

NOCoe Best Practices: Next Gen TIM Strategies

Report #13

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Introduction

OVERVIEW

Preliminary information from the National Highway Traffic Safety Administration indicates that traffic fatalities dropped to 36,640 in 2025 from 39,254 in 2024 and there were approximately 2.42 million injuries across 1,676,700 injury crashes¹. This does not include other types of roadway incidents such as property-damage-only crashes or roadway debris. Every roadway crash places first responders to traffic incidents at risk and may create conditions for secondary crashes.

The Federal Highway Administration (FHWA) Office of Operations has highlighted traffic incident management (TIM) through the Every Day Counts (EDC) program since its inception. The EDC program is a state-based initiative managed by FHWA to identify and rapidly deploy proven, yet underutilized, transportation technologies and practices.

The AASHTO *Transportation Operations Manual* (TOM) includes Chapter 20: Event Management Tactics that focuses on the continuum of related incident response types beginning with TIM:

- Chapter 20: Event Management Tactics
 - 20.1: Traffic Incident Management (TIM)
 - 20.1.1: Incident Locations
 - 20.1.2: TIM Components
 - 20.1.3: TIM Stakeholders
 - 20.1.4: Implementing a TIM Program
 - 20.1.5: TIM Performance Measurement

Next Generation Traffic Incident Management (Next Gen TIM) describes leading-edge applications of integrating technology, data, and training that support incident response and resolution. The goal of these applications is to support responders in their incident response and on-scene duties by providing:

- **Increased Safety.** NextGen TIM targets advances in safety through engineering, enforcement, education, and emergency services to help keep responders, drivers, and pedestrians safe across freeway, arterial, and multimodal travel.
- **Improved Travel Times.** Training, data, and technology combine to help local and State agencies reduce secondary crashes and clearance times, improving trip reliability and increasing motorists' awareness of active responders along their travel routes.
- **Improved Operations.** Integrating new and emerging technology, tools, and training can improve incident mitigation and safety throughout the whole TIM timeline, from incident detection to clearance on all roadways.

¹ Overview of Motor Vehicle Traffic Crashes In 2024 (DOT HS 813 791)
<https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813791>

Concepts

GPS-BASED EMERGENCY VEHICLE PREEMPTION (EVP)

Advanced emergency vehicle preemption (EVP) technologies improve responder safety and reduce emergency response times. Traditional EVP systems rely on dedicated optical or radio transmitters installed on emergency vehicles and intersection-mounted receivers on traffic signal poles or mast arms. The evolution of EVP technology is a system-based approach that integrates emergency agency computer-aided dispatch (CAD) systems, automated vehicle location (AVL) systems, advanced traffic management systems (ATMS), and GPS-based geofencing. Under this architecture, dispatch information and real-time vehicle locations are shared with the ATMS, allowing traffic signals to be preempted automatically as emergency vehicles approach intersections. Rather than requiring dedicated field hardware at every intersection, the system uses GPS-defined geofences around intersections to generate signal preemption requests when authorized vehicles enter a predetermined approach zone.

FHWA identifies several advantages of this system-based model. CAD integration enables the traffic management system to recognize when a unit has been assigned to a high-priority emergency call and, in some implementations, identify the preferred response route. AVL continuously tracks the responding vehicle, while GPS geofences surrounding intersections initiate signal preemption (or priority) in the controller. Because requests are generated centrally and dynamically, emergency vehicles are not limited to predefined routes and can receive signal preemption throughout an entire signal network on a response route. This approach is generally more scalable, less hardware-intensive, and easier to manage than vehicle-based systems.

