existing traffic management systems to ensure timely and efficient responses to incidents.

The deployment of PVBs presents a promising solution to mitigate the adverse effects of rubbernecking on freeway traffic. By reducing driver distractions, PVBs can improve traffic flow, decrease congestion, and minimize the risk of secondary crashes. The findings from this project provide valuable insights and practical guidelines for future deployments, contributing to safer and more efficient roadways in Florida.

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Abbreviations and Acronyms

EMS	emergency medical services
FHWA	Federal Highway Administration
FOV	field of view
FDOT	Florida Department of Transportation
FHP	Florida Highway Patrol
HOV	high-occupancy vehicle
ITS	Intelligent Transportation Systems
LOS	level of service
NHTSA	National Highway Traffic Safety Administration
NTIMC	National Traffic Incident Management Coalition
PVB	portable visual barriers
RISC	rapid incident scene clearance
RITIS	Regional Integrated Transportation Information System
RCI	Roadway Characteristics Inventory
SUV	sport utility vehicle
TIM	Traffic Incident Management
TTI	Texas Transportation Institute

1 Introduction

Rubbernecking, also known as gawking, is a common traffic issue that occurs when drivers slow down to look at crashes or other incidents in the opposite direction of their travel lanes, disrupting the flow of traffic behind them. This roadway phenomenon can result in long vehicle queues, traffic congestion (delay and capacity reduction), and secondary crashes. Roadway incidents can reduce roadway efficiency by up to 26%, regardless of whether the incidents are obstructive or non-obstructive [1, 2]. Similarly, the National Highway Traffic Safety Administration (NHTSA) noted that 25% of distracted crashes are caused by events outside the car [3].

Although many studies have examined the impact of incidents on traffic flow in the direction of the incident, there is limited research on the effects of incidents on traffic in the opposite travel lanes [4]. The impact of rubbernecking is illustrated in Figure 1-1. Traffic on I-75 southbound in Tampa, Florida, was heavily backed up with a long queue due to a crash, while northbound traffic experienced delays caused by rubbernecking rather than the incident itself. Roadway incidents can influence both directions of traffic [5]. After analyzing 637 incidents, research by Paulina Reina concluded that 12% of events prompted rubbernecking queues [6].

Source: CUTR

Figure 1-1. Illustration of rubbernecking scenario

Rubbernecking during a freeway incident can lead to traffic congestion in both directions and is also a major factor in secondary crashes. Approximately 20% of all crashes are secondary crashes initiated by congestion from an earlier incident [2]. Several organizations in the United States (U.S.), such as the National Traffic Incident Management Coalition (NTIMC), the National

Unified Goal for Traffic Incident Management, and the Federal Highway Administration (FHWA), recognize the issue of secondary crashes. For example, NTIMC noted that for every minute the initial incident remains hazardous (resulting in long queues, significant speed reductions, and rubbernecking), the likelihood of a secondary crash increases by 2.8% [2]. Additionally, many incident responders sustain serious injuries or are fatally injured in secondary crashes caused by distracted, impaired, or speeding drivers. Therefore, it is important to develop and implement incident response protocols and tools that can ensure the safety of these responders who work to protect and serve.

The mobility and safety of Florida roadways are the top priorities of the Florida Department of Transportation (FDOT). This project explores the causes, effects, and countermeasures of freeway rubbernecking and assists FDOT in reducing unnecessary congestion and secondary crashes caused by rubbernecking on freeways, expressways, or limited-access highways. A pilot deployment of a promising type of rubbernecking countermeasure—portable visual barriers (PVBs)—was conducted, along with data collection and analysis. Recommendations and guidelines on how to deploy PVBs to decrease rubbernecking are provided.

1.1 Project Objectives

This project has four main objectives:

- Conduct a comprehensive literature review on the impact of rubbernecking on traffic mobility and safety, and potential countermeasures to prevent rubbernecking; identify types of PVBs available and examine their potential use.
- Plan, coordinate, and conduct a pilot deployment of an approved PVB via FDOT Road Rangers operations to reduce rubbernecking due to freeway crashes.
- Perform in-depth data analysis to evaluate the effectiveness and benefits of deploying PVBs to reduce freeway traffic congestion and potential secondary crashes.
- Develop implementation guidelines on when, who, where, and how to deploy PVBs; document analysis results and research findings and provide recommendations for future deployments in Florida.

1.2 Organization of Report

The rest of this report is organized as follows: Section 2 summarizes the literature review on rubbernecking and countermeasures, Section 3 describes the overall project approach, Section 4 covers the simulation analysis, Section 5 explains the deployment of PVBs, and Section 6 provides conclusions and recommendations.

2 Literature Review

This section presents a literature review on rubbernecking, detailing the factors that contribute to its occurrence, the impacts it has, and mitigation countermeasures.

2.1 Effects of Roadway Characteristics, Traffic Conditions, and Crash Severity on Motorist Rubbernecking

2.1.1 Effects of Roadway and Traffic Conditions on Rubbernecking

Several factors can influence rubbernecking, such as roadway characteristics and traffic conditions. A recent study concluded that the probability of rubbernecking increases when on-ramps and high-occupancy vehicle (HOV) lanes are located at the incident site [6]. Based on the results, the odds of rubbernecking are nearly 2.5 times higher near an on-ramp and twice as high when an HOV lane is present, when other variables are held constant [6]. The author suggested that the increased rubbernecking near on-ramps may be linked to an increase in flow from merging traffic, causing reduced freeway capacity; the chance of rubbernecking increases due to heavier and slower traffic near on-ramps. Likewise, the doubling of rubbernecking instances when HOV lanes are present may be due to increased weaving maneuvers, which could slow down traffic. Slower traffic could lead to rubbernecking and have a higher impact when a freeway crash occurs in the opposite direction.

In their rubbernecking study, Masinick et al. compared roadways with barriers and without barriers (e.g., guardrails/grassy medians) and concluded that roadways with median barriers that block the vision of the opposite direction can significantly reduce rubbernecking and associated delays at those locations. As concrete barriers are costly and are available on some roadways for reasons other than rubbernecking (e.g., preventing roadway departure crashes), the authors suggested exploring the use of cost-effective barriers such as portable screens as a rubbernecking countermeasure during a freeway crash [7].

In addition to roadway characteristics, traffic conditions are an important determinant of motorist rubbernecking behavior. Earlier studies demonstrated that peak periods, weather, day/night travel, day of week, weekday travel, incident duration, volume-to-capacity (v/c) ratios of traffic before the occurrence of a crash, and percent of trucks significantly impacted the extent of rubbernecking and its associated delays [4, 6, 7]. For example, Masinick et al. discovered that weekday crashes would be more likely to cause rubbernecking in the opposite direction than weekend crashes. The authors attributed this result to higher traffic volume during weekdays than on weekends. The authors stated that “Under high-volume conditions, the potential number of motorists to rubberneck would be more than that under low-volume conditions” [7].

The same group of researchers also concluded that during peak periods, motorists are less likely to rubberneck because they are hurrying to reach work, home, or other destinations when they may have less time to look at crashes in the opposite direction of their travel lanes.

Thus, peak periods can curb motorist curiosity and bring rubbernecking under a certain amount of control. Similarly, during bad weather (rain/snow/ice), the probability of rubbernecking is lower. These conditions may require greater focus and attention from drivers, giving them fewer chances to rubberneck [7]. On the other hand, the impact of rubbernecking during peak hours or heavy traffic conditions is much larger and more likely to cause traffic congestion.

Research has also shown that drivers in passenger cars experience greater speed variations when in the median lane than in the shoulder lane [8]. Vehicle type, incident visibility, and type of driver are other factors that influence motorist rubbernecking [6, 8]. Based on these factors, countermeasures can be developed that target specific time periods, traffic volumes, and locations specified by these variables [4].

2.1.2 Effects of Crash Severity on Rubbernecking

In addition to roadway and traffic conditions, rubbernecking can be influenced by the severity of a crash. Severe and uncommon types of crashes are more likely to result in rubbernecking due to driver curiosity, which can disrupt traffic and cause long traffic queues. Some crash severity factors in previous studies include the number of people injured during a crash and the period it took to clear the crash [4, 9]. Clearance time can be used as a surrogate for the severity of a crash, as “a more severe incident would require a longer clearance process, making the duration of the incident longer” [4]. Occupancy level in the opposite direction of traffic, crash duration time, maximum congested time, and length of crash are other conditions that can trigger rubbernecking on roadways [9]. Overall, a good understanding of these factors can help address issues related to rubbernecking [4].

2.2 Effects of Rubbernecking on Traffic Mobility and Safety

This section elaborates on the effects of rubbernecking on both traffic mobility and safety. It highlights how rubbernecking can influence traffic congestion, speed, delay, and queue length. In addition, reasons why rubbernecking can create a safety hazard are also discussed.

2.2.1 Effects of Rubbernecking on Traffic Mobility

Numerous studies show that rubbernecking affects traffic mobility and can lead to major congestion. Previous studies focused primarily on congestion in the direction of a crash, but rubbernecking can also cause significant congestion in the opposite direction [9]. For example, one study noted that incidents could cause capacity reductions of about half of the free-flow capacity in both directions of traffic. Rubbernecking can lead to substantial capacity reductions in the direction of incidents [6, 10]. Likewise, Knoop et al. explored capacity reductions in four situations: 1) incident blocked shoulder lane, 2) incident caused one lane to be closed (out of three lanes), 3) incident caused two lanes to be closed (out of three lanes), and 4) rubbernecking lanes. They observed a higher reduction of capacity in the rubbernecking queues (31%) compared to queues in the shoulder lane group (28%), which showed the significant impact of rubbernecking on capacity reduction [11].

Some researchers attributed rubbernecking effects to drivers reducing speed near incidents in the opposite travel lanes. This is mainly linked to human nature rather than roadway or incident attributes [6, 12]. Similar issues that emerge from rubbernecking include rising mean headways and reaction time and decreases in bottleneck discharge rates [11, 12]. Rubbernecking can also lead to traffic oscillations. Chen et al. developed relationships between the percentages of rubberneckers, speed reductions, and traffic oscillation periods [13]. Gajananan et al. [5] confirmed comparable results by predicting the following:

- Headway of subject vehicles increases after passing an accident location.
- Subject speed decreases upon perception of an accident.
- Subject speed variance (delta speed) reduces after passing an accident site.

Other measures that can be used to assess the impacts of rubbernecking on traffic flow include queue length, congestion duration, and traffic delay [6]. Based on Reina's study, the maximum queue length and congestion durations within the rubbernecking queue were greater on average, than those noted in the direction of the incident. Maximum queue length can be measured "by measuring the distance between the nearest detector station to the head of the queue and the nearest detector station to the tail of the queue" [6]. Researchers can use speed and milepost information to locate loop-detector stations near crashes and estimate queue length and congestion durations. There are several ways to estimate delays, and delays (vehicle-hours) during an incident can be compared to delays during regular weekday or weekend traffic [6]. Similarly, Chung and Recker in 2013 evaluated various factors of traffic delays linked to rubbernecking and concluded that occupancy level in the opposite direction of traffic, incident duration, maximum congested time, length of the accident, and number of persons injured have significant effects in the delays associated with rubbernecking [9].

2.2.2 Effects of Rubbernecking on Traffic Safety

Rubbernecking causes driver distraction that can lead to secondary crashes [9, 14-17]. When rubbernecking, a driver's eyes may be on the crash scene rather than the direction of travel, which may result in secondary crashes. Researchers noted that distractions outside a car represent 35% of all crashes, and rubbernecking due to crashes or other incidents represents 16% of all crashes [4, 9]. The traffic congestion caused by rubbernecking can also lead to a secondary crash.

For example, a 2003 study by Virginia Commonwealth University's Transportation Safety Training Center showed that rubbernecking was the top cause of roadway crashes. The study noted that rubbernecking-related crashes were initiated by other earlier crashes or incidents but not by landmarks or other scenery [4]. Also, rear-end crashes can be triggered by rubbernecking [15].

An example of a rubbernecking crash is shown in Figure 2-1. The left photo shows the primary crash and emergency response, and the right photo shows a truck from the opposite lane that was rear-ended and pushed into the shoulder by the following vehicle due to rubbernecking. In this example of rubbernecking, another secondary crash occurred within 10 seconds after the first secondary crash. The video from which these images were taken shows several successive rubbernecking crashes caused by the single primary crash in the opposite direction.

Source: [18]

Figure 2-1. Multiple vehicle crashes caused by rubbernecking

2.3 Countermeasures to Prevent Rubbernecking

Research on countermeasures for rubbernecking is limited, with most studies focusing primarily on visual barriers. Visual barriers can be permanent (heavy) or portable (light), and their design can have an impact on their overall effectiveness. In addition to visual barriers, some researchers have noted that driver education can also be a useful countermeasure in reducing rubbernecking. This section documents several countermeasures, including visual barriers and driver education.

2.3.1 Visual Barriers

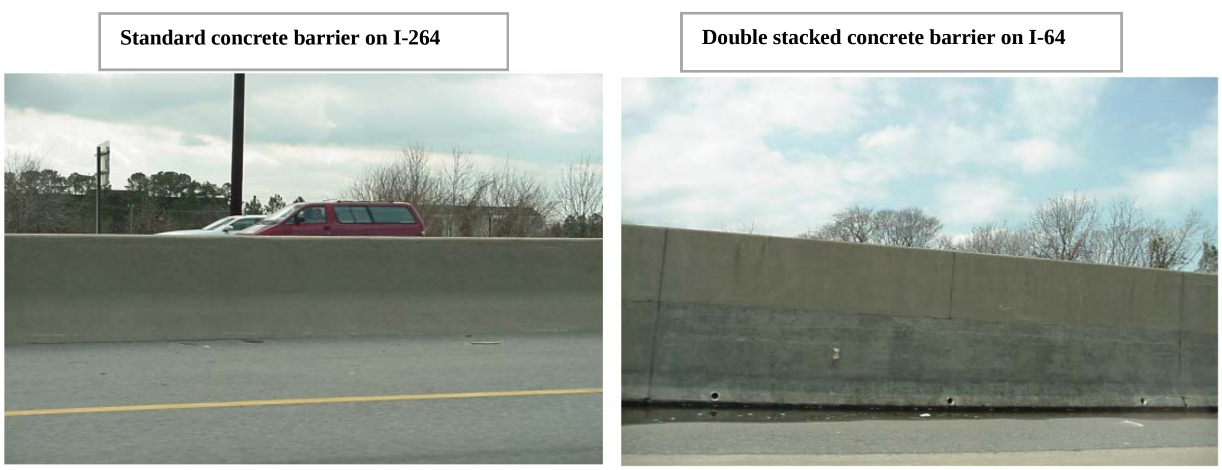
Freeway crashes capture the visual attention of drivers in the opposite direction of travel, which can lead to non-recurring congestion and secondary crashes. The importance of using visual barriers to prevent driver distraction at a crash scene or other roadway incident is stressed by many researchers [4, 10, 14, 19, 20], and it's a tool used internationally, such as in the United Kingdom [21]. One study used driving simulators to explore the effects of visual barriers on driver eye movement and steering wheel angle. It concluded that in the absence of barriers, drivers look at crash scenes for 12 seconds [14], however, previous research demonstrated that it takes only 2 seconds to create a hazardous situation or a crash when glancing off a travel direction [22].

Barriers have proven to make a difference, but barrier types and coverage play important roles in reducing distractions. For example, drivers look more at a crash scene when there is no barrier than when there is a partial or full barrier. Colon et al. also confirmed that barrier coverage is significant. Their experiment demonstrated that drivers had more eye movement with a partial barrier than with a full barrier even though the crash was obstructed by the partial barrier. It was suggested that the simplest indication of the presence of a traffic crash can cause driver distraction and incite them to look further due to curiosity. Hence, full barriers covering entire scenes are essential for reducing driving distraction during traffic incidents [14].

In addition to barrier coverage, barrier color can also have an impact. Although studies evaluating the effects of barrier salience are mostly lacking, low salience barriers are usually recommended. Bright-colored barriers, barriers with advertisements, or barriers with movement are likely to cause more distraction [14]. The following sections delve more into the types of visual barriers that can obstruct views of crash scenes.

2.3.1.1 Permanent Physical Barriers

As noted, permanent barriers are available on some roadways to reduce the number of cross-median crashes and rubbernecking. This countermeasure for cross-median crashes may be very costly and could not be justified when potential rubbernecking is the only issue. The effectiveness of these barriers against rubbernecking also depends on the height of the products. For example, the Hampton Roads freeway system in Virginia includes both standard 42-inch concrete barriers and double-stacked concrete barriers [4]. As shown in Figure 2-2, a double-stacked concrete barrier can be more effective than a standard 42-inch concrete barrier at obstructing views in the opposite direction of travel and reducing rubbernecking. By limiting rubbernecking, these barriers can help minimize unnecessary congestion and its associated delays. Therefore, a double-stacked concrete barrier can help reduce both cross-median crashes and rubbernecking, but it is an expensive countermeasure to prevent only rubbernecking. For the widespread use of barriers to prevent rubbernecking, cost-effective barriers are needed [4].



Source: [4]

Figure 2-2. Examples of concrete barrier heights on the Hampton Roads freeway system

Limited studies exist on the impact of barrier height on rubbernecking, traffic delay, and capacity reduction. Understanding the relationship between the height of a barrier and the occurrence of rubbernecking will be useful to provide better guidance on installing effective barriers [4]. Overall, barrier height and installation cost are just two of the many factors that can influence the widespread use of barriers. A more efficient and cost-effective system will be beneficial. The following sections discuss some of those options.

2.3.1.2 Portable and Non-Foldable Visual Screen Barriers

Another type of visual barrier that can be deployed to reduce rubbernecking is a portable and non-foldable visual barrier, which is often used to prevent rubbernecking. An example of this type of barrier is an incident screen, such as that used in the United Kingdom, to reduce congestion during major freeway crashes. The first time these screens were used along British highways after automobile crashes, congestion was quickly reduced in both directions of travel [19]. An article describing the deployments also highlighted a few limitations of such barriers, including that the screens tended to tip over on windy days and that setting them up on highways could be dangerous. Example photos of incident screens are shown in Figure 2-3. These incident screens are not foldable and need to be transported on a three-meter-long trailer, however, the manufacturer describes the entire assembly as very light screens with steel support holders. The company also explains that the system is made of 40 loose elements, which can be easily assembled by only two road workers. One set of the incident screens can cover 100 m, a long stretch of the roadway. Visual barriers of interest in this project are foldable barriers that can be set up by one person. Light, foldable, weather-resistant visual barriers could have widespread deployment against rubbernecking.

Source: [23]

Figure 2-3. Examples of incident screens

2.3.1.3 Light Portable and Foldable Visual Screen Barriers (PVBs)

Two barriers that are promising for this project were identified: one is available by "Barrier by Design" and the other by "Gawkstopper." Details and visuals for each are provided below.

