Innovations to Improve Nighttime Work Zone Safety

Image Source: FHWA

Developed by the American Traffic Safety Services Association

ATSSA
Safer Roads Save Lives

U.S. Department of Transportation
Federal Highway Administration

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Introduction

Transportation agencies restrict some highway construction and maintenance activities to nighttime hours, primarily to avoid the traffic impacts that would otherwise occur during the daytime. Nighttime periods may be specifically defined by agencies (e.g., 30 minutes prior to sunset up to 30 minutes after sunrise on the following day) or may include time-of-day contract restrictions that avoid work during peak hours for the specific roadway to minimize impacts on traffic. However, there are also challenges to working at night such as visibility, higher travel speeds, and drowsy or impaired drivers, all of which may lead to more significant crashes. In 2023, approximately half of all fatal work zone crashes occurred at night.[1] In addition, the potential for roadway departure incidents and vehicles striking construction vehicles or equipment is also a risk. Consequently, several tools and devices are available to alleviate these nighttime work zone challenges and help improve work zone safety. Such tools include balloon lights, speed feedback displays, speed limit trailers, portable temporary rumble strips, warning lights, and quick deploy technologies to help manage traffic and provide traveler information about nighttime activities.

This document is part of a series of products developed under the 2023 Federal Highway Administration (FHWA) American Traffic Safety Services Association (ATSSA) Work Zone Safety Grant. It outlines the application of technologies that can improve work zone safety during nighttime operations and provides information for agencies in selecting, deploying, and evaluating technologies that improve safety outcomes in nighttime work zones. The document highlights the use of Light Emitting Diode (LED) lighting systems, LED warning or sequential light systems, and quick deploy queue detection systems, along with several other general strategies for reducing nighttime work zone impacts.

To support the development of this publication, ATSSA held a product demonstration on February 24, 2026, at the Annual Convention and Traffic Expo in Houston, Texas (Figure 1). At this event, five vendors provided technical presentations and a demonstration of each device. Approximately 60 public and private sector individuals attended the demonstration and reviewed the devices. Based on a survey after the

Figure 1. ATSSA Product Demonstration Area (Source: ATSSA)

[1] https://www.fhwa.dot.gov/innovation/everydaycounts/edc_8/nighttime_work_zone_safety.cfm

event, all responding agencies have plans to use the devices demonstrated over the next five years.

In addition to the demonstration and in a parallel activity, FHWA's Every Day Counts 8 (EDC-8) Initiative also includes nighttime work zone safety as one of the primary innovations in the program. The EDC-8 *Advancing Nighttime Work Zone Safety* initiative offers strategies to help State Departments of Transportation (DOT) adopt safer, more innovative nighttime work zone practices. Given the focus of the EDC-8 initiative, this publication highlights some additional innovations and techniques for improving nighttime safety outside of the innovations included in the 2026 ATSSA Product Demonstration.

FHWA included the following topics in the EDC-8 program and highlighted the associated benefits to nighttime work zones:

- **Enforcement:** Active, passive, and tech-based measures all sharply reduce speeds in and near work zones.
- **Lighting:** Anti-glare lighting not only reduces glare, it improves hazard detection and reaction time, and helps lower speeds. The ATSSA Product Demonstration highlighted balloon lights.
- **Positive Protection Devices:** By containing and redirecting vehicles, positive protection devices (e.g., barriers) reduce the risk of vehicle intrusion, improving safety for workers and the traveling public.
- **Personal Protective Equipment (PPE):** Makes workers more visible so drivers can see them from farther away. For example, Indiana DOT is using green lighting devices on apparel in work zones. The ATSSA Product Demonstration also highlighted examples of wearable LED warning light devices.
- **Traffic Control Devices:** Rumble strips can lower speeds, boost awareness, and help fight driver fatigue. As an example, the Massachusetts DOT utilizes portable, temporary rumble strips to enhance safety in work zones, specifically targeting high-speed (45+ mph) lane closures to alert drivers and reduce speeds. Pavement markings keep lanes visible, lower driver stress, and reduce lane departures. Sequential lights and high-visibility sheeting make signs easier to see from farther away, encourage earlier merges, and help reduce nighttime fatal crashes.
- **Coordination:** Managing lane shifts, road closures and working schedules can reduce traffic risks, improve response times, and keep workers safe. ATSSA's New Products Rollout highlighted examples of systems that use worker presence devices to alert road users of active work locations.