Key Benefits:

Reduced emergency response times:

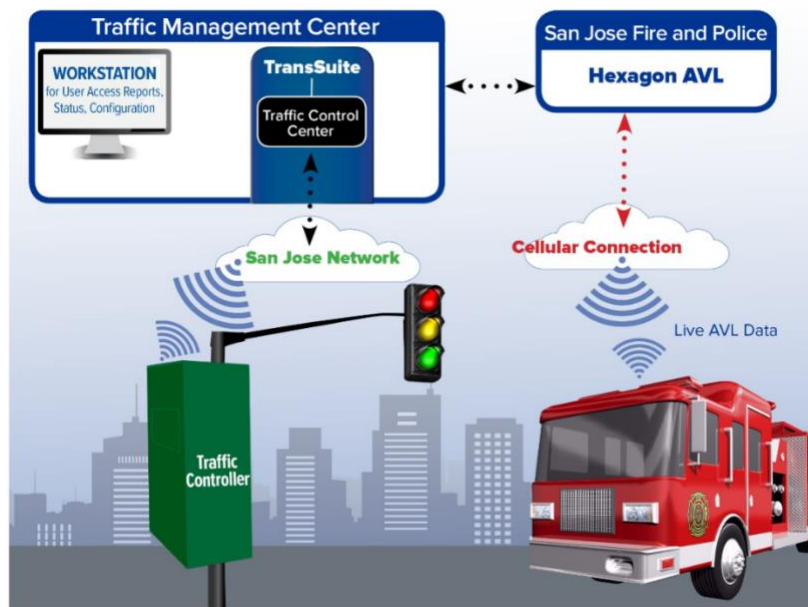
Real-time AVL and CAD integration allows signals to be adjusted ahead of approaching emergency vehicles, reducing delay at intersections.

Improved safety for emergency responders and motorists: Preempting conflicting traffic movements lowers the risk of intersection crashes involving emergency vehicles.

Lower infrastructure and maintenance costs: Use of centralized GPS-based systems and existing communications networks reduce the need for detector hardware at every intersection.

Network-wide scalability and routing flexibility: Agencies can extend service across large signal networks by leveraging existing AD, AVL, communications, and traffic management systems to enable preemption on any authorized route rather than only along predefined corridors.

Improved regional interoperability: Shared location and dispatch data can support mutual-aid responses across multiple agencies and jurisdictions.



The City of San Jose, California, is one of the most frequently cited U.S. examples of a centralized EVP deployment. Rather than equipping nearly 1,000 signalized intersections with traditional detector hardware, the city integrated its traffic signal management system with public safety CAD and AVL platforms. When a fire, EMS, or police vehicle is dispatched to an incident, AVL data continuously reports vehicle location to the central system. GPS-based geofences

along the response route identify approaching emergency vehicles and enable remote signal preemption through the traffic management center. The system leverages the city's advanced traffic management system, CAD platform, and police and fire AVL systems to control signals dynamically as emergency vehicles move through the network.

San Jose's approach is noteworthy because it shifted preemption decision-making from intersection hardware to the centralized software environment. This integration was implemented in the existing TransCore TransSuite traffic signal management system, Hexagon/Intergraph CAD and AVL systems, municipal communications infrastructure, and traffic signal controllers. By leveraging existing systems, San Jose was able to deploy citywide emergency vehicle preemption at a substantially lower cost than a traditional infrastructure-based approach. Evaluations documented by the USDOT ITS Knowledge Resource database reported implementation costs of approximately \$600,000 to \$750,000 and estimated lifecycle savings of roughly \$8 million compared to expanding conventional intersection-based EVP equipment throughout the city.

Beyond San Jose, other jurisdictions are pursuing similar GPS-enabled EVP strategies. The Maricopa Association of Governments (MAG) in metropolitan Phoenix, Arizona, coordinates EVP operations among more than 21 municipalities and numerous public-safety agencies. Building on an extensive regional traffic signal network, MAG completed pilot deployments of GPS-based EVP technology. The deployments in Mesa, Arizona, and Maricopa County evaluated a software platform that directly interfaced between fire department CAD systems and regional traffic management systems. The system used GPS locations from responding emergency vehicles and geofenced intersection approaches to automatically initiate traffic signal preemption requests. This regional approach is particularly valuable because emergency responses frequently cross jurisdictional boundaries through automatic-aid and mutual-aid agreements, making interoperability a significant operational requirement.

SMART EMERGENCY VEHICLE LIGHTING

Key Benefits:

Improved responder safety: Adaptive lighting reduces glare and improves motorists' ability to see responders working near incident scenes.