Barrier by Design – Highway Barrier System

In addition to the original source [24], several sources provided information on the SRN1000 barrier system [25-29]. Photos of how to set up the system, how to use it, and deployment examples are shown in Figure 2-4 through Figure 2-6. Attributes related to the privacy, safety, and security of the Highway Barrier System include:

- Each section of the barrier is 7 ft tall and 10 ft wide
- Weather-resistant that can support winds of 30 mph (strong magnets, bungee cords, 45 lbs of ballast weight bags of 15 lbs per tripod, steel ground spikes help hold system down in winds up to 30 mph)
- Each system includes two sections, three steel tripods and four convertible heavy-duty fabric (nylon) screens (foldable metal tripod stands)
- Easy to carry and set up
- Available in a portable bag (wheeled carrying case about the size of a typical golf bag)
- Retail price of $1,263.42 – $3,406.41
- They weigh about 50 lbs
- Extensions can be added to make the barrier longer
- Can be set up by a single person with no tools in less than five minutes, and can fit into any truck or inside a vehicle
- Customizable and can include the logo of law enforcement organizations

Source:[24]

Figure 2-4. SRN1000 example setup pictures

Source: CUTR

Figure 2-5. Rendering of the PVB used during a crash

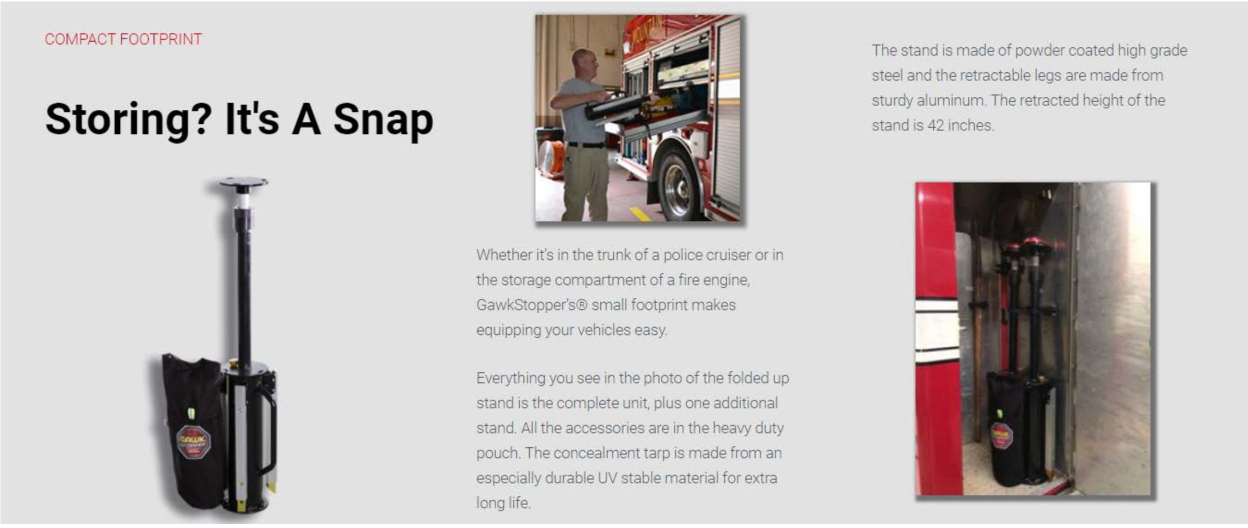
Source: [24]

Figure 2-6. Example deployments of SRN 1000

GawkStopper

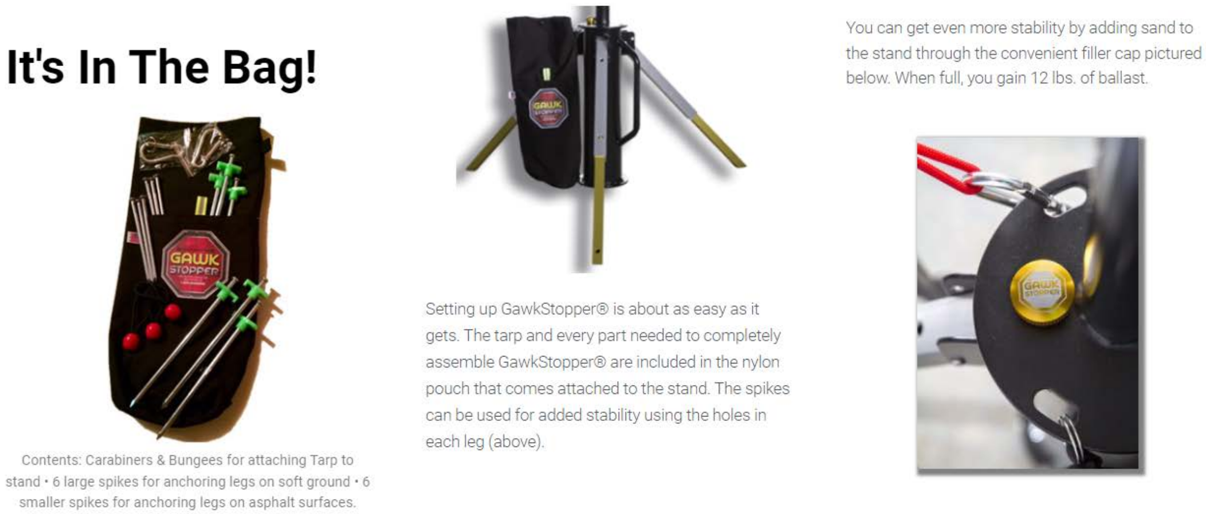
Gawkstopper offers PVBs and promotes its products on the company website as being the best built, quickest, and easiest-to-deploy portable incident screen system in the market (Figure 2-7). The product can be deployed in under one minute and has a storage bag (Figure 2-8). Other attributes provided on the company website are summarized as follows [30]:

- Each section is 10 ft wide by 6 ft tall
- Each stand weighs 30 lbs empty
- Stand filled with sand (for extra ballast) weighs 42 lbs; three aluminum legs use large spike for incomparable stability while deployed
- Each stand is 6 ft tall, extended, and 42-in. retracted
- 3 spikes (for leg holes) included for added stability
- Weighs 68 lbs
- All stands are powder-coated for lasting toughness
- All stand materials are rust-resistant
- Screens are waterproof, mildew-proof, and UV-protected
- Tripod style legs provide stability on uneven terrain
- Magnetic accessories can attach to stand top
- Patented stand design
- Can be adaptable and set up in any style configuration to handle toughest terrain and conditions



Source: [30]

Figure 2-7. GawkStopper easy storage illustration



Source: [30]

Figure 2-8. GawkStopper assembly parts

The GawkStopper system has a variety of options and prices to suit different needs, allowing users to select the option that suits them best. As noted, the system is adaptable to various conditions. GawkStopper products can be used for many circumstances, including preventing rubbernecking, and can be used inside or outside. Figure 2-9 shows examples of GawkStopper at incident scenes.

Source: [30]

Figure 2-9. GawkStopper deployment examples

Other types of PVBs are available worldwide, with some designed primarily for privacy purposes. One example is the portable privacy screen (Figure 2-10) by Solid Rescue in the Netherlands. Specifications for this screen are as follows:

- Size (L x H): 23.5 x 6 ft
- Size in bag (L x H x W): 3.6 x 1.1 x 1.1 ft
- Weight 33 lbs

Some characteristics of the portable privacy screen include the following:

- Quick set-up and take-down
- Lightweight construction
- Expandable
- Easy cleaning

Source: [31]

Figure 2-10. Portable privacy screen used in the Netherlands

One person can easily set up the screen within minutes and can be folded to take up little space. The barrier can be arranged into various formations, and multiple screens can be linked through straps attached on both sides of the screen. The barrier can support mild wind conditions without extra aids and can be anchored to the ground using tent pegs and guy lines in windy and uneven conditions.

Another kind of privacy screen was used in Germany, as shown in Figure 2-11. Police in Central Hesse in Germany used the screen for the first time after a fatal crash by creating a 30 m-long and 2 m-high privacy screen on site and confirmed the importance of the screen.

Source:[32]

Figure 2-11. Privacy screen used in Germany

Glare screens, primarily used to block headlights of oncoming vehicles, can also serve as rubbernecking countermeasures at locations where they already exist. An engineer in Illinois argued that other portable screens can encourage drivers to look around the screen. Glare screens on top of a median can naturally obstruct the view of the opposite lanes of traffic and the glare of oncoming headlights [1]. However, this kind of barrier may not be easily deployable in under five minutes (as can some previously highlighted) to prevent crash scene-related rubbernecking. Examples of glare screens are shown in Figure 2-12. Glare screens have the following features:

- Delineate median barriers
- Reduce rubbernecking in work zones
- Fast, easy installation and replacement
- Made of safe, durable, high-impact polymers

Source: [33, 34]

Figure 2-12. Examples of glare screen

2.3.2 Other Countermeasures

In addition to visual barriers, other countermeasures against rubbernecking are noted in the literature, such as educational strategies and traffic enforcement, when combined with traffic control measures [6, 12]. Additionally, message signs displaying short messages informing drivers about crashes can provide an early warning to motorists and suggest alternate routes [1].

3 Evaluation Approach

As part of the project, the team used two different approaches to evaluate the impacts of rubbernecking and PVBs on roadway mobility and safety:

- Develop and use traffic simulation models to investigate the impacts of PVBs on rubbernecking
- Deploy a selected PVB and evaluate its effectiveness

3.1 Traffic Simulation Models

Traffic simulation models were developed and used to evaluate the potential impact of rubbernecking and PVB on roadway mobility and safety. The research team also collected data after a real-world deployment to assess the impact of the PVB on traffic congestion caused by rubbernecking.

For the simulation, different scenarios were considered with varying traffic level-of-service (LOS), incident clearance duration, and percentage of drivers exhibiting rubbernecking behavior. The last measure was developed for this project and allowed the team to fine-tune the percentage of vehicles that followed certain rules in the simulation. This would simulate the percentage of drivers in the traffic stream who exhibit rubbernecking behavior while passing by an incident. This behavior includes slowing down to observe the incident scene and the activity of emergency or other personnel. Vehicle delay, as well as average and max queue length, were obtained as output for each scenario. Simulation data and graphs were produced for each scenario to facilitate visual comparison. Sensitivity analysis was also conducted to provide insights into the level and timing of the deployment of the PVB during an incident. The detailed traffic simulation modeling process, simulation results, and findings are presented in Section 4.

3.2 Real-world Deployment of Portable Visual Barriers

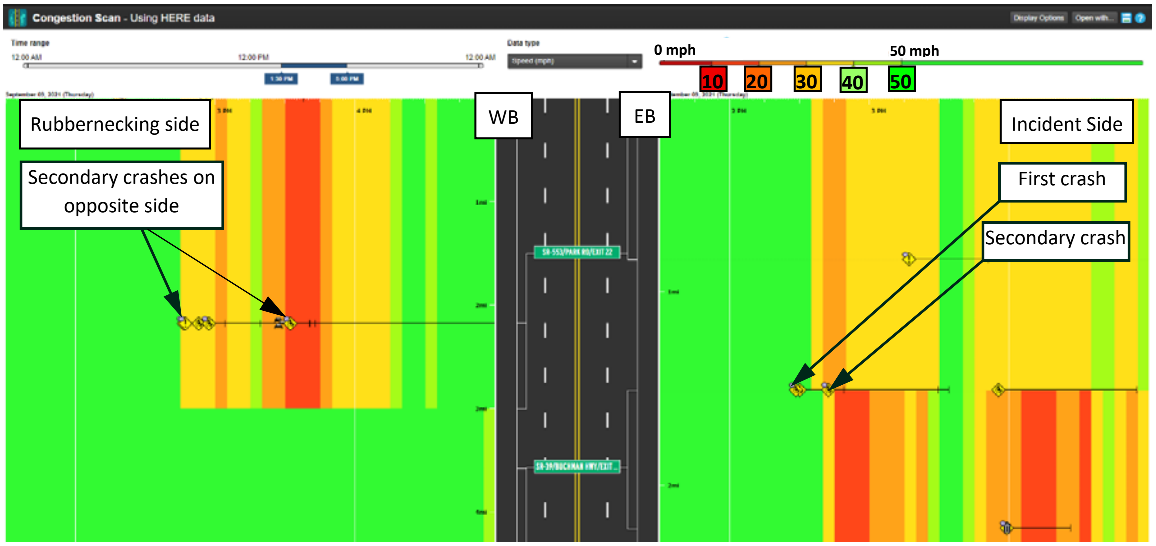
It is crucial to evaluate the effectiveness of PVB deployment in deterring rubbernecking by examining real-world scenarios on interstate highways. In this study, FDOT District 7 Road Rangers, in collaboration with CUTR researchers, identified appropriate situations for PVB deployment at crash scenes based on crash severity and prevailing traffic conditions, with the goal of reducing rubbernecking by drivers traveling in the opposite direction. A fatal motorcycle crash on I-75 in Wesley Chapel, Florida, served as the real-world case study. PVBs were deployed at the scene, and researchers analyzed the crash to assess the implementation of PVBs in a field setting. Field observations by Road Rangers, along with congestion levels, speed data, and queuing data collected from roadway sensors, were evaluated. Detailed PVB deployment procedures, data analysis, and research findings from this pilot field deployment are presented in Section 5.

4 Traffic Simulation Analysis

As mentioned previously, traffic simulation models were estimated to assess the impact of rubbernecking on traffic congestion due to the lack of sufficient data for traditional models. The study specifically focused on the segment of the I-75 and I-4 Interstates passing through Hillsborough County, Florida, where rubbernecking incidents are prevalent. The two primary types of blockages caused by incidents, i.e., blockages in main lanes and shoulders, were taken into consideration during the traffic simulations.

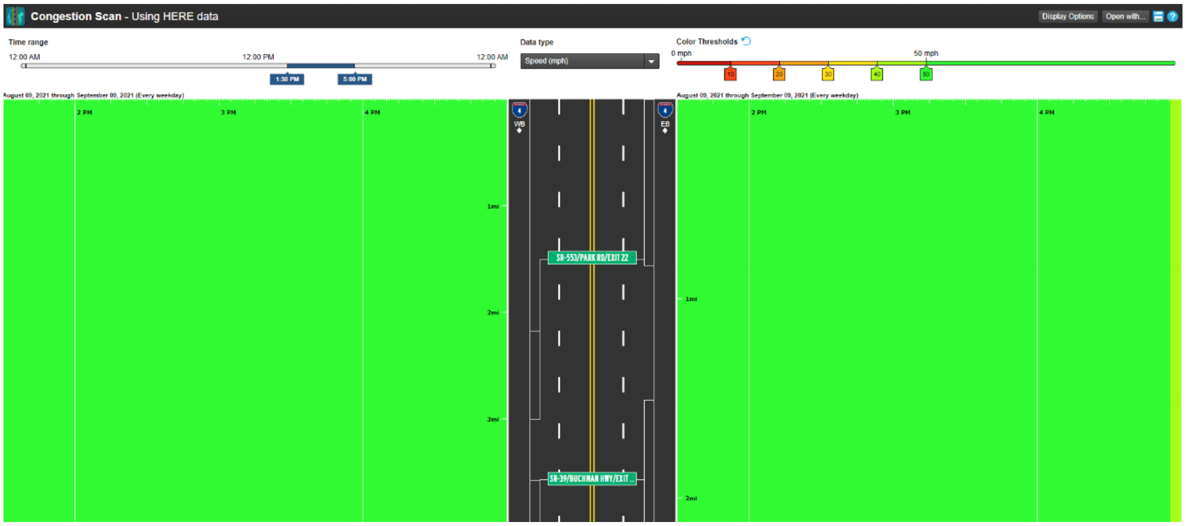
4.1 Data Collection

To develop the traffic simulation model, real-world incident data, including speed, incident information, and relevant geographic data, were obtained from the Regional Integrated Transportation Information System (RITIS) detector data. Several incidents where rubbernecking occurred were identified, and traffic data during those incidents were extracted from RITIS. Figure 4-1 shows a congestion scan output from RITIS during the time of a crash on I-4 in Tampa, Florida. The speed contour on the left shows no congestion (speeds above 50 mph) until the crash occurred in the eastbound (EB) direction (right). On the opposite side, westbound (WB), rubbernecking caused congestion, evident by the slower speeds up to the point of the crash. Downstream of WB, the speeds go above 50 mph as indicated by the green color. To confirm that this is not recurring congestion, Figure 4-2 shows the same congestion scan but for an entire month prior to the crash. As shown, there is usually no recurring congestion at this location. This confirms the finding of congestion in the WB direction due to the crash in the EB direction. Similar cases were identified using RITIS at times and locations where the project team members experienced rubbernecking due to a crash while driving in the Tampa Bay area.



Source: RITIS

Figure 4-1. Congestion scan during crash on I-4, 1:30 PM and 5:00 PM



Source: RITIS

Figure 4-2. Congestion scan on I-4 between 1:30 PM and 5:00 PM for 1 month prior to crash

The data collected included vehicle speeds, traffic volume, travel time for each detector location, and lanes blocked along the incident site. These detector locations are placed strategically at every half mile. The data was recorded every 15 minutes and extracted for a total of three hours after the incident start time. The geographic information included the latitude and longitude of where the incident took place, the incident duration, and incident clearance times. The roadway geometry was replicated using background images in VISSIM® that were extracted from Google Maps®. The roadway geometry, including curvatures, roadway width, and lane width, was verified to calibrate the model to be the digital twin of real-world conditions. This dataset was instrumental in calibrating the parameters of the VISSIM simulation model, particularly the car-following models. Subsequently, the calibrated models' accuracy was verified by comparing and cross-referencing the volumes and speeds recorded at each detector's location.

4.2 Simulation Method

The Wiedemann 99 car-following model for freeway driving was chosen for the simulations. This model was deemed suitable for accurately replicating the dynamics of vehicle behavior during rubbernecking incidents in the selected study area. Two incident types were considered in this traffic simulation: 1) the left shoulder of a freeway was blocked with three travel lanes open as shown in Figure 4-3, and 2) 350 ft of the left lane of a freeway was blocked with two travel lanes open for that segment as shown in Figure 4-4.

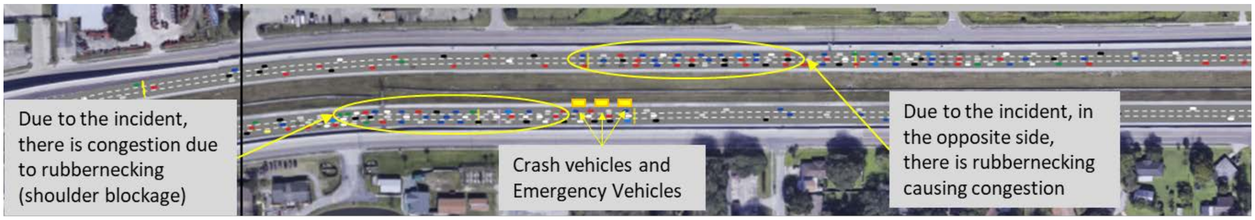


Figure 4-3. Simulation setup for shoulder blocked use case

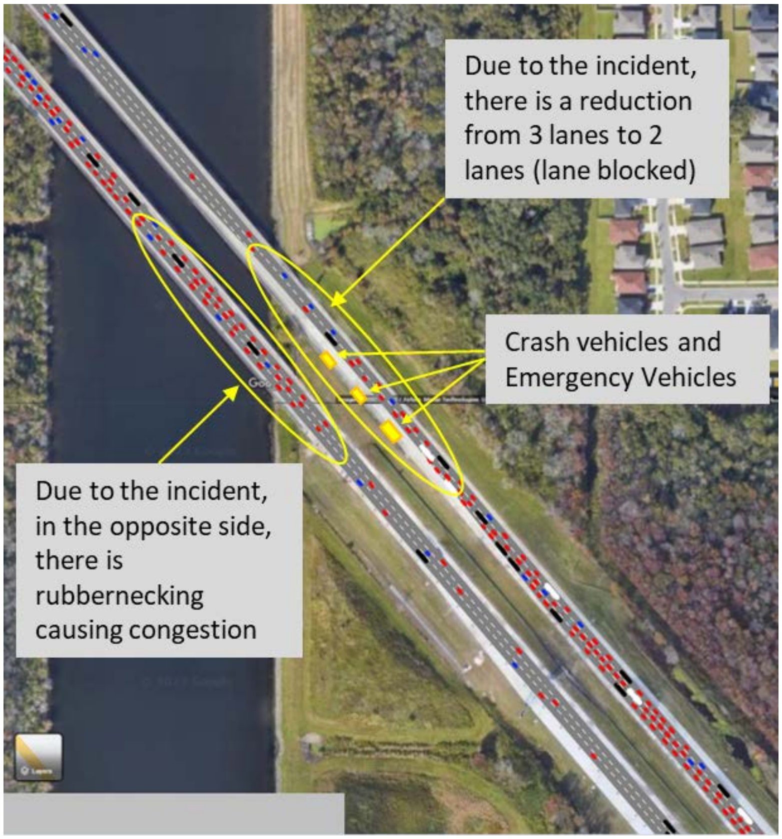


Figure 4-4. Simulation setup for lane blocked use case

For each type of incident - lane blockage and shoulder blockage - various scenarios were considered. The scenarios consisted of varying traffic levels of service, incident durations, and rubbernecking percentages. Table 4-1 shows the input in the simulation scenarios. As mentioned earlier, three main factors were considered for the simulation: 1) Traffic volume in vehicles per hour per lane (LOS), 2) incident duration in minutes, and 3) percentage of vehicles exhibiting rubbernecking behavior. To control the amount of simulation runs, only selected values for incident duration and percent of rubbernecking vehicles were used in the model, resulting in 45 runs for each use case for a total of 90 simulation runs.