As noted above, ATSSA's Product Demonstration highlighted several devices that complement the EDC-8 Program and associated topic areas. These tools can benefit work

zones by providing benefits to agencies interested in expanding their nighttime work zone safety toolbox. In addition, as FHWA implements the EDC-8 Program, this report can serve as a resource to assist with providing greater awareness of the available strategies to reduce the impacts from nighttime work zones.

Key product demonstration findings include:

- Agencies reported increasing use of nighttime construction and maintenance activities.
- Participants indicated strong interest in adopting emerging nighttime work zone technologies within the next five years.
- Queue detection systems, worker presence notifications, and enhanced lighting technologies were viewed as providing significant safety benefits.
- Agencies generally believed benefits outweighed costs.
- Training and implementation guidance were not viewed as major barriers.
- Technologies that improve driver awareness of workers and work zones generated the strongest interest.

In addition to the product demonstration and FHWA initiatives, several recent State DOT research publications highlight the importance of safety considerations for nighttime work, as referenced below.

- Illinois DOT evaluated pros and cons of nighttime work zones and published a document on the assessment to support the current capital improvement program.
- The Virginia Transportation Research Council published a report that analyzes Virginia DOT's allowable work hour restriction policies to balance daytime and nighttime work for short-term projects on two-lane roadways.
- Purdue University developed a report for Indiana DOT that evaluates strategies to mitigate the effects of disabling glare on motorists during nighttime work.

The following sections provide characteristics and uses of each device as well as common features and configurations. In addition, the report relates the application of the devices to some common field situations encountered.

Queue Detection and Intelligent Transportation Systems

The Manual on Uniform Traffic Control Devices (MUTCD) notes that the two primary reasons to work at night include lessened involvement with business activities and reduced traffic congestion. While nighttime work zones attempt to reduce queuing, queues can still occur at night, with additional visibility issues for approaching motorists. The MUTCD also notes that, in cases with lower traffic volumes, traffic speeds are typically

higher at night along with the instances of increased prevalence of impaired, fatigued or drowsy drivers.

Queue Detection and Warning Systems

Work zone queues contribute to rear-end crashes through speed variability at the back of the queue, especially on high speed roadways. Queue warning systems are designed to provide real-time information to motorists to allow for gradual slowing on an approach to a work zone queue. These systems can provide significant traffic safety benefits. For example, the Texas DOT developed an innovative queue warning system that reduced crashes by up to 45 percent on a 96-mile Interstate widening project.

One technology highlighted in ATSSA's Product Demonstration detects traffic speeds and provides real-time notification to motorists is the quick deploy queue warning system. As part of the system, connected speed sensors detect slowed or stopped traffic and provide data to support portable, queuing notifications. The ease of deployment makes the system practical for use in short-term nighttime work zones. The system not only provides real-time queue warning but also connects navigation tools to alert motorists of unexpected delays.

Portable sensors packaged inside a standard channelizing device warning light provide for ease of deployment and also capture speed data at certain intervals throughout the work zone. The device reports to specialized, proprietary software and, after setup, can monitor and collect speed data at the taper location and at specific intervals prior to the work zone. The components include a Doppler radar, 4G modem with GPS, a lithium battery and a solar regulator. Figure 2 illustrates the typical layout for the system. The system operates by detecting speed reductions upstream, transmitting data to a central platform, and activating dynamic warning messages for approaching drivers.