Clearer driver guidance: Directional sequencing and synchronized flash patterns communicate where motorists should move and how they should navigate around incidents.

Reduced secondary crashes: Better warning messages and reduced visual confusion help drivers react earlier and more appropriately when approaching incident scenes.

Automation of safety functions: Integration with vehicle systems allows lights to automatically change intensity or behavior based on operating conditions, reducing dependence on manual activation.

Foundation for connected-response operations: Integration with AVL, GPS, CAD, and other fleet-management technologies enables increasingly coordinated and data-driven emergency response

Intelligent emergency vehicle lighting systems move beyond simply maximizing light output to use advanced color, intensity, and synchronization systems to prevent driver blinding at incident scenes. Excessive or poorly managed warning lights can create glare, distract drivers, and reduce the visibility of responders working near traffic. The FHWA EDC-7 program promotes a SMART approach to emergency lighting: **Strategic placement, Meaningful messaging, Automatic features, Reduced pattern intensity, and Tiered operation.** Modern LED lighting systems and vehicle electronics enable agencies to automatically adapt lighting patterns to changing operating conditions, helping emergency responders communicate more effectively with motorists while reducing secondary crash risks.

For fire and emergency medical services (EMS) agencies, smart lighting increasingly incorporates vehicle data and operational status information. Many modern systems are connected to vehicle control networks (i.e., the CAN bus), allowing warning lights to respond automatically to events such as parking-brake engagement, vehicle speed, gear selection, or door operation. For example, forward-facing lights may automatically dim when a fire apparatus is parked at a scene, reducing glare

for oncoming motorists and improving the visibility of personnel working around the vehicle. Directional light sequencing and synchronized flash patterns can also provide meaningful visual guidance to approaching drivers, encouraging lane changes and speed reductions upstream of an incident.

Several agencies have implemented elements of these smart-lighting concepts. The Colorado Department of Transportation uses synchronized emergency-lighting practices that improve the consistency of warning messages presented to motorists approaching traffic incidents. The use of programmable lighting systems that can coordinate colors, flash rates, and directional patterns among multiple responder vehicles has expanded to multiple



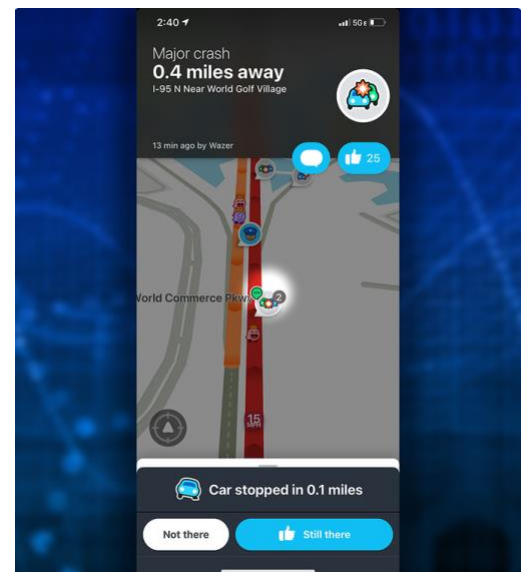
Source: FHWA.

Comparison of Calm Versus Chaotic Scene Lighting.

agencies. While many deployments currently operate at the vehicle level, the underlying technology increasingly supports integration with AVL, GPS, and dispatch systems that can activate operational modes automatically based on vehicle location and incident status. Agencies deploying advanced connected-response systems are increasingly combining automated vehicle location, dispatch data, and vehicle electronics to automate emergency-response functions. CAD and AVL integrations are already being used and have demonstrated the operational architecture needed to connect dispatch data, vehicle location, and emergency-vehicle subsystems. The same communication pathways can support increasingly sophisticated warning-light management and responder-safety applications as agencies modernize fleet electronics and connected-vehicle systems.