Table 4-1. Values Considered for Rubbernecking Scenarios

Variable	Values	
	Shoulder Blockage	*Lane Blockage*
Traffic Volume in Vehicles per Lane (LOS A) *	800	800
Traffic Volume in Vehicles per Lane (LOS B) *	1,300	1,300
Traffic Volume in Vehicles per Lane (LOS C) *	1,800	1,800
Traffic Volume in Vehicles per Lane (LOS D) *	2,150	2,150
Traffic Volume in Vehicles per Lane (LOS E) *	2,400	2,400
Incident Impact Duration in Minutes	4	4
Incident Impact Duration in Minutes	8	8
Incident Impact Duration in Minutes *	12	12
Incident Impact Duration in Minutes	16	16
Incident Impact Duration in Minutes	20	20
Incident Impact Duration in Minutes	24	24
Incident Impact Duration in Minutes	28	28
Incident Impact Duration in Minutes *	32	32
Incident Impact Duration in Minutes	36	36
Incident Impact Duration in Minutes	40	40
Incident Impact Duration in Minutes *	44	44
Incident Impact Duration in Minutes	60	60
Percentage of Driver Rubbernecking *	20%	20%
Percentage of Driver Rubbernecking	40%	40%
Percentage of Driver Rubbernecking *	60%	60%
Percentage of Driver Rubbernecking *	80%	80%
Percentage of Driver Rubbernecking	100%	100%

* *Values used in the simulation*

The simulation model was estimated to depict the real-world scenarios and match the data collected. To calibrate the model, the speeds and volumes from RITIS in a real-world rubbernecking case due to a freeway crash were included in the traffic simulation. Then the speeds from the real-world and simulated environment were compared, and the simulation model was adjusted so that these performance metrics matched. There were 4 locations in the simulation roadway geometry where the speeds were matched to make sure the simulation was realistic throughout the network. The results of the calibration are shown in Figure 4-5. As seen in the figure, the speeds from the real world and the simulation match and hence it is safe to assume that the simulation model is calibrated.

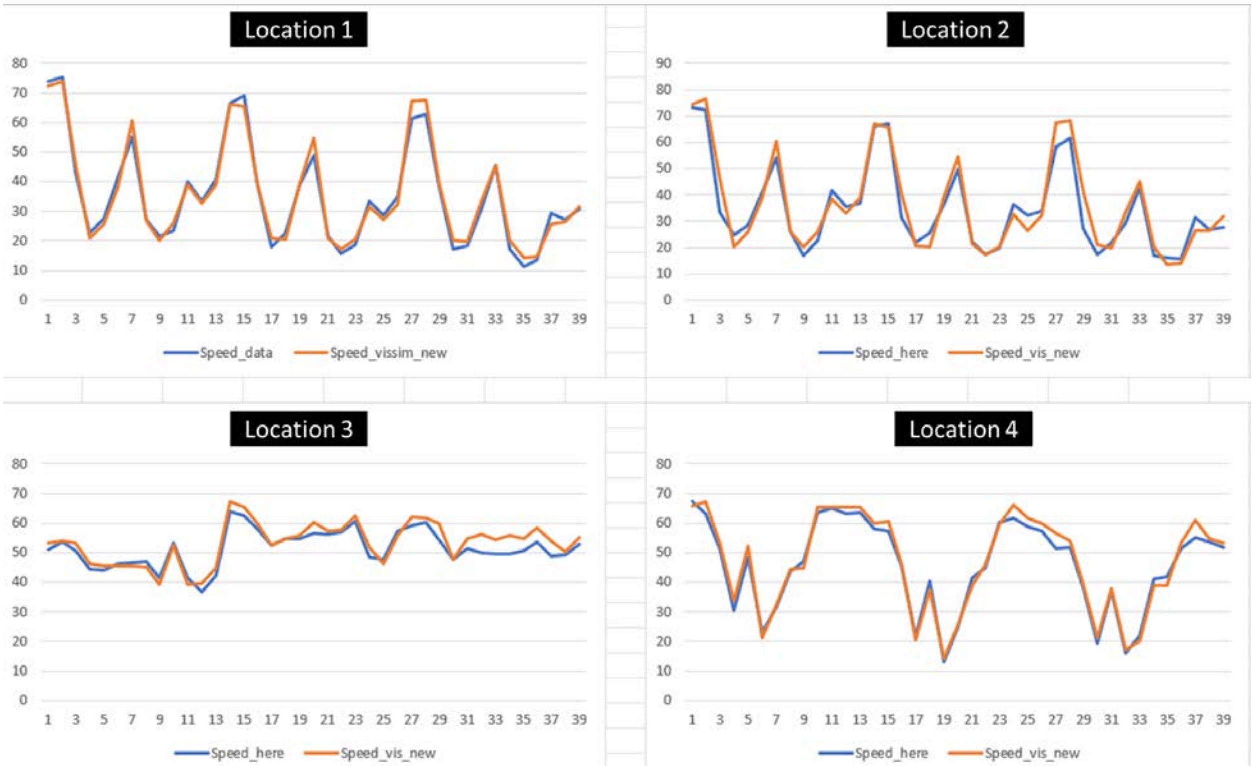


Figure 4-5 Calibration Results for VISSIM Roadway Geometry

A new vehicle class was introduced in the simulation to study the phenomenon of rubbernecking, specifically for vehicles engaged in rubbernecking behavior. These rubbernecking vehicles were designed to have properties similar to passenger cars. The vehicle composition of each of the classes remained constant throughout the simulation, except for normal passenger cars and the new class of rubbernecking cars. The vehicle composition of both these vehicle classes was altered according to the scenario being simulated. For example, a simulation where 60% of the vehicles exhibited rubbernecking behavior resulted in 40% standard passenger cars and 60% rubbernecking cars. As described earlier, the percentage of passenger cars engaging in rubbernecking behavior varied to investigate the impact of rubbernecking. This allowed the evaluation of the effects of PVBs on rubbernecking and related congestion.

The simulation scenarios were conducted over a total duration of three hours, with an initial 30-minute initialization period before the incident parameters were triggered. Additionally, a dissipation period of one to one and a half hours was implemented to allow the traffic queue to disperse gradually after the incident. The road network used in the simulation for both scenarios covered a total length of approximately 20 miles, with the incident location situated approximately five miles from the end of the road network, providing 15 miles in the opposite direction with rubbernecking for queue buildup. This setup allowed us to observe and analyze the behavior and effects of rubbernecking in a controlled and realistic environment.

4.3 Analysis and Results

The simulation results for the opposite side of the incident, referred to as the rubbernecking side, are analyzed. This study focuses solely on the opposite side, as the direction of travel where the incident occurs is not the primary concern of this study. Data were exported and visualized for each of the combinations of LOS, incident duration, and percent rubbernecking. The output for all simulation models was two traffic measures: queue length and vehicle delay. The queue length and delay results for the rubbernecking direction of the simulation are explained next.

4.3.1 Queue Length

The queue length caused by the simulated incidents for the opposite side is shown in Figure 4-6 for the shoulder blockage and in Figure 4-7 for the lane blockage scenario. The queue length was collected using queue counters in VISSIM, with minimum and maximum threshold speeds set at 0 mph and 20 mph based on values obtained from RITIS speed contour plots. The maximum headway was set to 65.6 ft (0.0124 miles), and adjacent lanes and links were considered. According to the simulation scenarios conducted (shown in Table 4-1) for visualization purposes, we chose to show three incident durations: 12 minutes long, 20 minutes long, and 28 minutes long.

Figure 4-6 and Figure 4-7 contain nine different plots (scenarios) each, representing increasing incident duration and percentage of vehicles involved in rubbernecking. For example, the top left plot in Figure 4-6 represents an incident duration of 12 minutes with 20% of vehicles rubbernecking. The plot shows the queue length in miles (y-axis) and simulation run time in minutes (x-axis). The lines represent the different LOS. The higher the LOS, the longer the queue is observed. The subsequent plots follow the same terminology.

Figure 4-6 depicts the shoulder blockage scenarios where, after the incident, the disabled and emergency vehicles are on the shoulder and are not blocking any travel lanes. We observed that LOS E queues take the longest time to dissipate within the three-hour simulation period for all possible scenarios. LOS E shows an increase to a maximum of approximately 10 miles and then a decrease in queue lengths. Expectedly, as incident duration or rubbernecking percentage increases, queue lengths also increase. LOS A, LOS B, and LOS C exhibit lower traffic flow volumes, resulting in smaller queues, which supports findings from previous studies.

Figure 4-7 displays queue lengths for the lane blockage case (left travel lane blocked from a three-lane freeway). Here, we observed the same phenomenon as in the shoulder blockage case. Lane blockage leads to congestion, causing fewer cars to enter the network, thus increasing the formation of queues in most scenarios. As with the shoulder blockage case, increasing incident duration, rubbernecking percentage, and LOS lead to higher queue lengths as well. The maximum queue length (10 miles) is observed when traffic is at LOS E for an incident duration of 28 minutes and with 60% of the vehicles rubbernecking.

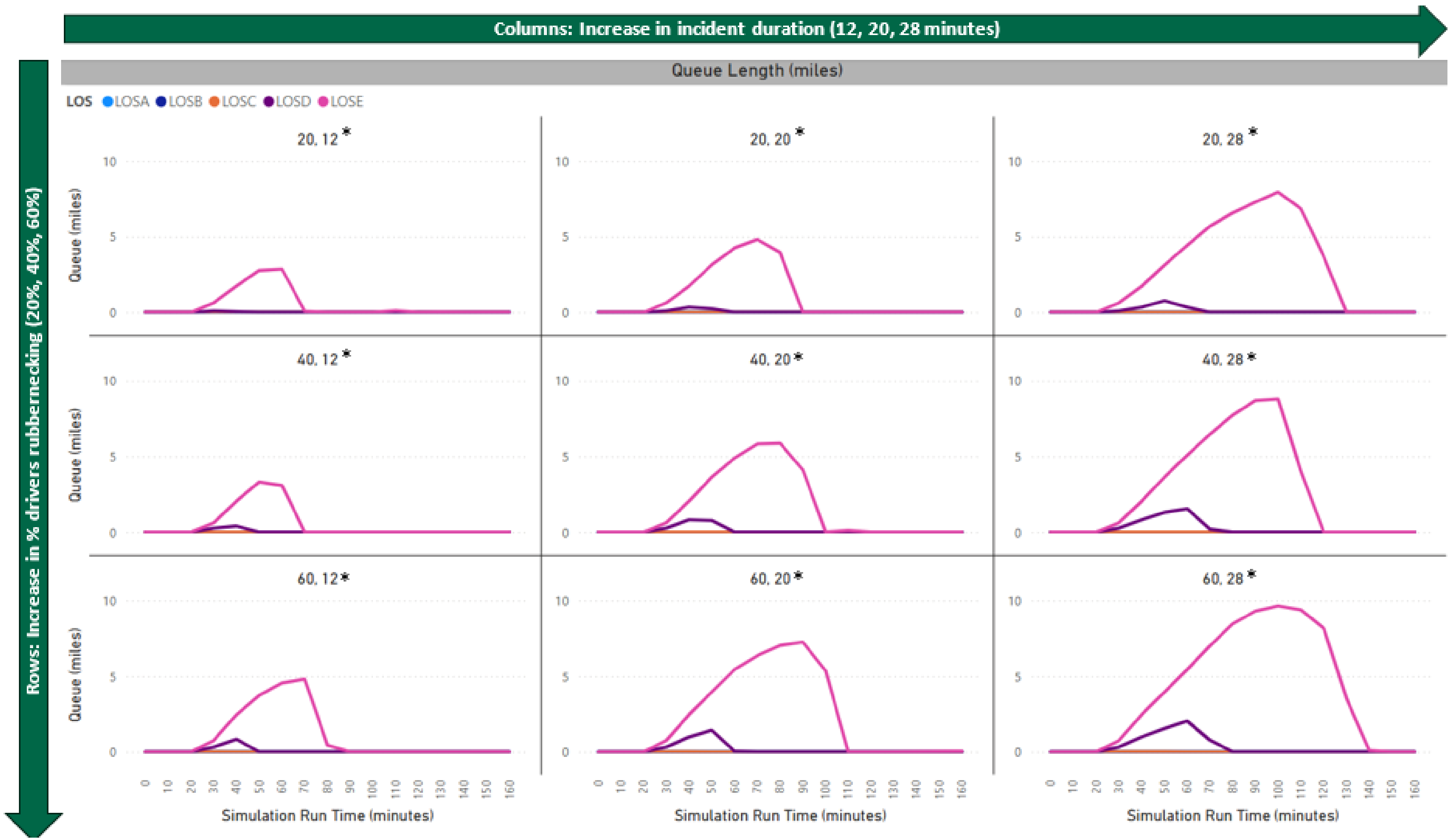


Figure 4-6. Queue length (shoulder blockage – rubbernecking direction)

* In (a, b), (a) represents the percentage of vehicles with rubbernecking behavior, and (b) represents the duration of traffic incident in minutes.

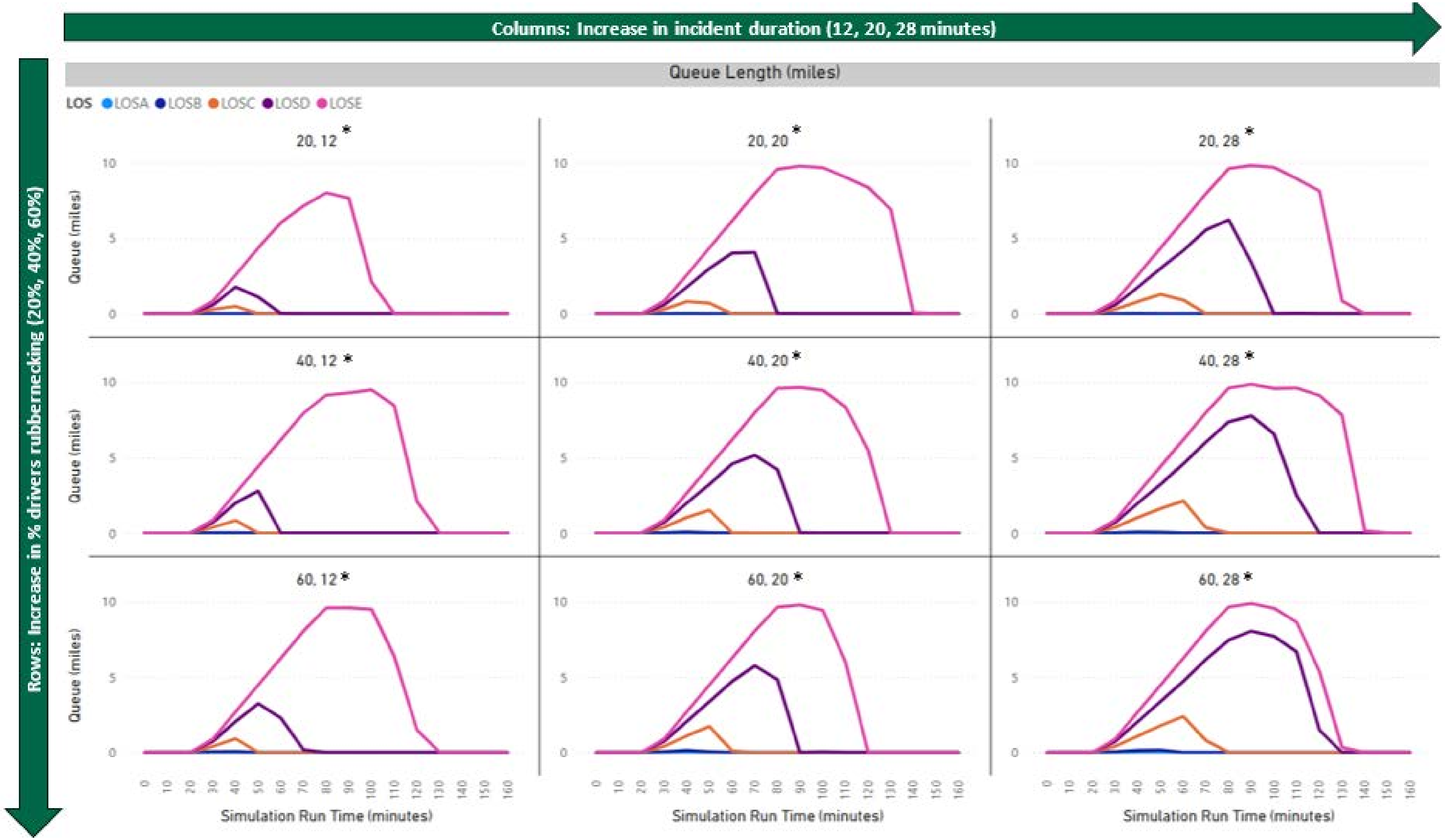


Figure 4-7. Queue length (lane blockage – rubbernecking direction)

* In (a, b), (a) represents the percentage of vehicles with rubbernecking behavior, and (b) represents the duration of traffic incident in minutes.

4.3.2 Vehicle Delay

Vehicle delay, measured in seconds, is illustrated in Figure 4-8 and Figure 4-9. These delays represent the additional time travelers spend on the road due to congestion, calculated from travel time measurements generated during the simulation. Vehicle delays provide a valuable metric for assessing and comparing the quality of mobility on roadways.

Each figure contains nine different plots (scenarios), representing increasing incident duration and percentage of vehicles involved in rubbernecking in the opposite direction of the incident. For example, the top left plot in Figure 4-8 represents an incident duration of 12 minutes with 20% of vehicles rubbernecking. The plot shows the average vehicle delay in seconds (y-axis) and simulation run time in minutes (x-axis). The lines represent the different LOS. The higher the LOS, the longer the delay is observed. The subsequent plots follow the same terminology.

The shoulder blockage and lane blockage cases both exhibit a spike in travel time during the incident period, followed by a gradual dissipation of delay. Similarly, an increase in incident duration, LOS, and the percentage of vehicles engaged in rubbernecking correlates with higher delays, which was evident in both cases. In the shoulder blockage case, the effects of shockwaves are observed, leading to a shift in travel patterns and upstream congestion, resulting in a fluctuating delay pattern depicted in Figure 4-8.

In contrast, for the lane blockage case, Figure 4-9 shows clearer impacts of incident duration, rubbernecking percentage, and LOS on delay. These plots reinforce the potential benefits of reducing these parameters to enhance mobility and safety.

In conclusion, analyzing vehicle delays in both cases underscores the importance of minimizing incident duration and the amount of rubbernecking for higher LOS to improve overall transportation efficiency and safety. In the context of controlling any of these factors, Traffic Incident Management (TIM) programs focus on reducing incident clearance and incident duration time, but not much can be done about traffic volume (LOS). Therefore, the only remaining factor, reducing rubbernecking, is the factor that can be controlled by the deployment of a PVB, thereby minimizing the effect of rubbernecking on delay.