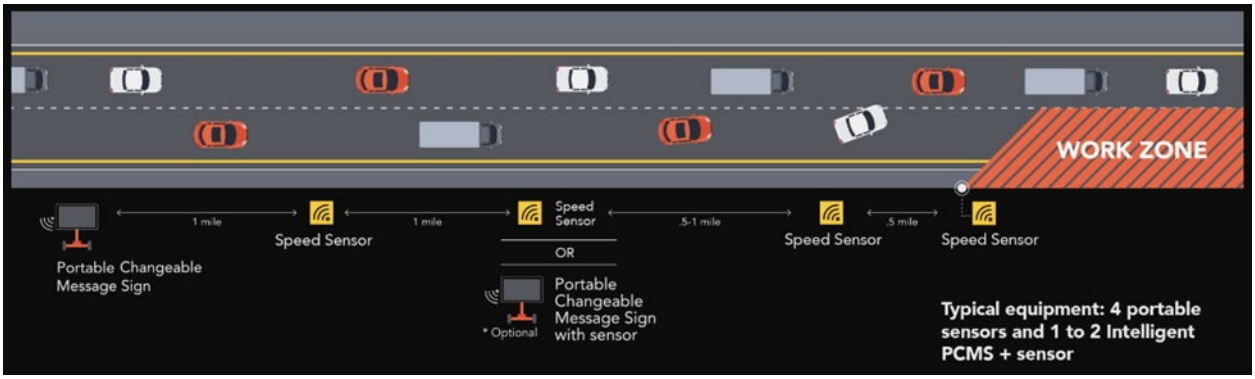

Figure 2. Example Queue Warning System (Source: Vermac)

Active Worker Presence Warning Systems

The presence of workers is an important work zone feature that, when communicated to road users, can provide greater awareness on the part of users and improve worker safety. Another type of system included in the product demonstration uses worker presence data via smartphone app to relay information to navigation tools to provide warnings to motorists. One challenge in using this type of system is ensuring the correct worker presence status for the work zone, particularly in ensuring consistent detection and activation, as well as minimizing false alerts. There are several techniques currently in use including manual switches to activate worker presence features such as on smartphones, wearable devices, and equipment-mounted devices that automatically detect movement and set the status to active.

For example, the system may communicate the activity status to users based on connected apparel or using devices placed in the worker's pocket that indicate the presence of workers based on movement. Some systems enable roadway workers to notify the traveling public of their presence in a work zone. Workers "check in" and "check out" using a smartphone app to flag the activity status for the work zone.

When a worker toggles the system on through a smartphone, drivers receive an alert within their navigation app or connected original equipment manufacturer (OEM) navigation system. The system provides presence information to help drivers be aware of active work areas. These systems also automatically detect workers entering and leaving the work zone, so the public receives real-time, accurate data that is anonymized to maintain individual worker privacy. The systems send worker-presence alerts directly to drivers through navigation platforms to provide real-time and automatic detection as workers enter or exit a work zone. This countermeasure can be especially useful for work zones where activity increases during nighttime periods. Currently, the example system noted here is being used by DOTs and contractors in more than 11 States including South Dakota.

Figure 3. Worker Presence System Demonstration Example (Source: ATSSA/OnStation)

Light Emitting Diode (LED) Lighting Systems

Figure 4. Nighttime Work Zone Using Balloon Lighting (Source: Michigan DOT)

LED lighting systems provide several benefits for nighttime work zones, including faster setup and takedown and reduced glare compared with traditional light towers. The LED systems also experience longer run times, lower power consumption, simplified maintenance and increased durability. These lighting devices can be used on equipment such as paving machines or as stand-alone devices to illuminate general work areas. Some balloon light units with portable bases have been crash tested to Manual for Assessing Safety Hardware (MASH) criteria.

North Carolina DOT developed a specification for presence lighting, which requires a light source at certain intervals throughout the work zone. The specification requires lighting units to be capable of being elevated up to 14 feet high and provide at least 14,000 lumens over at least a 3,000 square foot area. Devices have a required spacing depending on the lumens provided and begin a half mile downstream of the project's portable changeable message sign.

Some of the lighting applications highlighted help to meet minimum illumination requirements from work zone standards. For example, the MUTCD notes that "desired illumination levels vary depending upon the nature of the task involved. An average horizontal luminance of 5 foot candles can be adequate for general activities. Tasks requiring high levels of precision and extreme care can require an average horizontal luminance of 20 foot candles." One foot candle represents the light intensity of one lumen falling on a one-square-foot surface from a one-foot distance.