ADVANCED DIGITAL ALERTS

Back-of-queue warning systems and responder-to-vehicle (R2V) digital alert technologies are intended to reduce secondary crashes, improve driver awareness, and protect emergency responders and stranded motorists. Motorists often do not recognize a traffic queue, crash scene, or roadside emergency until they are dangerously close to it. By transmitting warnings directly into navigation applications, connected vehicles, smartphones, or vehicle infotainment systems, agencies can provide drivers with additional time and distance to slow down, change lanes, or prepare for stopped traffic ahead.



Source: Pennsylvania Turnpike Commission.

Smart Phone App Display of R2V

Key Benefits:

Reduces secondary crashes: Advance warnings help motorists recognize slowing or stopped traffic ahead and adjust their driving behavior before reaching the incident area.

Improves responder safety: Digital alerts provide approaching drivers with more time and distance to comply with Move Over laws and avoid roadside responders.

Enhances driver situational awareness: Warnings delivered directly through navigation applications, smartphones, and connected vehicles increase awareness beyond what flashing lights alone can provide.

Supports faster and safer incident management: Better-informed motorists are less likely to create additional traffic disruptions that complicate response and clearance operations.

Improves overall traffic operations: Early notification of congestion, queues, lane closures, and crash scenes enables more predictable traffic flow and improved travel reliability.

Back-of-queue warning systems typically use traffic management center data, roadway sensors, probe data, connected vehicle information, or other real-time traffic feeds to identify where congestion is forming and where the end of a queue is located. Once a queue is detected, agencies can automatically generate warnings through dynamic message signs, connected vehicle messages, or in-vehicle alerts. These systems are an important safety countermeasure because unexpected queues frequently contribute to rear-end crashes and traffic shockwaves. Warning of slow traffic ahead or an active queue allows approaching drivers to reduce speed gradually rather than making abrupt braking maneuvers near the back of queue.

R2V Alerts, sometimes called digital alert systems, use GPS-enabled emergency vehicles, maintenance vehicles, safety service patrols, tow trucks, or temporary traffic control devices to transmit incident information to navigation platforms and connected vehicles. Motorists may receive alerts through systems such as Waze®, Google®, Apple®, TomTom®, smartphone applications, connected vehicle onboard units, and through factory-installed in-vehicle systems. The alerts may activate automatically when emergency warning lights or equipped traffic-control devices are activated. The Pennsylvania Turnpike equipped

large portions of its incident-response fleet with digital alert capability to warn approaching motorists about roadway incidents.

In addition, state transportation agencies, toll authorities, and public-safety organizations have increasingly deployed these technologies through platforms such as Safety Cloud®, HAAS Alert®, Waze for Cities, and connected vehicle programs. Implementations have included highway service patrol vehicles, DOT maintenance fleets, snowplows, towing and recovery vehicles, work zones, emergency responders, and incident-management units. This mirrors the Safe System Approach philosophy of creating multiple layers of advance warning so that motorists receive notification before they encounter a queue, disabled vehicle, emergency response scene, work zone, or roadway hazard. The combination of back-of-queue detection with in-vehicle incident alerts reduces secondary crashes and protects both motorists and responders.

DEBRIS REMOVAL TOOLS

Roadway debris is a common cause of crashes, secondary incidents, and responder injuries. In order to reduce responder exposure and improve roadway clearance, transportation agencies are exploring or have deployed vehicle-mounted debris-removal equipment that allows operators to clear debris while remaining inside the protection of their vehicle cab. These technologies support the longstanding TIM principle of minimizing the time responders spend on foot in active travel lanes. While FHWA has promoted rapid clearance innovations broadly, several agencies have specifically documented testing, evaluation, or deployment of specialized debris-removal devices designed for in-cab operation.

During 2023-2024, Maryland State Highway Administration (MDSHA) and its Coordinated Highways Action Response Team (CHART) evaluated the LaneBlade® system, a vehicle-mounted debris-clearing device operated from within the patrol vehicle. Field testing concluded that the technology effectively cleared various debris types under real-world conditions, including adverse weather, while reducing responder exposure and allowing debris removal without requiring lane closures. MDSHA's research summary specifically states that the results support procurement and installation of debris-removal systems on CHART patrol vehicles and identifies the LaneBlade® system as the preferred technology evaluated. The agency subsequently sought FHWA Accelerated Innovation Deployment funding for statewide implementation under a project titled *Enhancing Roadway Responder Safety through Innovative Debris Clearance and Collection*, identifying the effort as a Next Generation TIM innovation.