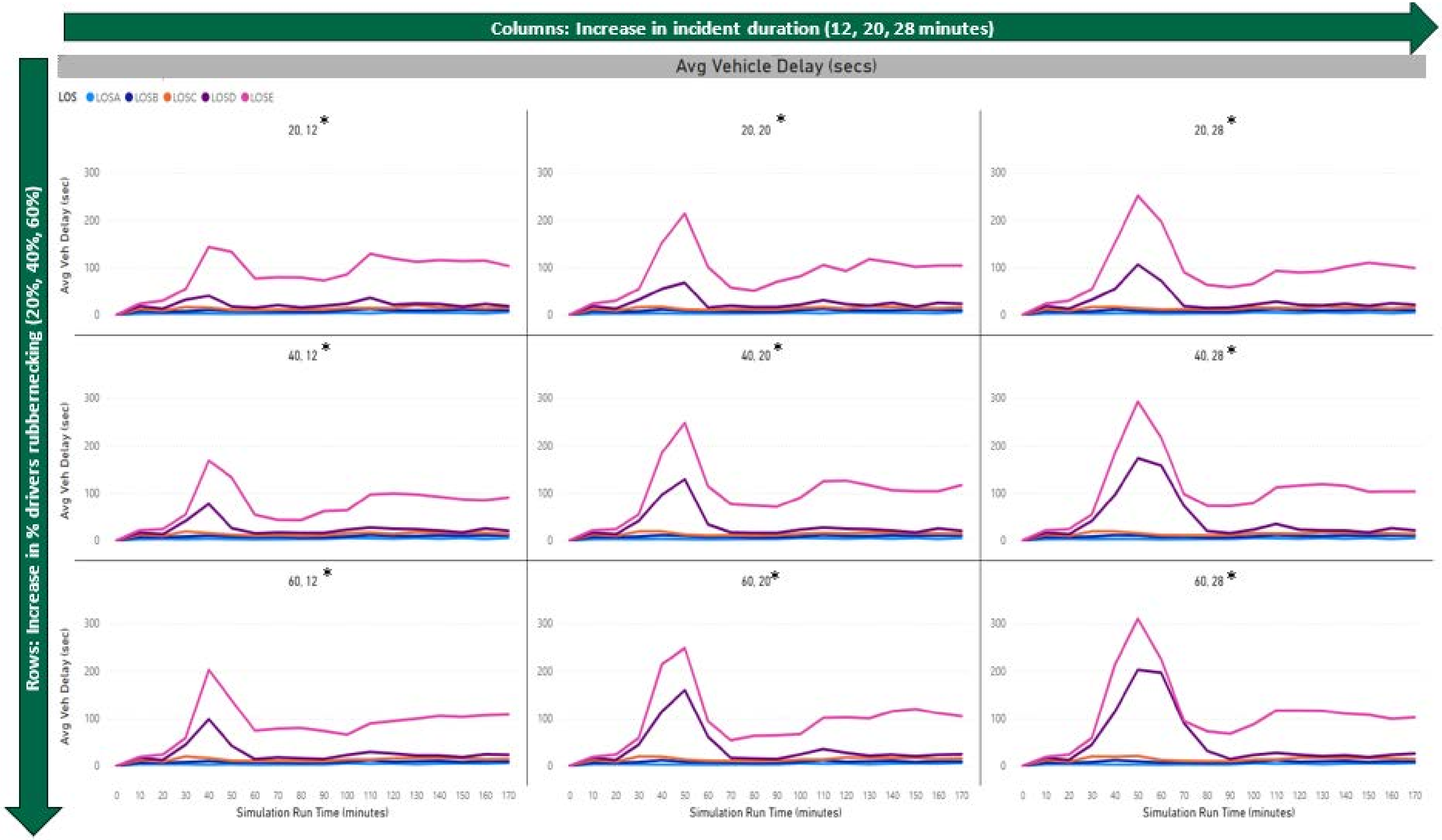


Figure 4-8. Average vehicle delay (shoulder blockage – rubbernecking direction)

* In (a, b), (a) represents the percentage of vehicles with rubbernecking behavior, and (b) represents the duration of traffic incident in minutes.

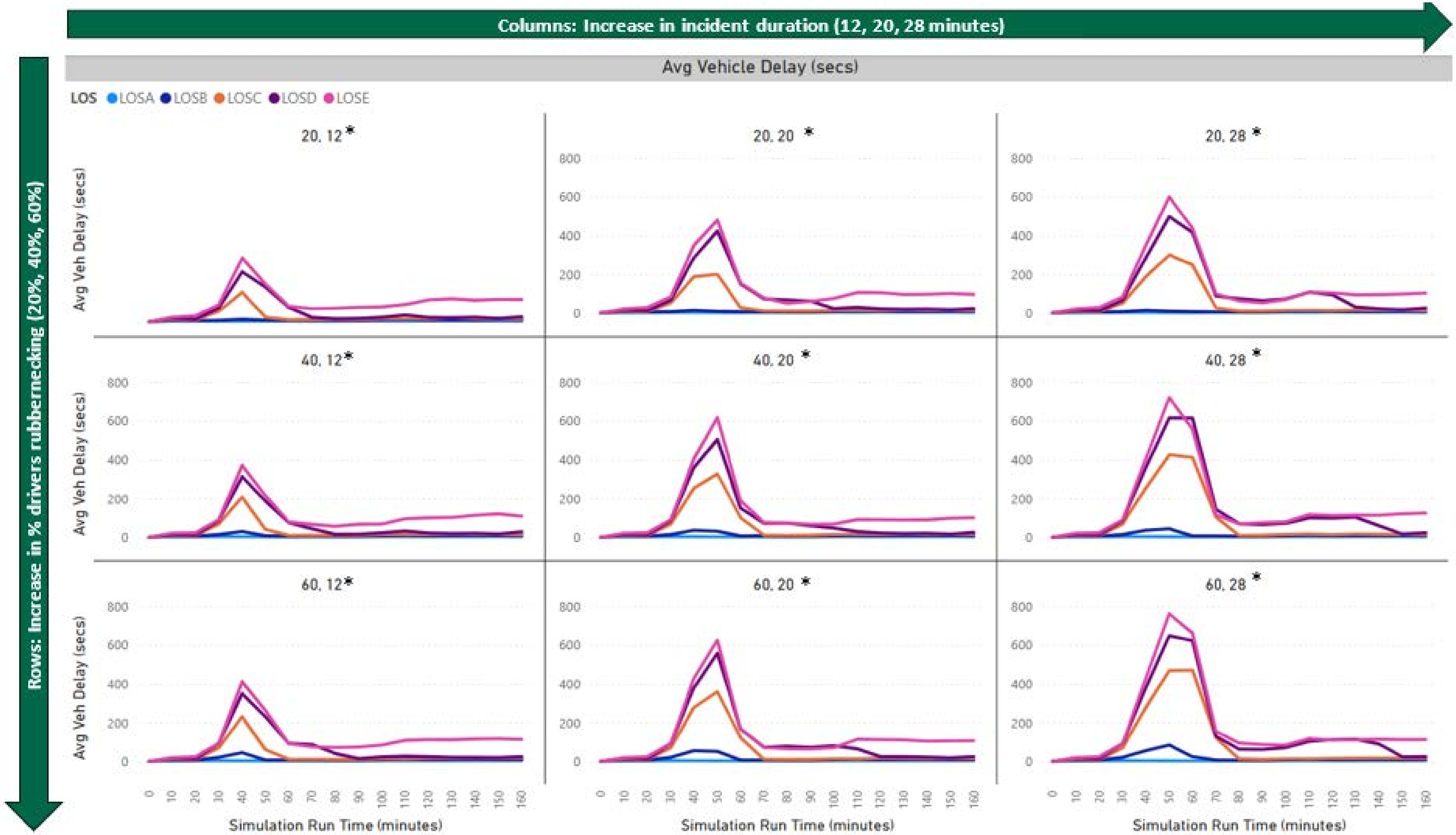


Figure 4-9. Average vehicle delay (lane blockage – rubbernecking direction)

* In (a, b), (a) represents the percentage of vehicles with rubbernecking behavior, and (b) represents the duration of traffic incident in minutes.

4.3.3 Secondary Crashes

Based on previous study [35] data about the relation between incident impact duration and secondary crashes, the project team was able to create a link between the percentage of vehicle rubbernecking, incident impact duration, safety outcome (secondary crash probability reduction based on a reduction in incident impact duration), and mobility outcomes (queue length and average vehicle delay). Table 4-2 presents the worst-case scenario, where the opposite direction is operating on LOS E. For this scenario, the three rubbernecking scenarios (20%, 40%, 60% of drivers rubbernecking) and three incident duration times (12 min, 20 min and 28 min) show the queue and average vehicle delay based on the simulation models. The longer the incident duration, the higher the queue, delay, and probability of secondary crashes. Future research can investigate the relationship in further detail.

Table 4-2. Relation Between Rubbernecking Percentage, Incident Impact Duration, Safety and Mobility Outcomes

Percentage of Vehicle Rubbernecking	Incident impact duration (min)	Mobility Outcome (LOS E)				Safety Outcome Probability of Secondary Crash (%)		
		Queue Length (miles)		Average Vehicle Delay (secs)		Estimate	95 % confidence interval	
		Shoulder Blockage	Lane Blockage	Shoulder Blockage	Lane Blockage		Lower Bound	Upper Bound
20%	12	2.85	8.01	142.80	312.80	15.3%	15.3	15.3
	20	4.82	9.78	213.89	479.47	26.7%	26.7	26.8
	28	7.95	9.82	250.92	599.63	39.3%	39.3	39.4
40%	12	3.31	9.49	168.10	371.38	15.3%	15.3	15.3
	20	5.88	9.65	247.71	617.06	26.7%	26.7	26.8
	28	8.80	9.86	292.27	720.15	39.3%	39.3	39.4
60%	12	4.81	9.59	202.48	412.61	15.3%	15.3	15.3
	20	7.26	9.77	248.76	624.39	26.7%	26.7	26.8
	28	9.64	9.87	310.03	761.55	39.3%	39.3	39.4

5 Deployment of Portable Visual Barrier

The research team worked closely with the ITS support manager, Road Rangers / TIM / RISC / FMS / AMS Specialist III, in FDOT - D7 Traffic Operations, to facilitate the deployment of three PVBs on freeways in Hillsborough County.

5.1 Planning, Acquisition, Coordination, and Deployment of PVBs

5.1.1 PVB System Acquisition Process

The project team explored several PVB systems as part of the initial phase of the project, including light portable foldable screen barriers, portable non-foldable visual screen barriers, and permanent physical barriers. Light, portable, and foldable visual screen barriers that are effective, wind-resistant, easily transported, and deployed in a short time are the choice for the pilot deployment of this project. Two main PVBs were identified in the market as plausible candidates for deployment. The companies that market those products comprise a local company and an out-of-state company, as follows:

- Barrier by Design (SRN1000) (Bradenton, FL)
- GawkStopper (Mills River, NC)

The project team contacted those companies to acquire more information about their PVB products. The team visited the local company in October 2022 for a showcase and to speak with its president and CEO. The barrier is a two-section 6-feet wide and 6-feet tall screen that uses two tripods for setup (Figure 5-1). The team also spoke with the president of the second company in North Carolina (NC) to acquire information about their system. It is a similar design with two tripods and one screen section that is 10 feet wide and 6 feet tall (Figure 5-2).

Source: CUTR; taken in 2022

Figure 5-1. SRN1000 screen

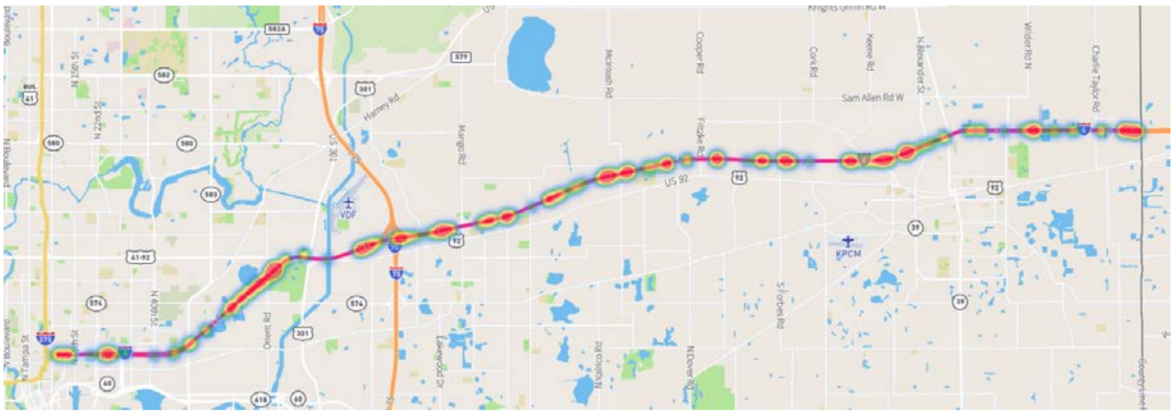
Source: [30]

Figure 5-2. GawkStopper screen

5.1.2 Selection of Road Rangers-Patrolled Freeway Segments for PVB Deployment

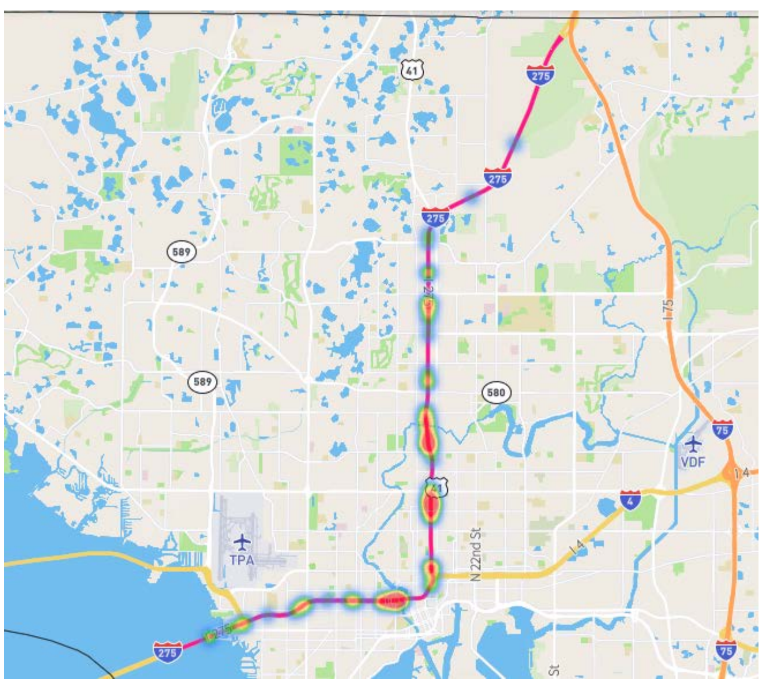
The project focuses on Hillsborough County, especially the three main interstates that pass through the county: I-75, I-275, and I-4. Since most rubbernecking occurs when there are injuries and fatalities, crashes with fatalities and incapacitating and non-incapacitating injuries between January 2021 and December 2022 were used to create heatmaps for the three major interstates. Figure 5-3 through Figure 5-5 show the segments of I-4, I-275, and I-75, respectively.

Hot spot segments with serious crashes are likely to continue to have serious crashes occur. These segments were used to serve as the candidates for deployment of the PVBs.



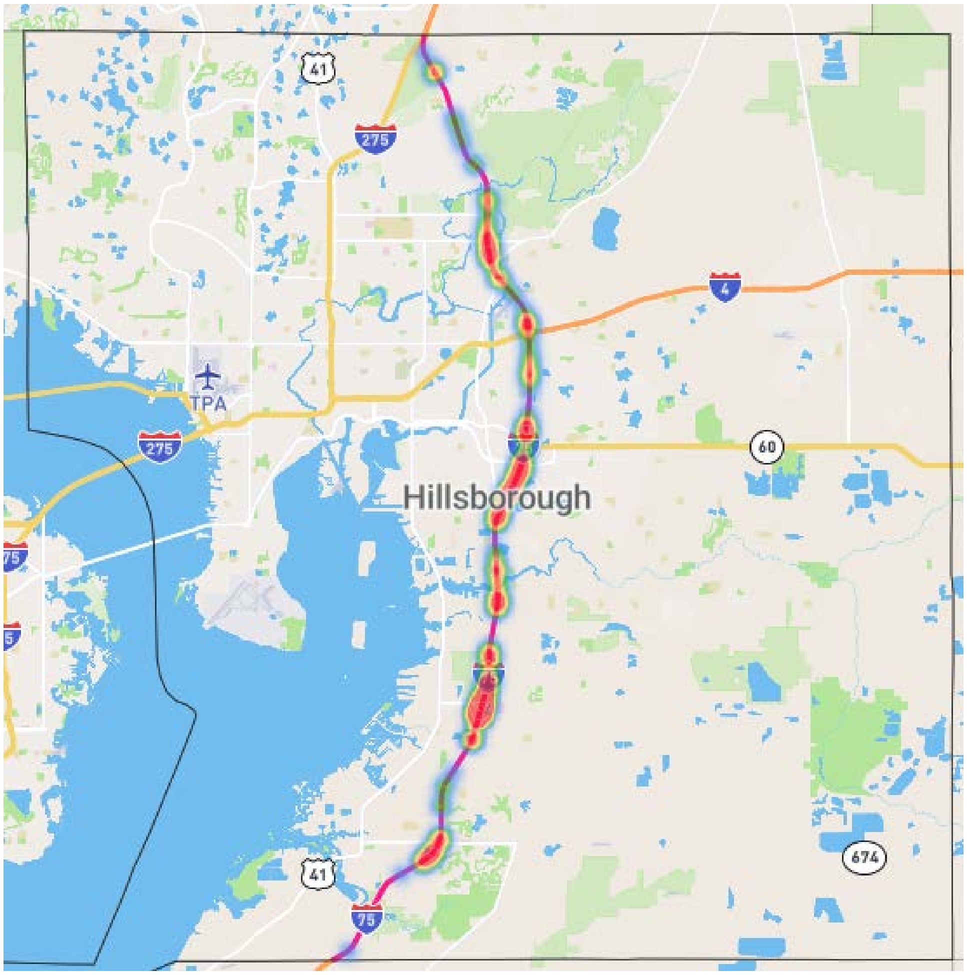
Source: Signal 4 Analytics

Figure 5-3. I-4 segment in Hillsborough County



Source: Signal 4 Analytics

Figure 5-4. I-275 segment in Hillsborough County



Source: Signal 4 Analytics

Figure 5-5. I-75 segment in Hillsborough County

5.1.3 Coordination with FDOT District 7 on PVB Deployment

The project team held meetings with the project manager and representatives from FDOT District 7 Road Rangers division. In the first meeting held in November 2022, the above-mentioned stakeholders discussed the deployment criteria, the selected PVB systems, and gathered suggestions, feedback, and comments from the group that would deploy the system. The project team also trained the FDOT Road Rangers members on how, when, and where to set up the PVB system.

The project team held a second meeting in December 2022 at the manufacturing facility of one of the barrier systems located in Bradenton, Florida. The CEO of the company met with representatives from FDOT District 7, the Road Rangers Service Patrol, and the CUTR project team at the facility, where he demonstrated the PVB, as shown in Figure 5-6.