Balloon light examples include a variety of power levels, illumination outputs and voltages and operate using generators or batteries. Some units can be controlled and managed remotely using an app. The devices can be used to improve visibility in temporary traffic control situations including stationary work zones and at flagger locations as required by the MUTCD for nighttime activities.

As an additional resource, Indiana DOT commissioned a study to evaluate the benefits of presence lighting combined with digital speed limit trailers in reducing traffic speeds during nighttime work zone operations. The study evaluated several locations and noted speed reductions of 4 to 13 mph observed between the hours of 11pm and 7am.

LED Warning and Sequential Light Systems

Several devices are available to provide additional visibility in advance of lane closures or near other general work activity. For example, sequential flashing or steady warning lights and flashing light devices placed on top of channelizing devices are designed to increase visibility in the work zone. Overall, LED lighting systems enhance nighttime work zone safety by improving visibility, promoting more consistent driver behavior, and reducing glare compared to traditional lighting. These advantages, combined with lower energy consumption and faster deployment, make LED systems a more effective and reliable solution for nighttime work zone operations.

Sequential Warning Light Systems

Figure 5. Demonstration of Sequential Warning Light System (Source: ATSSA/pi-lit)

Modeled after aircraft sequential warning lights for navigation, these defices communicate wirelessly to create synchronized flashing patterns guiding drivers through transitions by channelizing traffic. In Section 6K.01, the MUTCD notes that "A series of sequential flashing warning lights may be placed on channelizing devices that form a merging taper in order to increase driver detection and recognition of the merging taper." The California DOT (Caltrans) is currently using these devices on projects that include lane closures and other DOTs are in the early stages of piloting the devices. Utility providers are also using the devices during emergency events at night. Each device is designed to be crashworthy because the light is built inside the cone and does not add external components. If a cone overturns, that device is taken out of sequence automatically and when placed back upright it rejoins the sequence.

The primary benefit of this system is that vehicles slow sooner and move over farther upstream than with traditional channelizing devices. In addition, a research study showed positive benefits such as reduced speeds at merge locations and earlier merging and better compliance on the part of drivers.

LED Warning Light Devices

Some devices provide upstream visibility for drivers approaching a work zone using lighting devices that attach to existing channelizing devices. One device includes a ring light placed on top of cones for visibility up to a mile away. There are several types of devices available, and some designs can be mounted to the top of taller channelizing devices such as drums to provide greater visibility in nighttime work zones. The devices are USB rechargeable and use a photocell to activate during periods of darkness. There are varying attachments by device type that can be used. One circular ring device fits between retroreflective bands on the top of a standard cone, while others are designed to fit around a standard hardhat; and others are designed for larger channelizing devices such as drums and type 3 barricades.

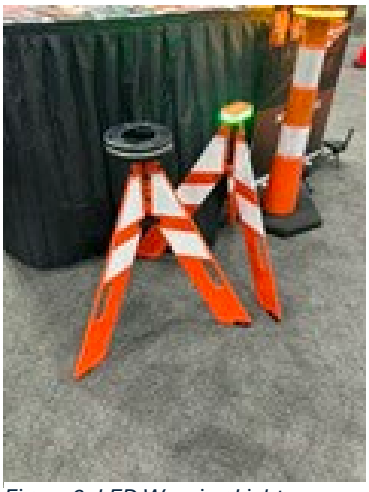

Figure 6. LED Warning Light Examples (Source: ATSSA/Nite Beams)

With visibility up to one mile away, these devices enhance work zone safety at night by providing better warning to motorists of work conditions ahead. Vendors have also created illuminated high visibility safety apparel, such as Class 3 vests with LED lights that can flash or be placed in steady mode for greater visibility.

Other Example Nighttime Work Zone Safety Practices and Procedures

The following sections provide additional examples outside of the devices demonstrated at the 2026 event. They provide examples of how agencies apply countermeasures to improve work zone operations at night that emphasize the combined role of enforcement, monitoring, and inspection.