Key Benefits:

Improved responder safety: Debris can be removed without requiring personnel to exit the vehicle and enter active traffic lanes.

Faster incident clearance: Allows debris removal immediately upon arrival without establishing extensive traffic control.

Reduced lane closures and traffic disruption: Many debris-removal operations can occur while traffic continues flowing.

Lower risk of secondary crashes: Quicker removal of roadway hazards and shorter exposure durations for responders.

Enhanced operational efficiency: Enables a single operator to collect debris using equipment mounted on existing patrol or maintenance vehicles.



Source: Maryland State Highway Administration.

Example Mounting of LaneBlade® Debris Removal Device



Source: Maryland State Highway Administration.

Example Mounting of Gator Getter Debris Removal Device

Missouri Department of Transportation (MoDOT) publicly presented its debris-removal practices through the Safety Service Patrol network and has documented acquisitions of Road Rake equipment, a roadway debris and litter collection system. Separately, public documentation associated with the Gator Getter identifies testing by both the North Carolina Department of Transportation and MoDOT. The Gator Getter is designed to mount on existing maintenance or patrol vehicles and remove roadway debris at traffic speeds without requiring personnel to enter travel lanes. These deployments and evaluations illustrate a growing national trend toward using engineered, vehicle-based debris-removal systems to support responder safety, faster roadway clearance, and reduced incident-related congestion.

Another example is from the Pennsylvania Turnpike Commission, whose TIM staff participated in a nationwide Safety Service Patrol debris-removal technology exchange organized through SafeHighways.org and the National Operations Center of Excellence. The session highlighted technologies including the LaneBlade®, Road Rake, and Gator Getter systems and featured presentations from agencies actively evaluating debris-removal strategies. The Turnpike Commission took a leadership role in evaluating and sharing lessons learned regarding debris-removal technologies.

Additional documented agency use and testing has occurred elsewhere. The

UNMANNED AIRCRAFT SYSTEMS (UAS/DRONES)

The use of Unmanned Aircraft Systems (UAS), commonly called drones, has been shown to be a proven method for rapidly documenting crash scenes, supporting incident management, and significantly reducing roadway closure durations. Traditional fatal-crash investigations often require extensive measurements and mapping activities that can keep travel lanes closed for hours. FHWA has highlighted UAS as a technology that enables crash investigators to collect high-resolution imagery and three-dimensional scene data much more quickly than conventional surveying methods, allowing responders to reopen roadways sooner while still preserving evidentiary-quality documentation.



Source: FHWA.

Tethered Drone Launch

Key Benefits:**Reduced roadway closure durations:**

Drone-based mapping can collect crash-scene measurements much faster than traditional methods, allowing traffic lanes to reopen sooner.

Improved responder safety: Faster data collection decreases the amount of time investigators and emergency personnel spend exposed to live traffic.

Enhanced situational awareness: Real-time aerial imagery helps responders assess incident conditions, traffic queues, detours, and emerging hazards.

Lower operational costs: UAS platforms generally cost substantially less to acquire and operate than manned aviation resources while producing high-quality mapping products.

Higher-quality crash documentation: Orthomosaic imagery and 3-D scene models improve reconstruction accuracy and provide visual evidence that is easier for investigators, attorneys, and juries to understand.

FHWA's documented state-of-practice examples demonstrate substantial operational benefits. A field comparison cited by the North Carolina Department of Transportation (NCDOT) found that UAS-based mapping achieved more than a 300 percent time savings compared with 3D laser mapping techniques. The Washington State Patrol reported an estimated 80 percent reduction in roadway closure time across more than 125 serious-crash investigations after implementing drone-based scene mapping. Similarly, the Tippecanoe County Sheriff's Office in Indiana found that UAS deployment reduced overall incident-scene time by approximately 60 percent. FHWA also references research showing that drone-based data collection can be one to two hours faster than traditional total-station surveying approaches.