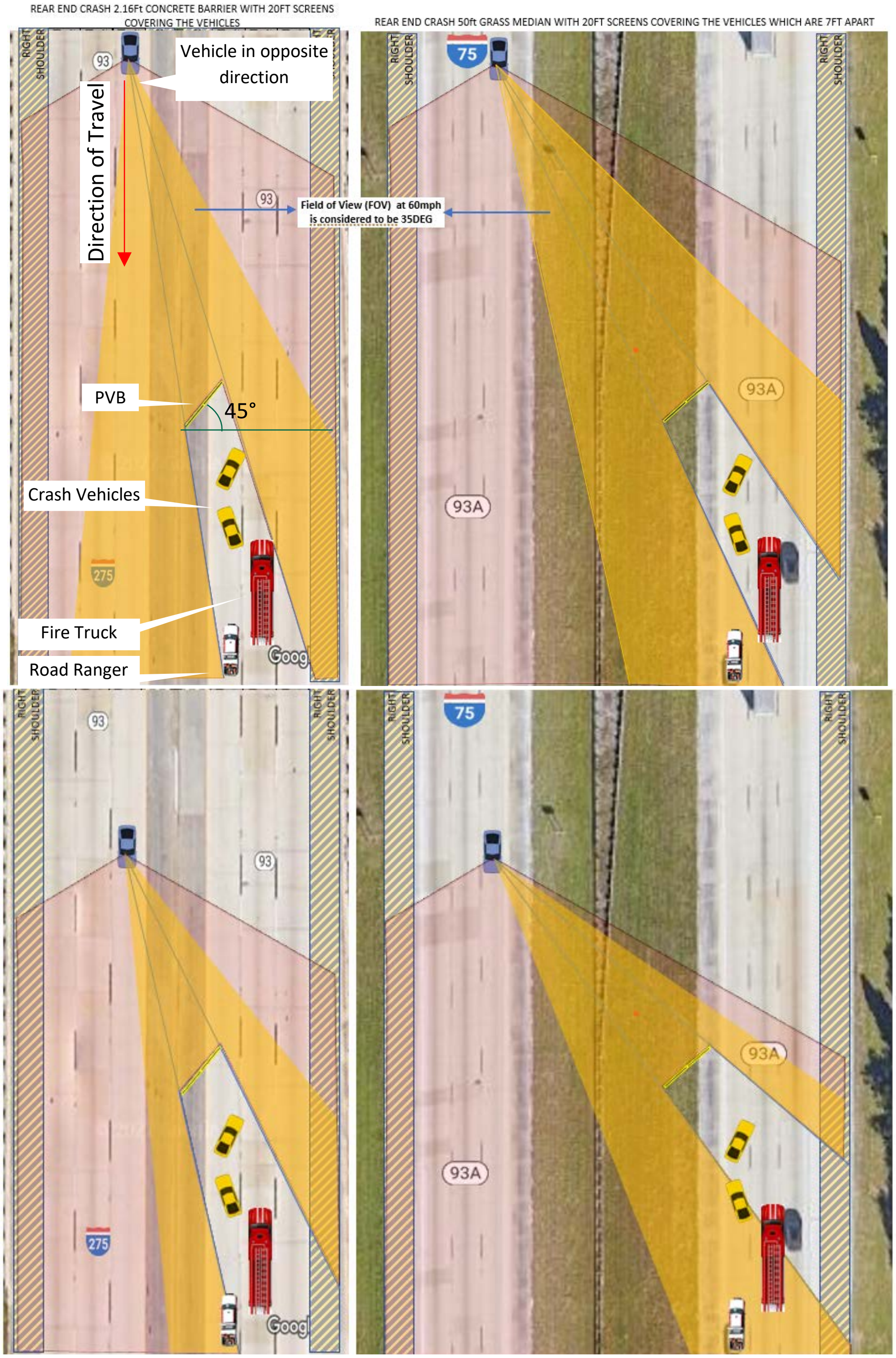
Source: CUTR

Figure 5-6. The PVB at the manufacturing facility

5.1.4 Deployment Conditions

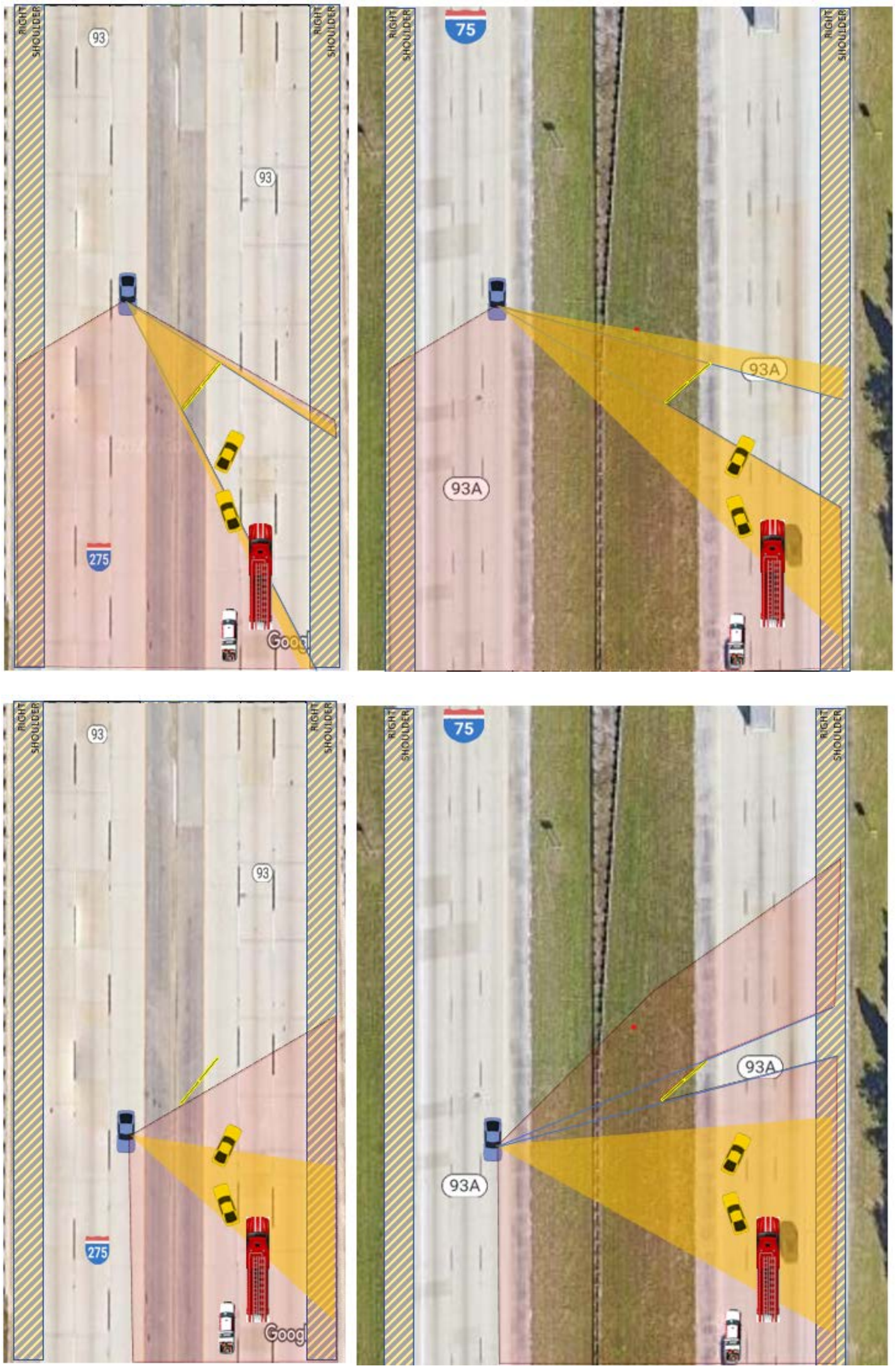
As discussed earlier, specific traffic conditions have to exist so that there is a need for the deployment of the PVB. The research team developed drawings of the deployment to simulate the distance and locations where the PVB can be most effective in obscuring the scene of an incident.

Figure 5-7 and Figure 5-8 show an example of the PVB deployment during an incident on the highway. The incident involves two vehicles (yellow), a road ranger truck, and a fire truck. The left image shows a section of the road with a concrete barrier, and the right image shows a wide grass median. The oncoming vehicle (blue) is approaching the incident in subsequent figures. The placement of the PVB is 1-2 car lengths in front of the forward vehicle and at an angle of approximately 45° from the traffic lanes. The yellow shaded area shows the driver field of view (FOV) for acute vision, and the red shaded area shows the approximate peripheral vision. Once the blue vehicle comes in a position past the PVB (last image), presumably they will continue to drive forward since they have not been able to see anything before and are traveling with a higher speed which is not conducive to stopping.



Source: CUTR

Figure 5-7. Driver's view from opposite direction of an incident with deployed PVB



Source: CUTR

Figure 5-8. Driver's view from opposite direction passing incident location with deployed PVB

5.2 Data Collection for PVB Pilot Deployment Evaluation

This section summarizes an overview of the data sources and data collection methods for the evaluation of the PVB pilot deployment. Multiple data sources and applications are utilized to evaluate the effectiveness of PVB. The data, including category, variables, and sources, are presented in Table 5-1. The data included roadway incidents recorded in Sunguide software and shared with the Regional Integrated Transportation Information System (RITIS), historical crash data obtained from Signal 4 Analytics, roadway information obtained from the FDOT roadway characteristics inventory (RCI), and traffic congestion information obtained from RITIS and the Probe Data Analytics Suite or the Florida Traffic Online portal.

Table 5-1. Data and Sources

Data Category	Variables	Sources
Traffic incidents	Start time, closed time, open/closed, location, latitude, longitude, road, direction, county, state, EDC incident type, roadway clearance time, duration (incident clearance time), notifications sent, DMS used-dynamic messaging signs, vehicles involved, max or percent of lanes closed, shoulder blocked	RITIS
Historical crash data	Vehicle crashes for up to 5 years, including information about severity, date/time, duration, location	Signal Four Analytics
Roadway	Roadway functional classification, roadway alignment, lane configurations, median type, shoulder type, speed limit, Other geometric data	FDOT RCI database FDOT GIS layers Google Maps
Traffic/ Congestion scans	Running speed, AADT, volume-to-capacity (v/c) ratios, percent of trucks, peak period traffic information	RITIS, FDOT Traffic Online

The project team gathered as many cases as possible within the data collection timeframe. The data collection process is shown in Figure 5-9.

Historical crash data were used to identify serious injuries and fatalities on I-75, I-275, and I-4. Crash details, such as date, time, duration, direction of travel, and closest intersections are included in RITIS to retrieve congestion scans. An example input for retrieving congestion scans from the RITIS platform is illustrated in Figure 5-10. Among available data sources, the HERE data source is selected, which provides historical travel times and speeds. The data was extracted with 5-minute intervals, and for each road segment in question. The example in Figure 5-10 shows a segment on I-75 on the map selected for the congestion scan.

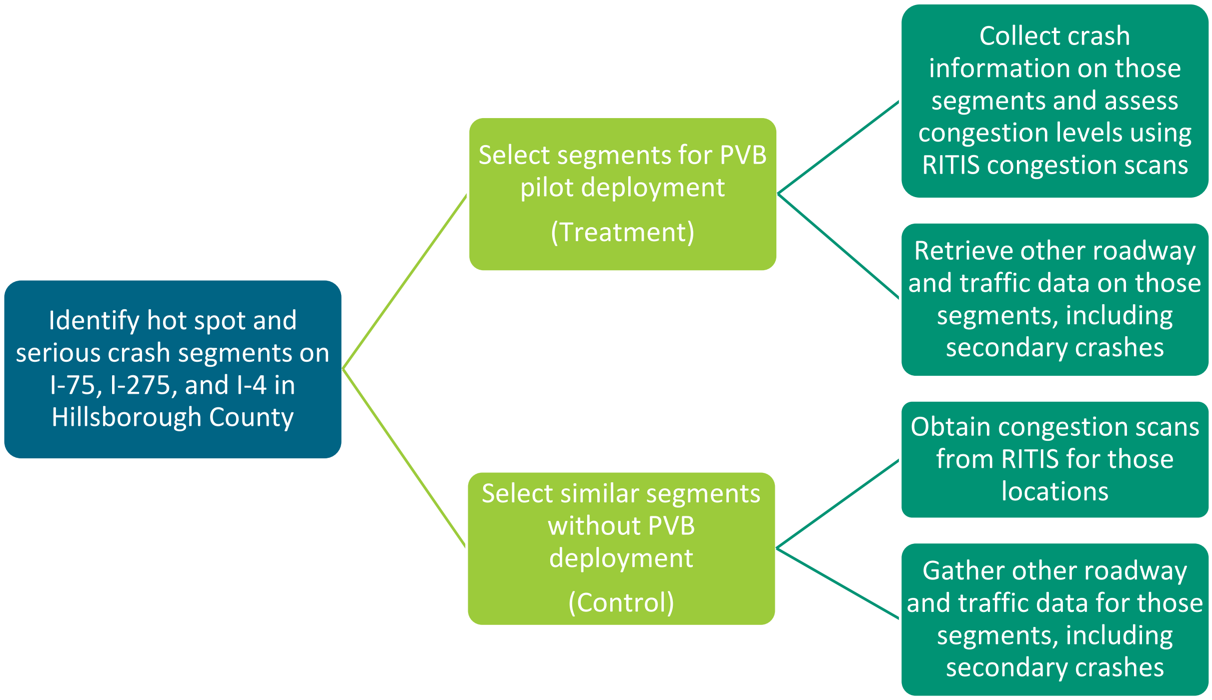
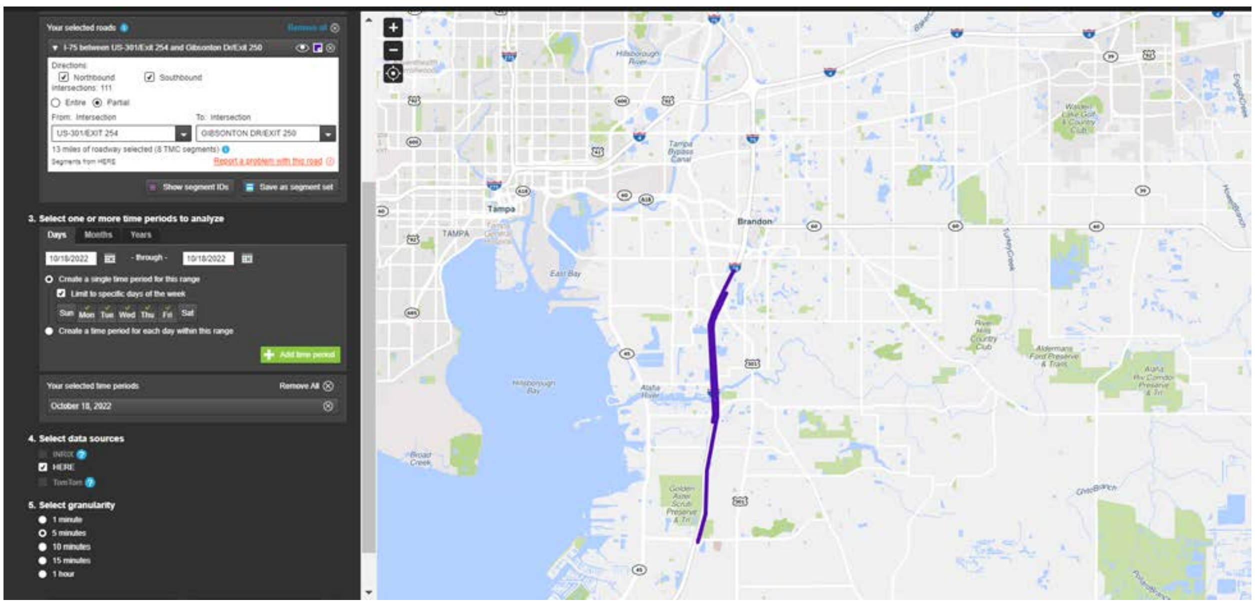


Figure 5-9. Data collection process



Source: RITIS

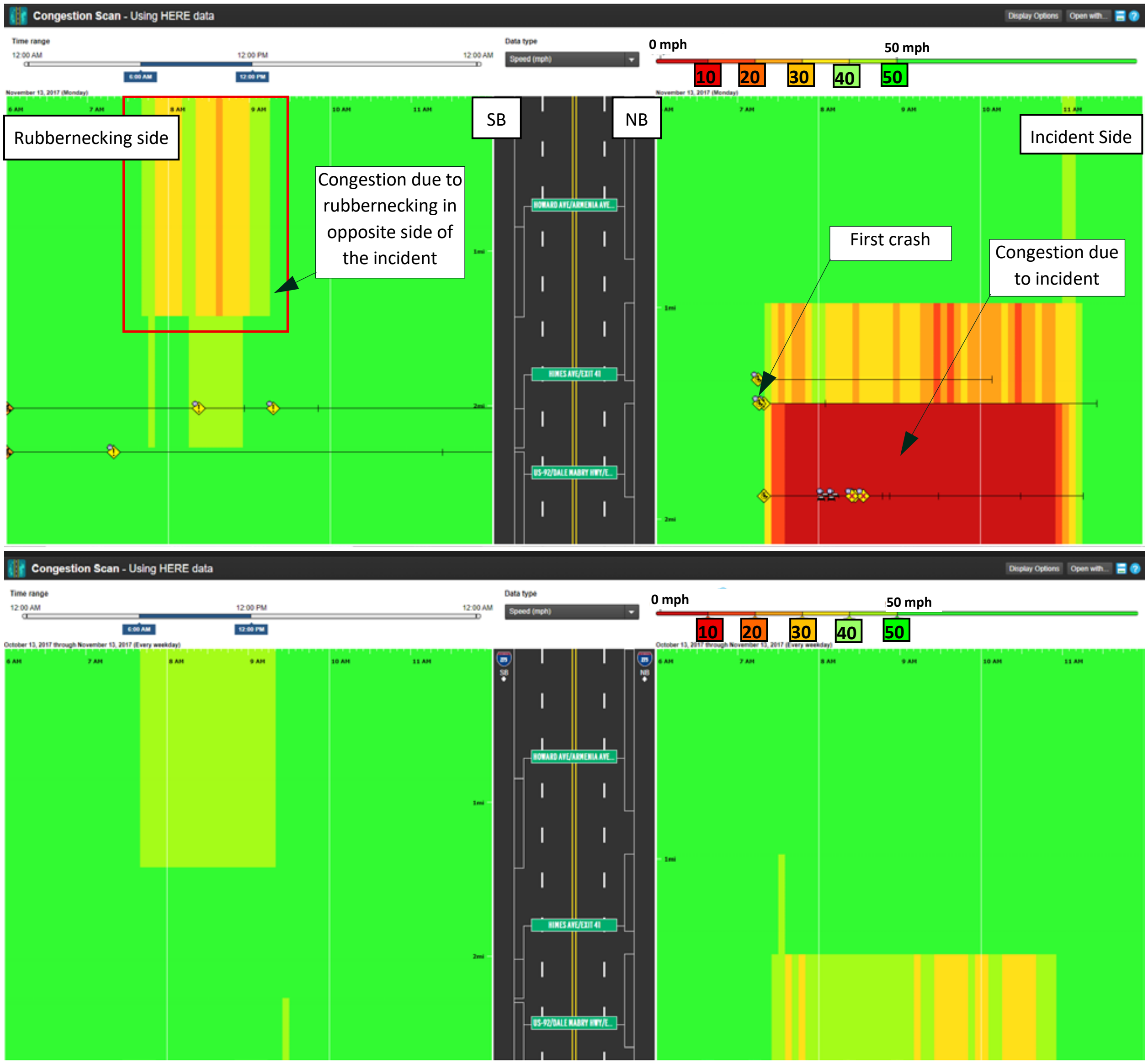
Figure 5-10. Example of congestion scan input

For a preliminary data collection, several congestion scans during severe crashes were retrieved from RITIS. Among those congestion scans, the ones with potential rubbernecking cases were visually identified.

The output of the congestion scan shown in Figure 5-11 shows the road segment in the middle of the image, and the traffic speed for the southbound direction on the left, and the northbound direction on the right. On the left top bar, the time period is shown to be 7:00 AM - 10:00 AM. On the right top bar, the speed scale shows the speed in different colors. Dark red represents below 10 mph, and light green represents above 50 mph. The yellow icons show the traffic incidents reported. On the left top bar, the time period that the scan covers is shown. As an example, in Figure 5-11, the scan shows from 7:00 AM-10:00 AM. The whole scan represents a snapshot of the speed profile on the road at the time of the incident. If rubbernecking occurs in the opposite direction due to the incident, it is visible on the opposite side of the incident. For example, on Figure 5-11, the incident is on the SB section (left), and visible slowing speeds are observed on the NB section (right) after the incident occurs.

To check if the congestion observed is due to rubbernecking or not (recurring or not recurring), a second scan is done covering the same time period, for the same segment, but for an entire month for weekday crashes, and two previous months for Saturday crashes. This shows the average conditions of traffic. If this scan is clear (green – speed > 50mph), it means that the reduced speeds observed on the first image are likely due to rubbernecking.