Kentucky Transportation Cabinet Speed Safety Cameras

Figure 7. Example Work Zone Speed Detection System and Associated Signing (Source: Kentucky Transportation Cabinet)

In 2025, the Kentucky Legislature passed House Bill 664 which allows law enforcement officers to issue citations based on the automated collection of information on traffic violations. The Bill notes that motorists can be cited when "traveling more than 10 miles per hour over the posted speed limit in a highway work zone when a bona fide worker, a peace officer, and a marked vehicle are present." Signing and active displays inform motorists upstream that the system is active, and once officers receive the information on the violator, they perform a stop and issue a moving violation citation directly. This approach contrasts with other common speed safety camera systems that have an officer on site but issue mailed citations for speeding violations. In 2026, a speed safety camera system is in use on Interstate 64 near Louisville in addition to other project deployments. These systems can be especially effective to combat increased speeds at night that may occur due to lower traffic volumes. The FHWA EDC-8 initiative is also focused on traditional enforcement techniques as well as technology-based applications, where State legislation permits speed safety cameras and other tools.

Michigan Nighttime Work Zone Inspection Form

Michigan DOT created a tailored work zone inspection form that includes documentation on lighting provided during nighttime work zone operations. Once each project's lighting plan is installed and activated, field observations of the work zone lighting are performed by driving and walking through the work zone. The field checks are conducted from the vantage point of the motorist and workers to ensure that glare is controlled, and the lighting is adequate for the work being done. The contractor is also required to submit a lighting plan to the project engineer 30 days prior to the start of work. As an additional example, Figure 6 highlights Michigan DOT's inspection form that references illuminance measurements using a light meter.

11.	**Work Zone Lighting**		Supplemental Flood lighting Readings: 10.95 min., 153.3 max, & 26.8 Avg. & Ballon Lighting: 14.52 min., 95356 max, & 18.46 Avg. Meets requirements per 12SP-812CC-01. 10 Fc
	Type: (Balloon / Spot Light) Visibility, Glare, Shadows, Etc.	A	
	Workers Wearing Headlamp	A	
	View of Lighting from Opposite Direction	A	
	Night Light Reading Taken	A	

Figure 8. Michigan DOT Work Zone Lighting Inspection Form Example (Source: MDOT)

The procedure includes a requirement for minimum, maximum, and average readings near the device. If the operation is stationary and similar in setup each night, spot checks of lighting should be sufficient. If the operation is moving and changing location, there is a need to check more often, as the location and nearby ambient light can play a role in the readings.

As another similar example, some State DOTs may require that a photometer be furnished on the work site so illumination measurements can be taken to verify that the necessary lighting levels in the work area are met. For example, New York DOT requires the engineer in charge to use tools to check proper illumination levels and to identify and correct severe glare that may impact visibility. These examples demonstrate practices that are readily transferable to other DOTs, as they rely on adaptable policy frameworks, commercially available technologies, and standardized inspection procedures that can be implemented based on state-specific regulations, resources, and project conditions.

Summary and Conclusions

Temporary traffic control operations performed during hours of darkness provide unique challenges. Two initiatives in 2026 focus on improving nighttime work zone safety, including an ATSSA Product Demonstration and FHWA's EDC-8 Initiative. The product demonstration included five devices designed to improve safety and visibility and reduce overall safety impacts of nighttime work zones. FHWA's EDC-8 initiative also includes several strategies to reduce impacts and improve safety during nighttime highway operations. Collectively, these technologies demonstrate significant potential to reduce crash risk, improve driver awareness, and enhance worker safety in nighttime operations. Wider adoption, supported by training and agency guidance, can meaningfully improve safety outcomes nationwide.

A summary of each device is illustrated in the table below.

Table 1. Nighttime Operations Product Demonstration Summary

Technology	Primary Purpose	Potential Applications	Key Benefit
Active Worksite	Worker presence notification	Maintenance, short-duration work	Driver awareness
Queue Warning System	Queue detection	Lane closures	Reduced rear-end crash risk
Balloon Lighting	Work area illumination	Flagging, work activities	Reduced glare
Smarter Cone	Channelization	Lane closures	Earlier driver recognition
Cone Commander	Visibility enhancement	Nighttime work zones	Long-range visibility

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- Airstar (Balloon Light Demonstration)
- Pi-lit (Sequential Warning Light Demonstration)