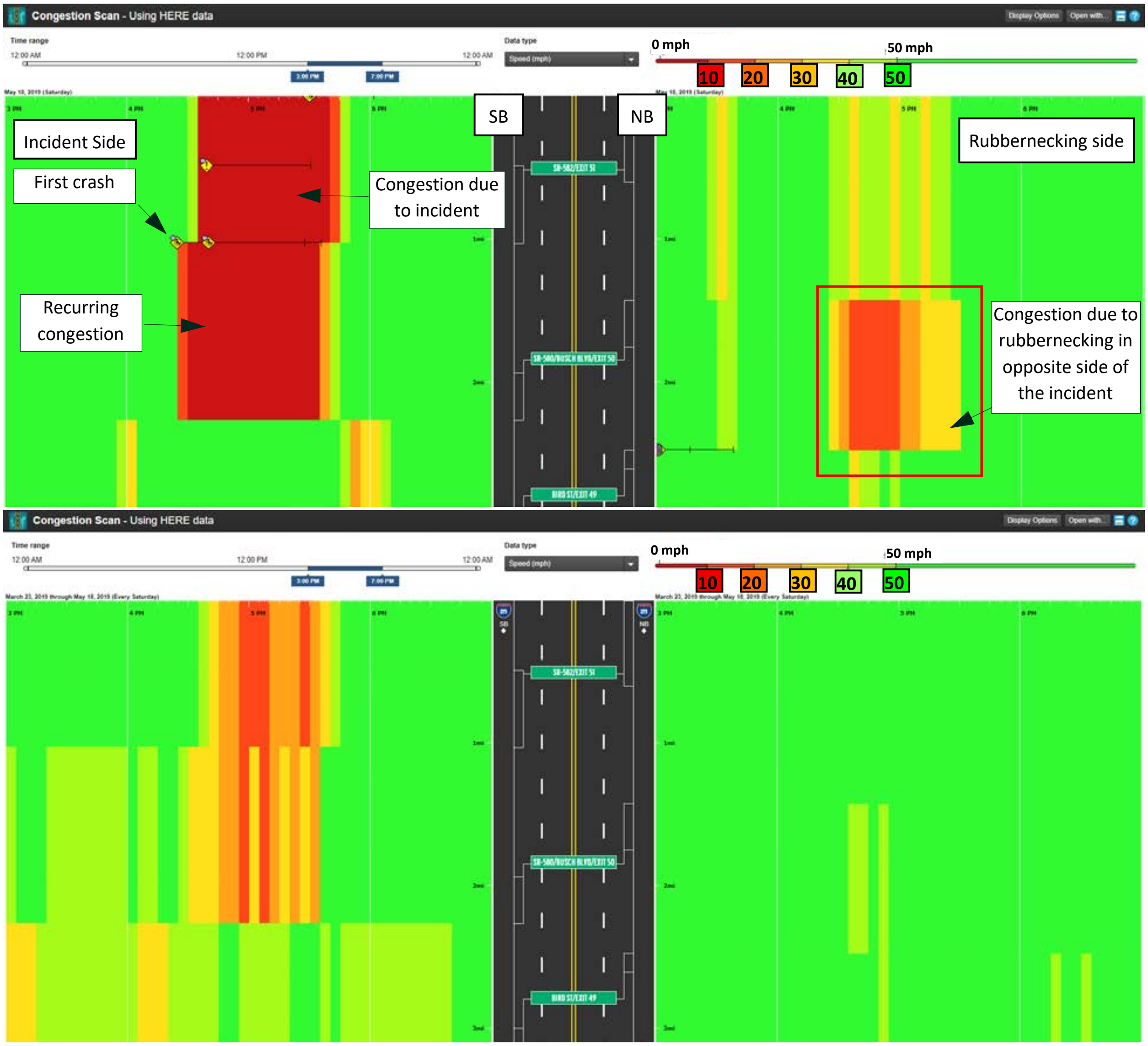
The selected rubbernecking congestion scans, along with their monthly average scans, are shown in Figure 5-11 to Figure 5-14. There are a total of four crashes that show both sides of the road, the incident side and the rubbernecking (opposite) side. The top figure shows the congestion scan during the incident, and the bottom scan shows the same location speeds over the previous month for comparison. The congestion might not match the exact location of the incident sometimes due to the way the speed sensors work. Each sensor covers a section of a road, and the whole section is represented with the same speeds (there is no speed variation within each section represented by the same sensor).



Source: RITIS

Figure 5-11. Congestion scan of a crash on I-275 NB with rubbernecking on 11/13/2017

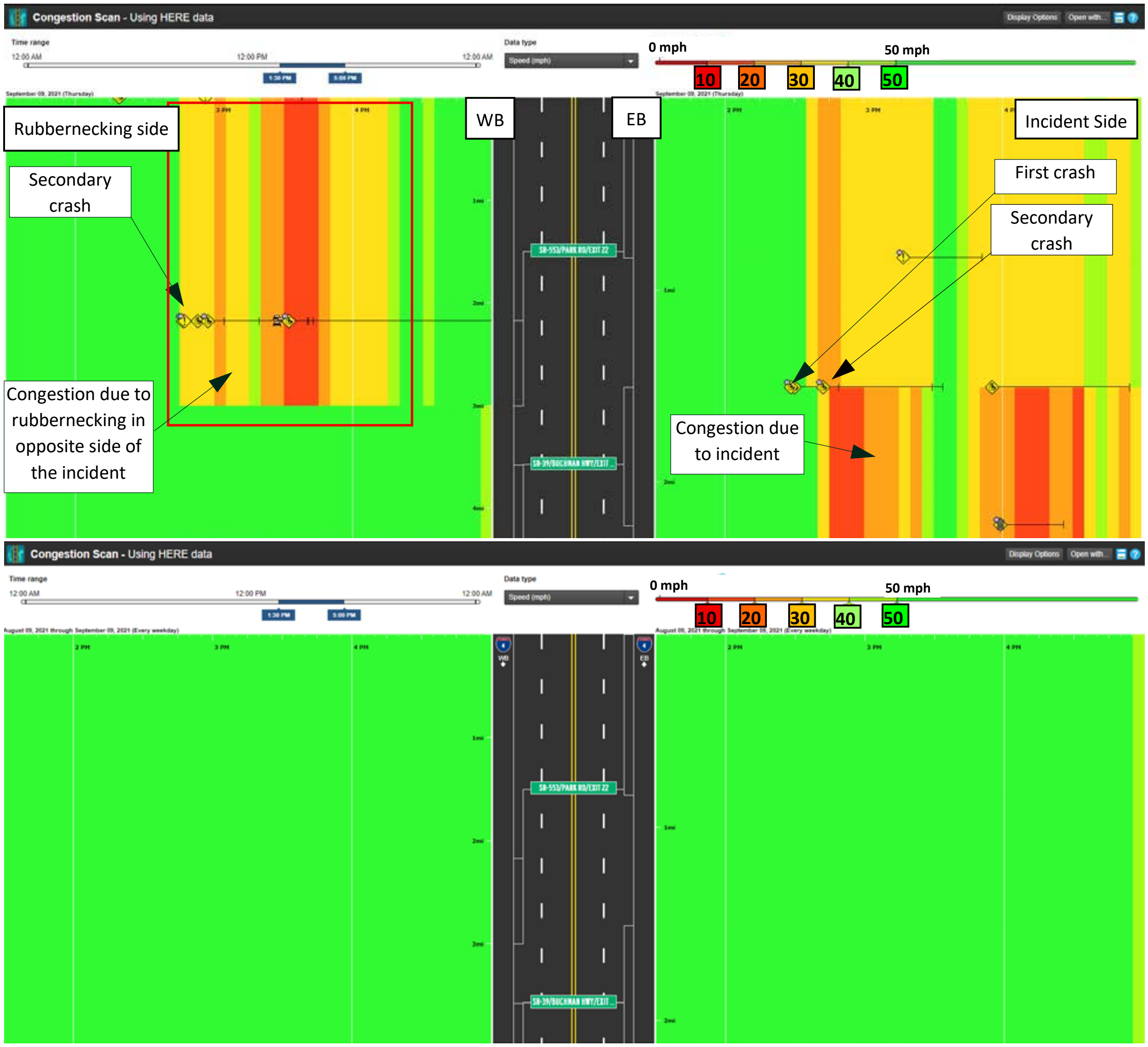
Figure 5-11: Top: A crash on I-275 NB between 6:00 AM and 12:00 PM (at Himes Avenue) on 11/13/2017. Bottom: The same location and time as the previous month (from 10/13/2017 to 11/13/2017).



Source: RITIS

Figure 5-12. Congestion scan of a crash on I-275 SB with rubbernecking on 5/18/2019

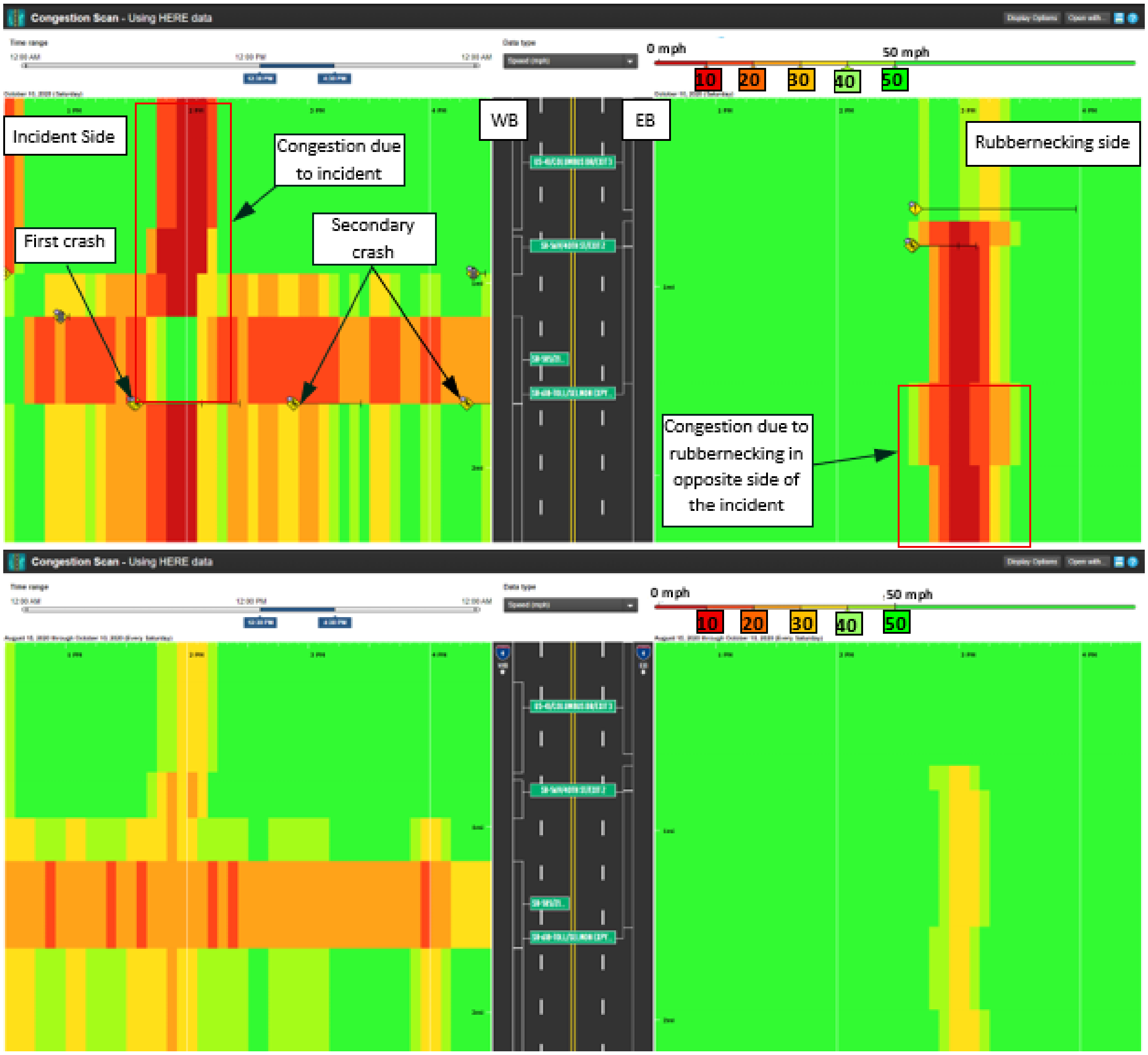
Figure 5-12: Top: A crash on I-275 SB between 3:00 PM and 7:00 PM (from Exit 51 to Exit 50) on 5/18/2019. Bottom: The same location and time as the previous month (from 03/23/2019 to 05/18/2019, Saturdays only since the crash was on a Saturday).



Source: RITIS

Figure 5-13. Congestion scan of a crash on I-4 EB with rubbernecking on 9/9/2021

Figure 5-13: Top: A crash on I-4 EB between 1:30 PM and 5:00 PM (from SR-533 to SR-39) on 9/9/2021. Bottom: The same location and time as the previous month (from 08/09/2021 to 09/09/2021).



Source: RITIS

Figure 5-14. Congestion scan of a crash on I-4 WB with rubbernecking on 10/10/2020

Figure 5-14: Top: A crash on I-4 WB between 12:30 PM and 4:30 PM (from Columbus Dr. to Selmon Expressway) on 10/10/2020. Bottom: The same location and time as the previous month (from 08/15/2020 to 10/10/2020, Saturdays only since the crash was on a Saturday). This site experiences recurring congestion on regular days evident by the bottom graph so it was already congested during the incident time.

5.3 PVB Pilot Deployment and Findings

The project team worked closely with the FDOT D7 Intelligent Transportation Systems (ITS) support manager to deploy the three PVB systems via the Road Rangers. The ITS support manager met with the Road Rangers and Rapid Incident Scene Clearance (RISC) managers to identify the best method for deployment. The following requirements and conditions were discussed:

- The deployment party needs to be on the incident scene as quickly as possible after the incident occurs.
- The PVB needs to be deployed at the earliest opportunity after the regular duties for response.
- The PVB needs to be on scene as long as the scene is active and removed when the incident is cleared. Even if vehicles are removed from the main lanes and staged on the shoulder, the PVB needs to cover the activities of the emergency responders that may still cause rubbernecking.
- The PVB needs to be placed in such a way as to maximize the coverage of the scene. Detailed instructions were developed and are presented in the appendix.

After discussions with the Road Ranger and RISC managers, it was clear that certain limitations would render the deployment difficult to execute. The Road Rangers usually respond to the scene first, but do not stay longer than 30 minutes. They leave the scene after other emergency response personnel take over. This poses a problem for PVB custody because while the Road Rangers might be able to set it up, they will not be able to remove it; therefore, would not have it in their truck for the next incident. The RISC response usually comes to the scene later, towards the end of the incident, to clear the roadway. This is also not useful as the PVB needs to be set up from the beginning to have an effect.

Subsequently, the ITS support manager suggested collaborating with the Florida Highway Patrol (FHP) supervisors who will go to a scene of a serious incident with injuries or fatalities, presenting an opportunity to deploy the PVB.

This required re-engineering the PVB to make it short enough to fit inside standard FHP patrol sedans or the back of FHP sport utility vehicles (SUVs).

The team met with captains from FHP Troop C and provided training on how, when, and where to set up the PVB during an incident. Figure 5-15 shows the team members, including FDOT D7 ITS support manager, staff, and FHP Troop C supervisors. Figure 5-16 shows the training of the FHP personnel and demonstration on how to set up the PVB at the incident scene.

Source: CUTR

Figure 5-15. Meeting at the FDOT D7 Headquarters

Source: CUTR

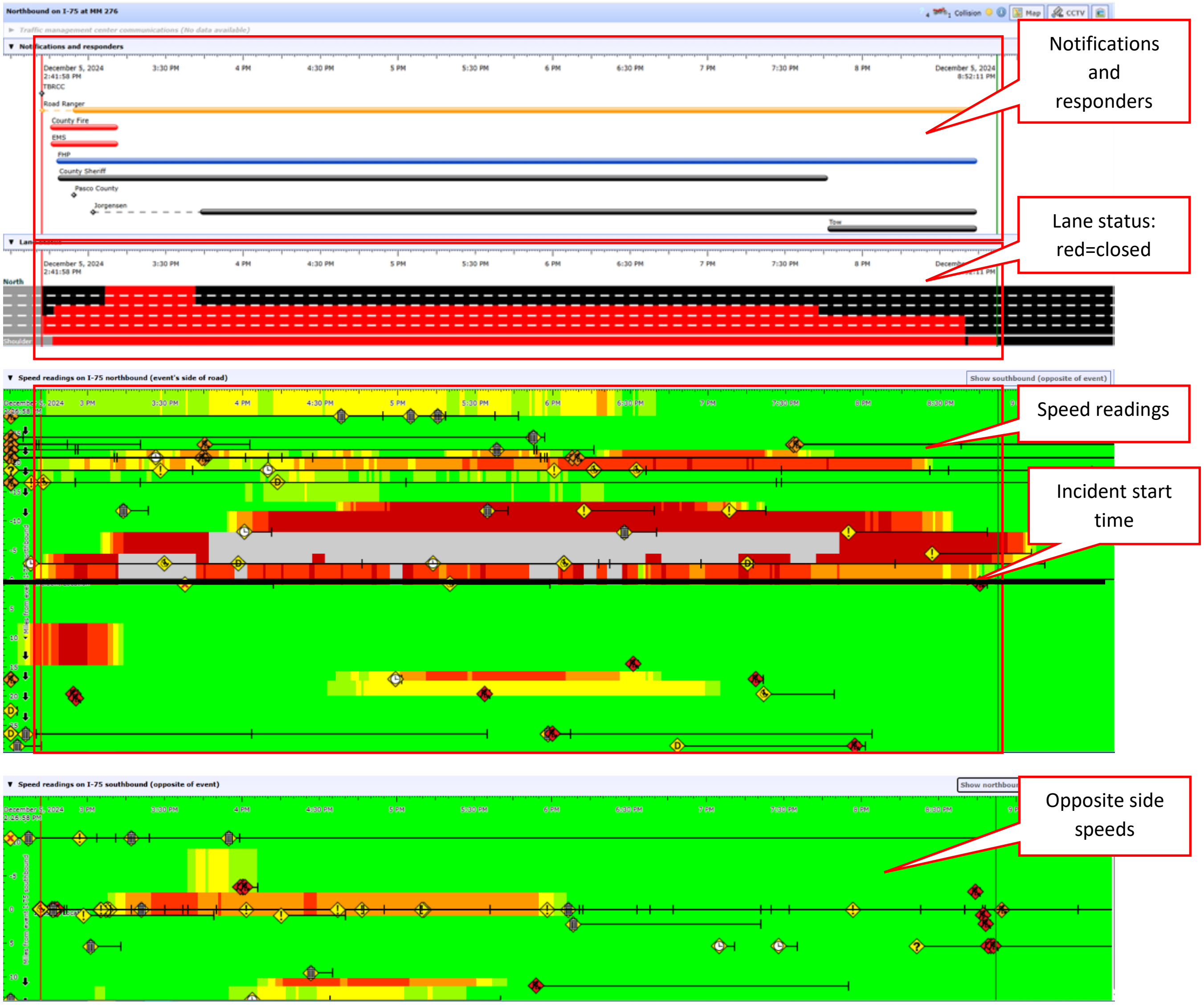
Figure 5-16. Training and demonstration for PVB setup

Source: CUTR

Figure 5-16. Training and demonstration for PVB setup (continued)

The first successful deployment of the PVB was conducted on December 5, 2024. During this incident, a fatal motorcycle crash, the responding ranger deployed the PVB. The incident was first reported to FDOT at 2:41:58 PM and was cleared at 8:52:11 PM. Due to the fatality, the incident took more than six hours and required all lanes to close for approximately 34 minutes and some partially open for four hours.

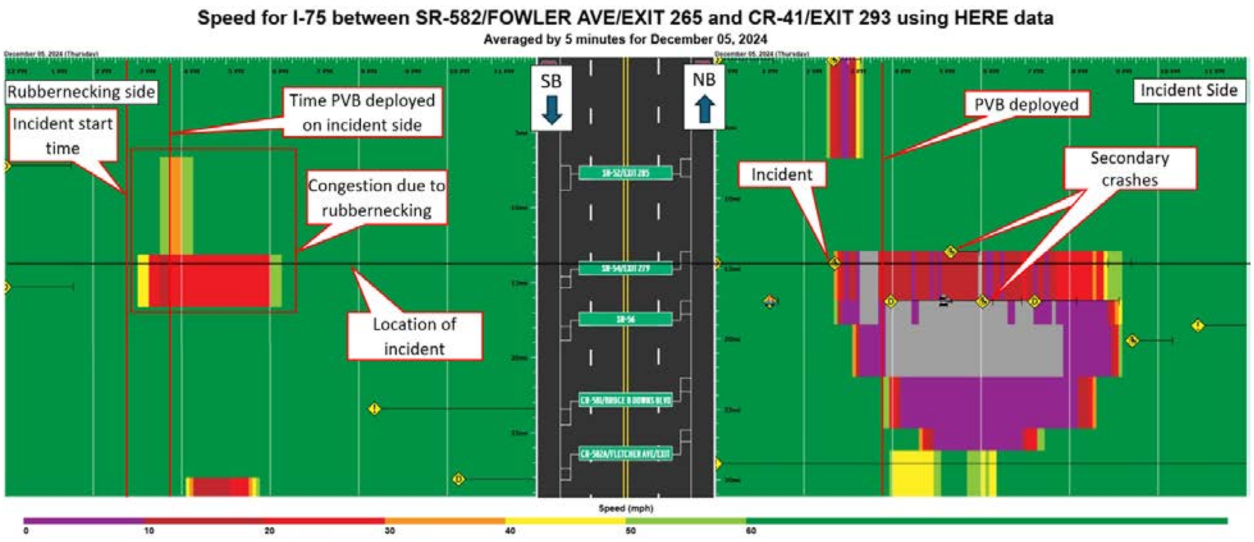
The incident timeline is shown in Figure 5-17. The first part of the figure presents notifications and responders along with the amount of time each spent at the scene. The second part of the figure shows the number of lanes and which ones were blocked. For example, in this incident, all lanes were closed for 34 minutes, and then the two inside lanes were opened to traffic. The third part shows the speed profile of the vehicles traveling on the side of the crash. The x-axis shows time, and the y-axis shows distance in miles. The location of the incident is shown, along with the congestion that followed. The fourth part of the figure shows the speed profile of vehicles traveling in the opposite direction. This is the side of the road where rubbernecking occurs. As shown in the figure, there is congestion at the same location as the incident, but it does not extend as far back as on the side of the crash.



Source: RITIS

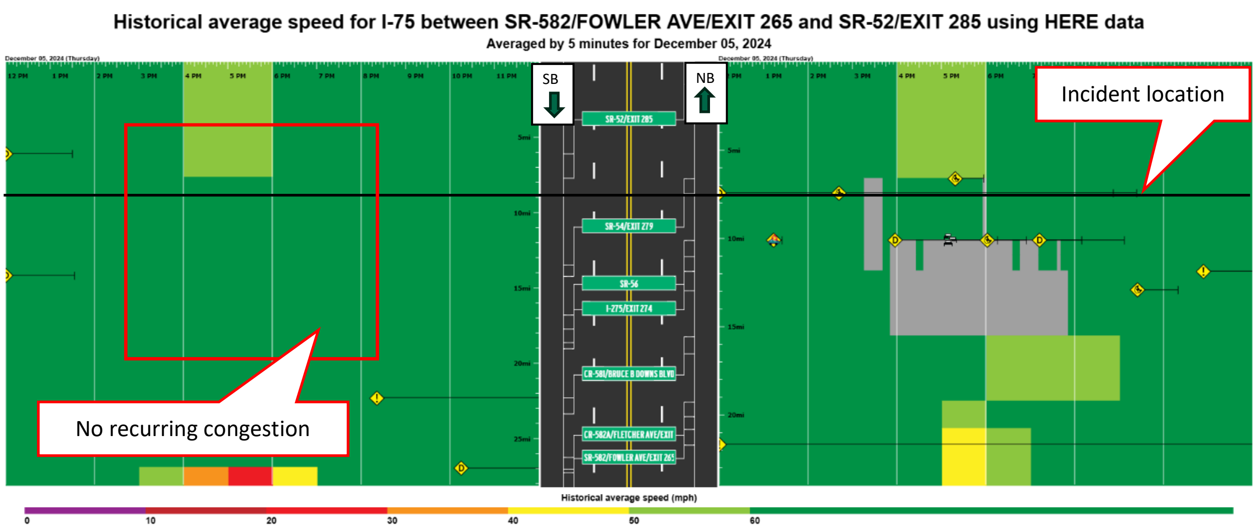
Figure 5-17. Timeline of a fatal motorcycle crash on I-75 NB with PVB deployment

To investigate the impact of the PVB on the opposite side of the incident, a congestion scan was created for the incident. The speed profile of vehicles on both sides of the road is shown in Figure 5-18. There is congestion on the right side (incident side), that extends up to 14 miles upstream of the incident, and for approximately 7.5 hours after the incident start time. On the left side (opposite side of the incident), congestion starts around 3:00 PM and lasts for about 3 hours and 15 minutes (until 6:15 PM). To confirm this congestion was due to the incident, a historic average scan was conducted, as shown in Figure 5-19. This shows the average speed for the previous months for the same location/times. Since this scan shows no congestion (speeds > 60mph) then there is no recurring congestion, and the congestion seen the day of the incident was due to rubbernecking.



Source: RITIS

Figure 5-18. Congestion scan of a fatal motorcycle crash on I-75 NB with PVB deployment



Source: RITIS

Figure 5-19. Historical average speed scan for the I-75 incident location

The PVB deployment was successful, as the congestion following the incident was brief and did not last as long as in other rubbernecking incidents. Compared to congestion shown in other incidents with rubbernecking (Figure 5-11 to Figure 5-14), the congestion that drivers experienced in this incident was much shorter. Although the incident occurred on the right shoulder and not the left shoulder (closer to the median), and the barrier was deployed about one hour after the crash time which is not ideal, the PVB deployment still made a significant difference to prevent serious traffic congestion on the opposite side of the crash. Figure 5-20 shows the scene from CCTV cameras before the barrier was deployed. During this time, only one lane was open on the incident side. Figure 5-21 shows the PVB deployed, blocking the scene in the opposite direction.

Source: FDOT D7

Figure 5-20. Crash scene before barrier deployment

Aerial view

Street view

Source: FDOT D7

Figure 5-21. PVB deployment at crash scene

5.3.1 Benefits of PVB Deployment

To further quantify the benefits of the potential impact of a PVB deployment during the incident, the research team identified two main components of the cost of congestion. The first component is the time delay costs or congestion costs. These refer to the value of time lost due to slower travel speeds and longer travel times in congested traffic. It affects both individuals (such as personal drivers, passengers, freight operators, and freight drivers) and businesses (through delayed deliveries and productivity losses). According to the 2023 Urban Mobility Report published by the Texas Transportation Institute (TTI), the 2022 value of delay time for personal travel is $34.68 per personal vehicle, not including the cost of fuel [36]. In addition, according to the Tampa Bay Next program from the FDOT Freight Office, the average cost per hour delay for large semi-trucks is $250.

To estimate the delay cost on the rubbernecking side (southbound I-75) on December 5, when the PVB was deployed, the research team conducted a queue analysis to calculate the total delay experienced by drivers and passengers between 3:00 PM and 6:15 PM. Hourly traffic volume data for this period was obtained from the FDOT Traffic Online platform. A comparable analysis was also performed to estimate the delay cost that would have occurred on the rubbernecking side if the PVB had not been deployed on the incident side. In the absence of the PVB, traffic congestion on the rubbernecking side was expected to persist longer—extending from 3:00 PM to 8:00 PM—due to reduced travel speeds. The data and queuing diagrams for both scenarios—with and without PVB deployment—are presented in Appendix B.

Table 5-2 presents the impact of PVB deployment on congestion costs on the rubbernecking side and compares it to the same incident scenario without PVB deployment. With PVBs in place, the estimated congestion delay on the rubbernecking side was 3,575 vehicle-hours. Without the PVB deployment, the delay would have increased to an estimated 6,513 vehicle-hours. The reduction in congestion cost was calculated by subtracting the delay cost with PVB deployment from that without it. Assuming a truck volume of 10%, the total congestion cost without PVBs was estimated at $366,109, compared to $200,958 with PVBs—resulting in a cost reduction of $165,151. This corresponds to a 45% (= 100% x 165,151 / 366,109). decrease in congestion cost on the rubbernecking side due to the deployment of the PVB on the incident side of I-75, mitigating delays caused by rubbernecking behavior.

Table 5-2. Total Congestion Cost Comparison

Scenario	Total Queue Time (hours)	Average Queue Length (miles)	Speed Range of Vehicles in Queue (miles per hour)	Total Delay (vehicle-hours)	Unit Delay Cost ($/hour)	Congestion Cost ($)	Total Congestion Cost ($)
Without PVB Deployment	5.00	6	0 - 30	6,513	$34.68 (cars) $250 (trucks)	$203,284 (cars) $162,825 (trucks)	**$366,109**
With PVB Deployment	3.25	3	30 - 50	3,575	$34.68 (cars) $250 (trucks)	$111,583 (cars) $89,375 (trucks)	**$200,958**
Difference	1.75	3	--	2,938	--	--	**$165,151**

The second element is the reduction of the probability of having a secondary crash. Experiencing less congestion, less queue and delay reduces the probability of having a secondary crash in both sides of the road. Therefore, using the values presented in Table 4-2, there can be a reduction in the probability of a secondary crash from 39.3% to 15.3% (reduction of 24%). Secondary crashes are likely to be property damage only (PDO) which cost $9,500 according to the U.S. Department of Transportation [37]. Even more an injury crash can cost up to $329,500 so reducing the probability of having a secondary crash increases the benefits of deploying a PVB. In the deployment example on December 5th, no secondary crashes were observed on the rubbernecking side (opposite side of the incident), but two were observed on the incident side.

6 Conclusions and Recommendations

6.1 Conclusions

Rubbernecking, a form of distracted driving in which drivers divert their attention from the road to look at traffic incidents, poses significant risks to roadway safety and mobility. This study aimed to explore the impact of Portable Visual Barriers (PVBs) as a countermeasure to mitigate rubbernecking effects on traffic congestion. The research first employed simulation models to assess the impact of rubbernecking on traffic congestion for different traffic LOS, considering incident duration and percent of drivers that exhibit rubbernecking. The study focused on the I-75 and I-4 interstates passing through Hillsborough County, Florida, where rubbernecking incidents are prevalent.

Results from simulation scenarios revealed that incidents with shoulder blockage or lane blockage experienced increased queue lengths and delays during the incident period. Queue lengths were influenced by incident duration, rubbernecking percentages, and traffic LOS, indicating the potential for reduced congestion by minimizing these factors. Controlling traffic volume, however, is a difficult challenge, so the potential to reduce rubbernecking is of great value to state DOTs.

Full barrier coverage is expected to be most effective; however, a short PVB that is easy to deploy can quickly aid in reducing congestion when an incident occurs. It is anticipated that implementing a PVB during an incident will reduce the percentage of rubbernecking vehicles, shifting it from a high percentage (60%-100%) to a lower percentage (5%-10%) of people rubbernecking. Deploying PVBs strategically can contribute to improved traffic flow and reduced congestion during incidents, minimizing the chances of secondary crashes occurring.

A deployment of a PVB during a fatal motorcycle crash on December 5, 2024, showed that the barrier was able to reduce a significant vehicle delay and queue length of congestion for the rubbernecking side. Also, testimonials from the Road Rangers on scene reported that after the barrier was deployed, the congestion eased, and traffic flowed smoothly. It was estimated that the PVB deployment during the fatal motorcycle crash on I-75 NB in December 2024 reduced traffic congestion caused by rubbernecking on the SB side by approximately 45%, saving over $165,000 in congestion-related costs—and even more if secondary crashes were avoided.

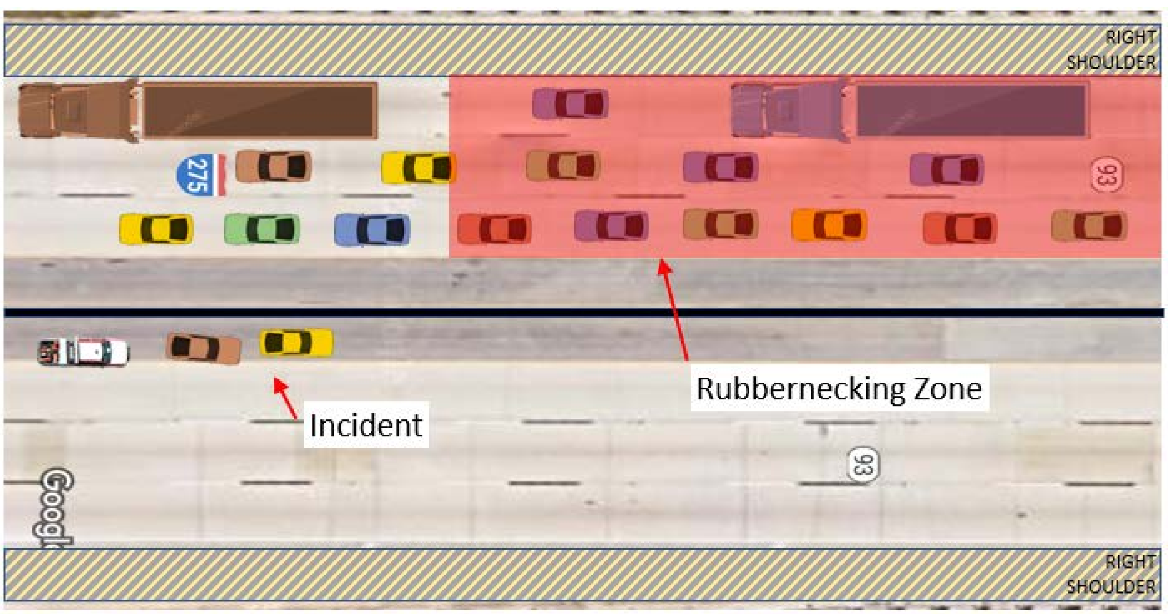
Both traffic simulation and field PVB deployment results highlight the impact of incident duration, reduced rubbernecking percentage, and deployment of PVBs on traffic congestion and safety. Transportation agencies can utilize these insights to develop effective strategies for managing rubbernecking and enhancing roadway mobility and safety.

In this FDOT-funded research project, five PVBs were acquired and deployed in the field to assess their effectiveness in mitigating rubbernecking-related congestion during major freeway incidents. While the number of PVBs and the unpredictable nature of major crashes limited the amount of field data collected, the findings underscore the potential value of this intervention.

Due to the logistical challenges for deployment, an extended deployment period and continued data collection are recommended to further validate the simulation models and quantify long-term impacts. Despite the limitations, this research project represents a significant step forward—it establishes a critical foundation and serves as a scalable model for future deployments of PVBs across Florida and beyond. The outcomes highlight the potential of targeted, real-time information strategies in alleviating secondary congestion and improving safety and efficiency on freeway networks.

6.2 Recommendations

Knowledge from the literature review and the professional experience of the project team was used to develop the PVB deployment guidelines for FDOT Road Rangers. The guidelines comprise specific conditions that trigger rubbernecking. The conditions not only include traffic conditions and crash severity for PVB deployment, but also the distance from the incident for the PVB setup. For example, based on the study conducted by Shah et al. (2015), the rubbernecking zone in the opposite direction is between 66 feet and 131 feet in the middle lane and between 164 feet and 230 feet in the right (outside) lane [8]. The same authors stated that at a distance between 98 feet and 131 feet, the drivers travel at the lowest speed to look at the incident (2) (see Figure 6-1). Based on those numbers, PVBs can help when they block the view ***between 50 feet to 250 feet*** from the incident.



Source: CUTR

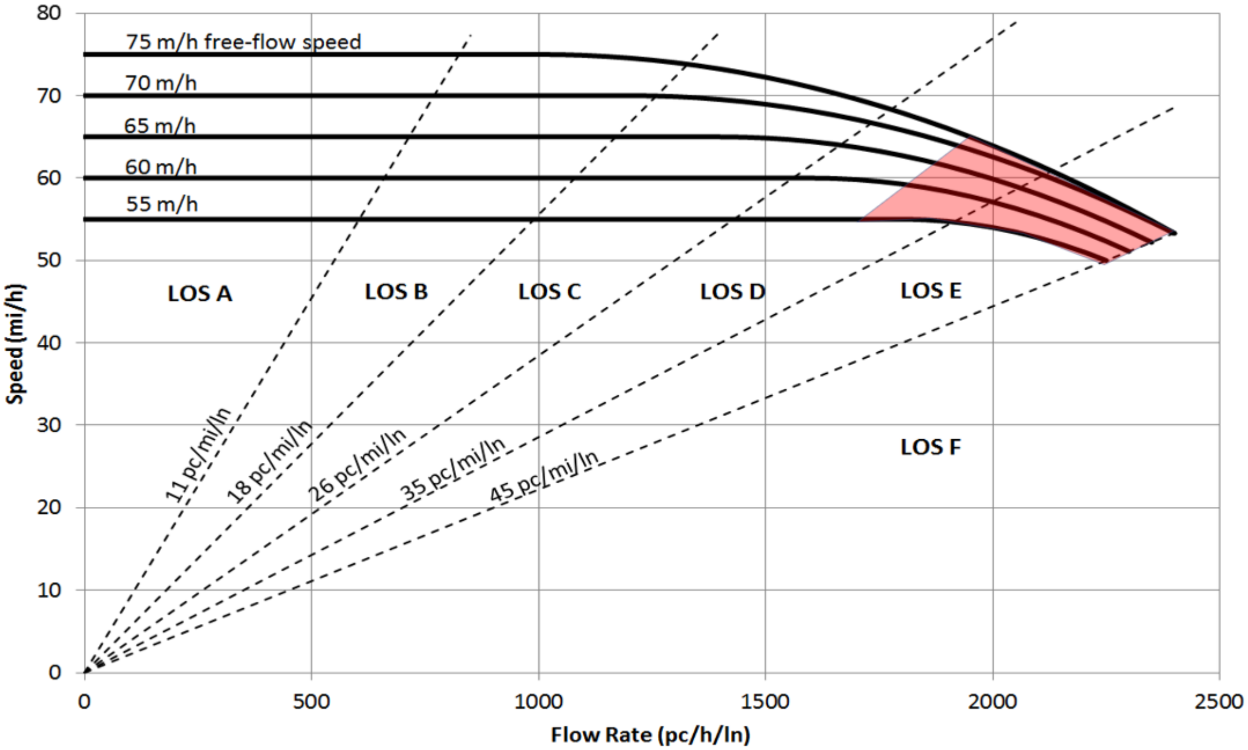
Figure 6-1. Rubbernecking zone in opposite direction of incident

Among all the reviewed research, there was a consensus that slower or heavier traffic is more likely to lead to serious traffic congestion due to rubbernecking during a freeway crash in the opposite direction. Other factors found in the reviewed research include the following:

- ***Weekday***, which increases rubbernecking due to higher volume of traffic compared to weekend
- ***Absence of visual median barrier***, which increases rubbernecking
- ***Truck presence***, which increases rubbernecking
- ***Higher volume-to-capacity (v/c) ratios***, higher volume increases rubbernecking
- ***Maximum congested time,*** longer congestion time increases rubbernecking
- ***High occupancy level in opposite direction of traffic***, which increases rubbernecking delay
- ***Nice weather*** (Severe weather was determined to decrease rubbernecking since drivers need to focus on the roadway under those conditions)
- ***Serious crashes with more than one or two severe injuries or fatalities***
- ***Incident covering a large stretch of the roadway***
- ***Long incident clearance time,*** long incident impact duration
- ***Percent of lanes closed (25% or more)***

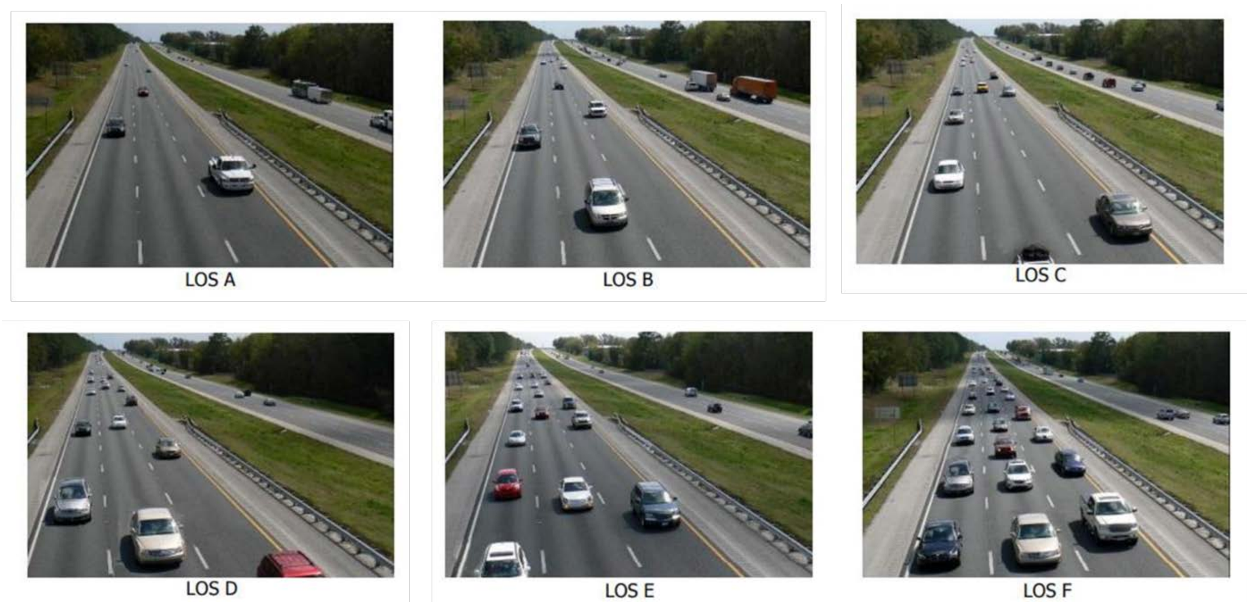
Based on the literature and professional experience, the project team developed initial deployment criteria for FDOT Road Rangers as follows:

- Crash close to the median, or all lanes are closed (e.g., left shoulder blocked)
- Traffic is flowing at (LOS) D near LOS E and LOS E, traffic is heavy and moving (see shade area in Figure 6-2, and examples of LOS service in Figure 6-3)
- Crash with serious injury or fatality (e.g., longer incident duration, heavy Emergency Medical Services (EMS) presence)
- Crash with rollover vehicles or vehicles on fire
- No barriers or large trees blocking the view from the opposite direction
- Time periods: 7:00 AM - 10AM, 11:00 AM – 2:00 PM, and 3:00 PM – 8:00 PM



Source: HCM

Figure 6-2. HCM Exhibit 12-16 basic freeway segment speed flow curves



Source: HCM

Figure 6-3. LOS service examples for basic freeway segment in HCM

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Appendix A

Portable Visual Barrier (PVB) Set-up Instructions

PVBs are designed to cover activities likely to cause driver rubbernecking in traffic flowing from the opposite direction of the incident.

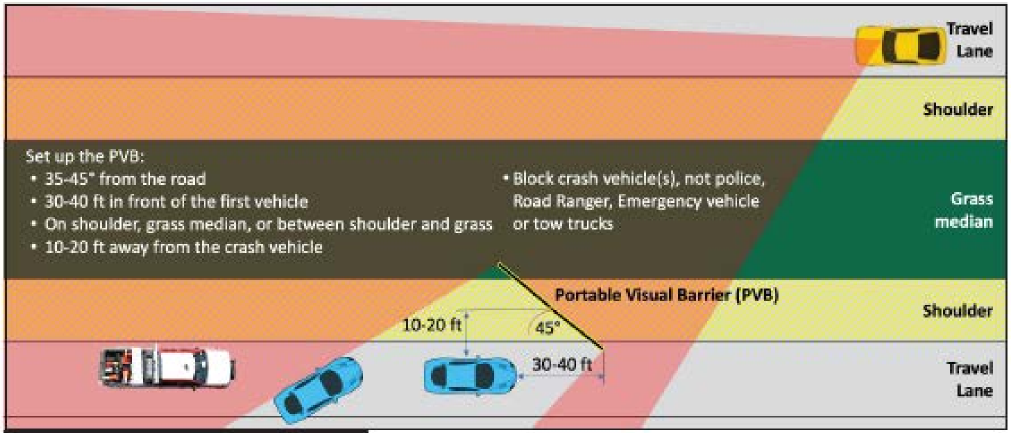


Figure 1 - PVB placement instructions

Figure 2 - Deployed PVB

Deploy PVBs under these conditions:

- Incident is likely to cause rubbernecking (serious/fatal crash, overturned vehicle, fire, etc.).
- Sustained winds/gusts under 15mph (13 kts).
- Opposite direction of traffic is Level of Service (LOS) D or E, which means with a minimal slowing down of vehicles, congestion is likely to occur.

Figure 3 - Opposite flow of traffic to crash site

Portable Visual Barrier (PVB) Set-up Instructions

Step 1

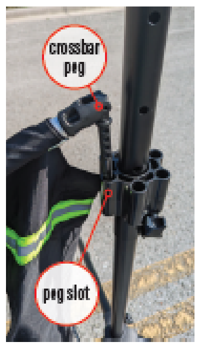
Unfold two tripods, extend tripod to its full height and insert the tripod lock pin in the appropriate slot on the tripod's extension stem; then tighten the lock nut. Place tripods to ensure the barrier is located at the proper distance and angle from the crash site. (See Figure 1 on reverse side for placement instructions.)

Step 2

Locate the bottom barrier (labeled). Unfold and connect the two aluminum crossbars.

Step 3

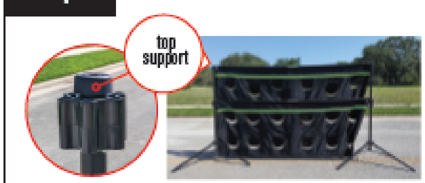
Insert the crossbar peg into one of the peg slots on the first tripod's bottom support. On the opposite end of the barrier, insert the crossbar peg into one of the peg slots on the second tripod's bottom support.



Step 4

Locate the top barrier (labeled). Unfold and connect the two aluminum crossbars.

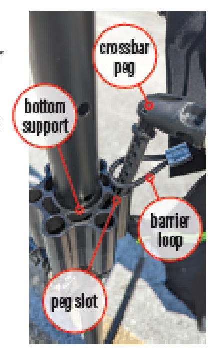
Step 5



Insert the crossbar peg into one of the peg slots on the first tripod's top support. On the opposite end of the barrier, insert the crossbar peg into one of the peg slots on the second tripod's top support.

Step 6

Hook the barrier loop on each side around the lower barrier's crossbar peg.



Step 7

Secure the top barrier to the bottom crossbar using the midsection clip on the top barrier.

Step 8

Place weight bags over each tripod leg for stability.

Step 9

If needed, set up the third tripod in the desired direction, approximately 10 ft from one of the other two tripods and repeat Steps 2–8.

Appendix B

The queuing diagram for the incident with the PVB deployment is shown in Figure B-1. There is a queue between 3:00 PM and 6:15 PM. The PVB was deployed at 3:40 PM.

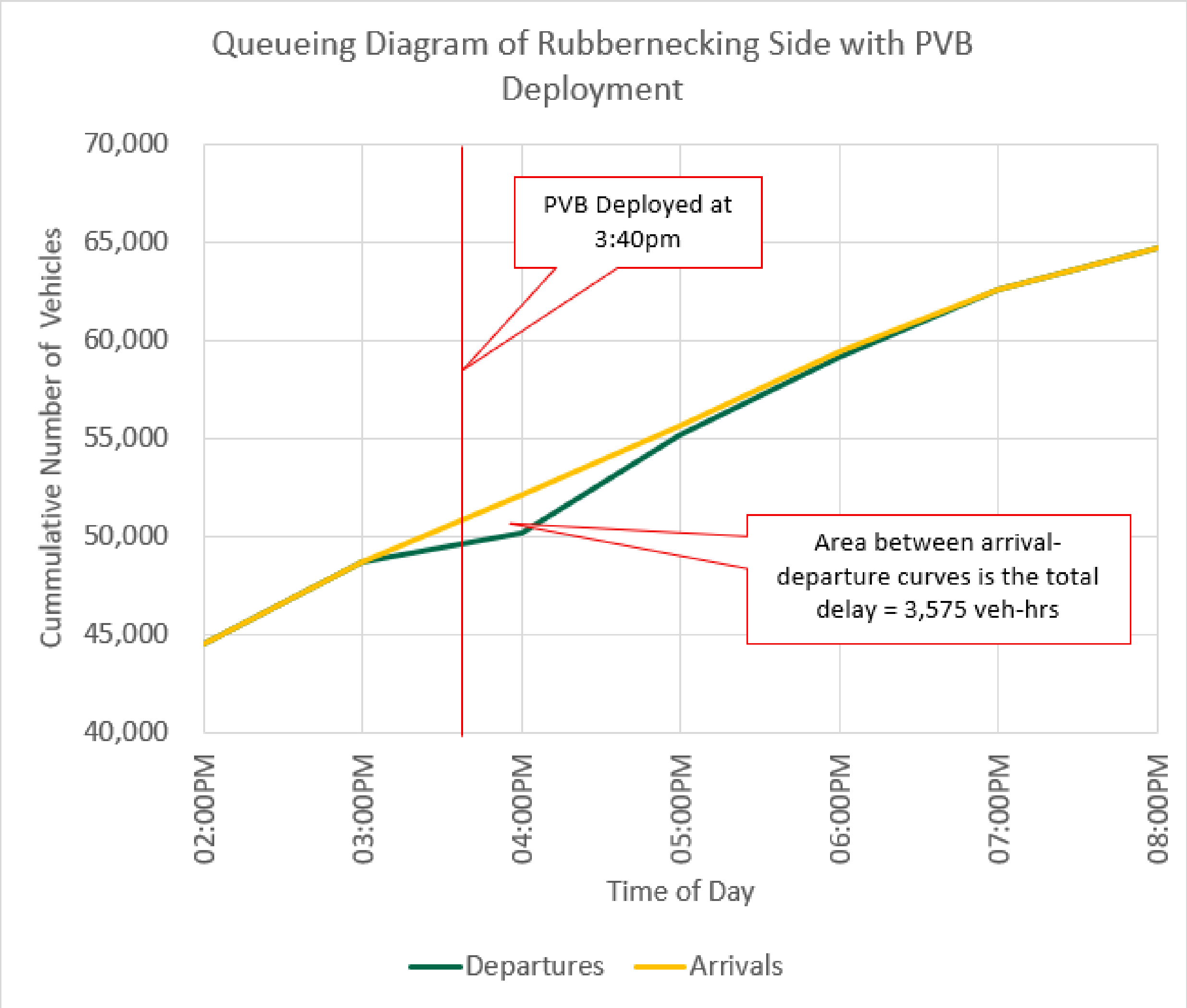


Figure B-1. Queueing diagram for the rubbernecking side with PVB deployment on the I-75 incident side

The calculations for the congestion costs including the 10% trucks is shown in Table B-1.

Table B-1. Total Congestion Costs for the Rubbernecking Side with PVB Deployment on the I-75 Incident Side

Vehicle Type	Total Delay Share (veh-hrs)	Congestion Cost $/hr	Congestion Cost
Cars	3,217.5	34.68	$111,583
Semi-Trucks	357.5	250	$89,375
	3,575		**$200,958**

The queuing diagram for the incident without the PVB deployment is shown in Figure B-2. There is a queue between 3:00 PM and 8:00 PM. This analysis uses the same arrival rate (volume) as the incident with PVB deployment but with the assumption that without the PVB deployment, the queues and delay are longer.

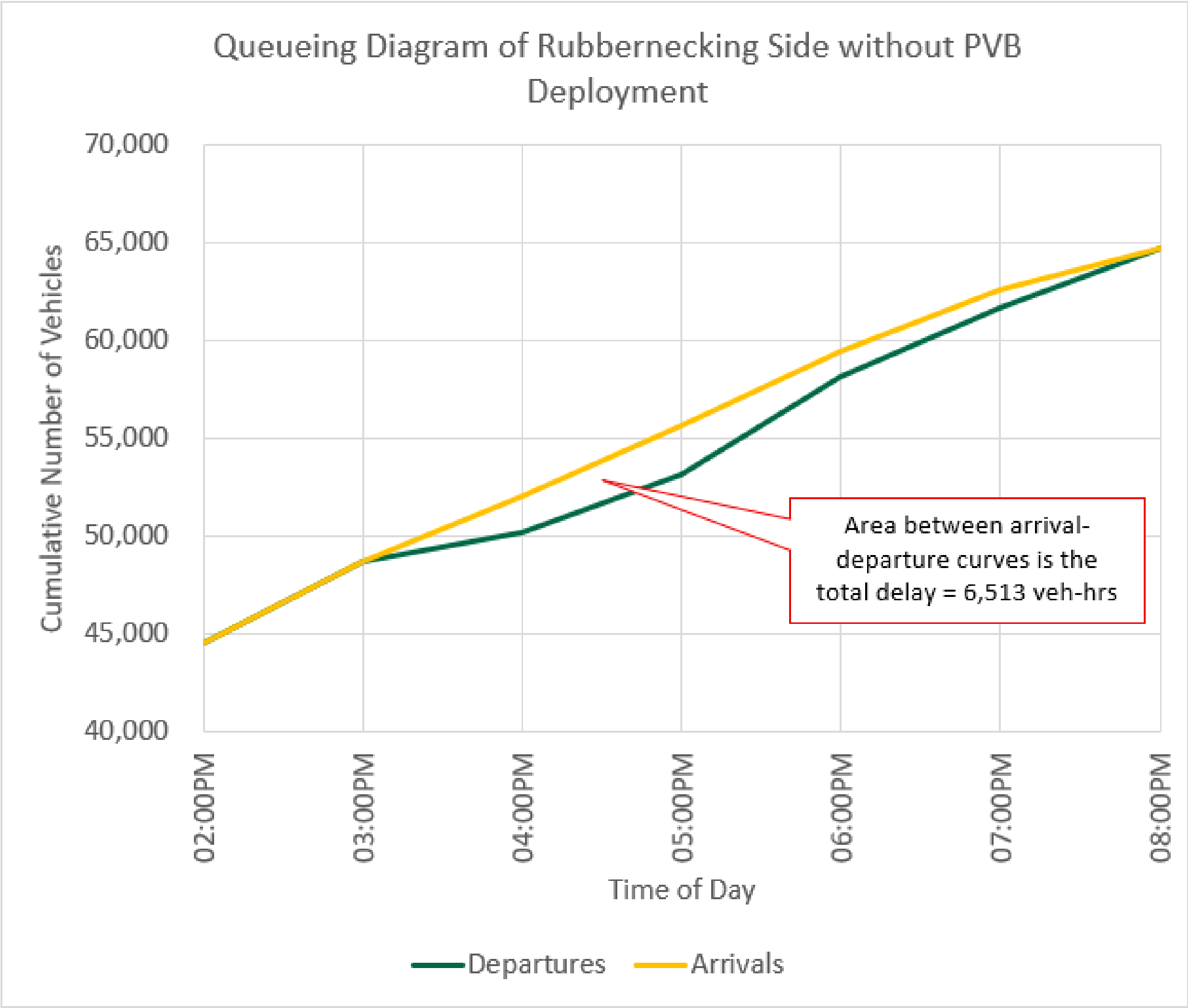


Figure B-2. Queueing diagram for the rubbernecking side without PVB deployment on the I-75 incident side

The calculations for the congestion costs including the 10% trucks is shown in Table B-2.

Table B-2. Total Congestion Costs for the Rubbernecking Side without PVB Deployment on the I-75 Incident Side

Vehicle Type	Total Delay Share (veh-hrs)	Congestion Cost $/hr	Congestion Cost
Cars	5,861.7	34.68	$203,284
Semi-Trucks	651.3	250	$162,825
	6,513		**$366,109**

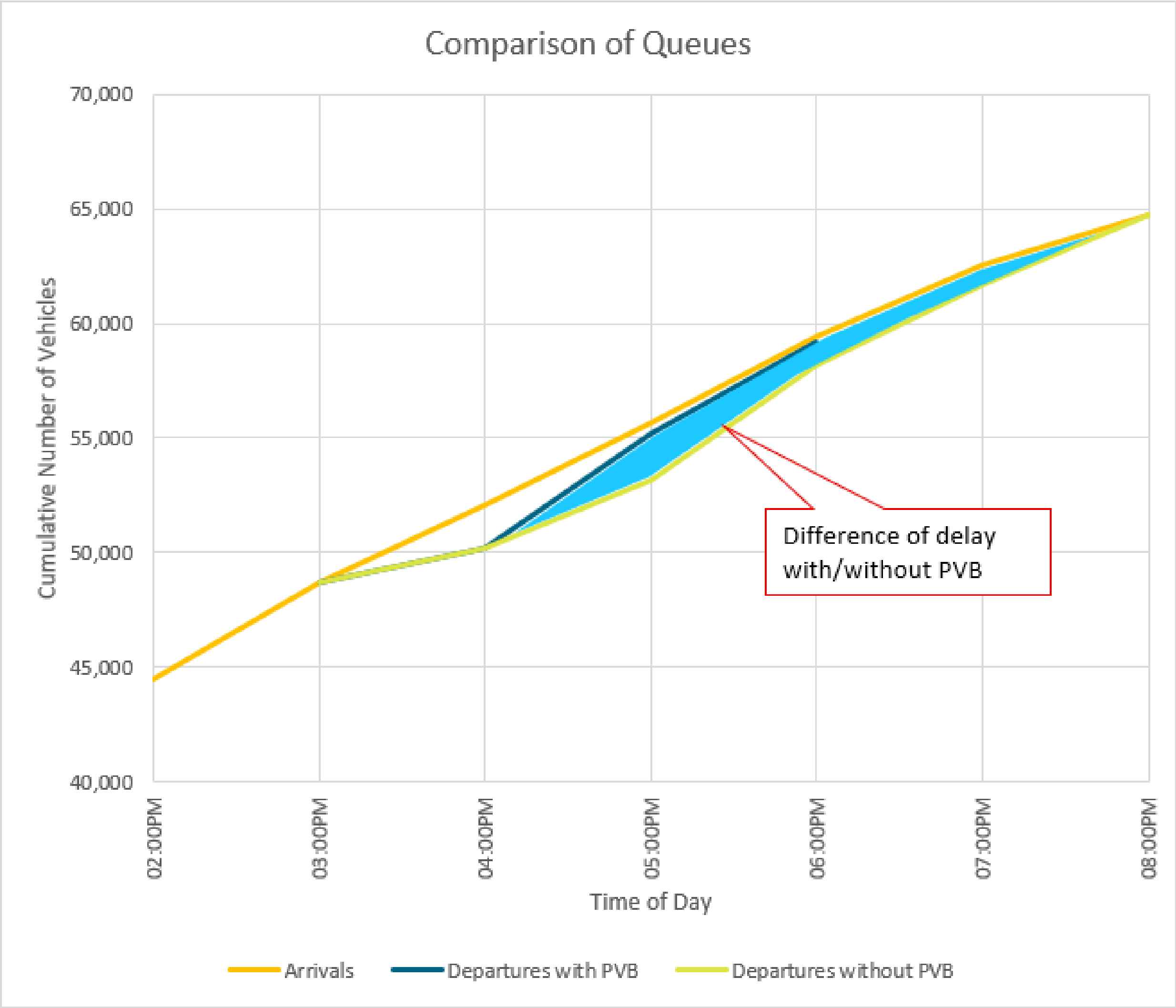


Figure B-3. Comparison of queues on the rubbernecking side with and without PVB deployment on the I-75 incident side during a fatal motorcycle crash