Beyond crash reconstruction, agencies are increasingly using drones for broader traffic incident management functions. FHWA's EDC program notes that UAS can support incident verification, detour-route monitoring, queue detection, secondary-crash detection,

response routing, and real-time situational awareness. The agency has highlighted emerging deployments of tethered drones capable of providing continuous aerial video to responders and transportation management centers. For example, NCDOT Incident Management Assistance Patrol personnel have evaluated tethered UAS to monitor diversion routes and observe traffic conditions during major incidents, enabling real-time traffic management decisions while improving responder awareness of conditions beyond the immediate crash scene.

Additional deployments extend well beyond FHWA EDC demonstrations. Research sponsored by the Texas Department of Transportation evaluated drone-based crash-scene reconstruction under real-world conditions and demonstrated the value of combining UAS imagery with photogrammetry software to create accurate three-dimensional reconstructions while minimizing roadway occupancy times. The Utah Department of Transportation has also examined the use of drone livestreaming to improve situational awareness for incident management teams, particularly where fixed camera coverage is unavailable. These implementations illustrate a broader national trend toward integrating drones into routine transportation operations, public safety response, and crash investigation workflows.

EMS POST-CRASH CARE SUPPORT



Source: FHWA.

EMS Vehicle at Crash Scene

Post-crash care is a key component of the Safe System Approach. Technology-supported post-crash care extends beyond patient treatment and includes the integration of responder training, emergency vehicle operations, scene management technologies, data sharing, and responder safety measures that allow EMS personnel to reach patients more quickly and provide care in a safer environment. Technologies such as CAD integration, emergency vehicle preemption, responder-to-vehicle alerts, advanced warning systems, and smart emergency vehicle lighting are intended to reduce response times, improve situational awareness, and

create safer working conditions for EMS providers before patient transport begins.

A major theme of current U.S. practice is improving the flow of information to EMS personnel before and during arrival at a crash scene through the integration between 911 systems, CAD platforms, transportation management centers, geographic information systems (GIS), and emergency response agencies. These systems help responders obtain more accurate crash locations, receive incident details earlier, coordinate roadway access, and share operational information among transportation, law enforcement, fire, and EMS agencies. CAD-to-transportation management center integration is a proven approach for improving incident detection, resource deployment, and responder safety. Meanwhile, the National EMS Information System (NEMSIS) provides a nationwide framework for standardized EMS data collection and exchange, supporting performance measurement, system improvement, and evidence-based EMS operations.

Several jurisdictions have implemented elements of these post-crash care support strategies. Statewide and regional deployments of CAD integration in states such as Kentucky, Florida, Oregon, and California improve information sharing and incident management performance. In addition, widespread deployment of Next Generation 911, GIS-based location services, and NEMSIS-compliant electronic patient care reporting systems across numerous states is enabling more accurate incident location, better patient information capture, and more effective coordination among EMS, hospitals, public safety agencies, and transportation operators. Another approach is to explicitly incorporate post-crash care into a jurisdiction's safety action plan, as Tazewell County, Virginia, has done.

Beyond transportation operations technologies, national EMS and highway safety programs increasingly emphasize clinical innovations that support decision-making before hospital arrival. Examples include electronic patient care reporting, real-time transmission of patient information, trauma-system coordination, and prehospital blood transfusion programs that

provide advanced treatment capabilities at the crash scene. The USDOT's EMS and Highway Safety program identifies improved data sharing, earlier crash detection, accurate location information, coordinated dispatch, and enhanced clinical tools as key strategies for reducing preventable roadway fatalities occurring after a crash but before definitive hospital care is available.

Resources

AASHTO

Transportation Operations Manual (TOM)

- Chapter 20: Event Management Tactics
 - 20.1: Traffic Incident Management (TIM)
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 - 20.1.3: TIM Stakeholders
 - 20.1.4: Implementing a TIM Program
 - 20.1.5: TIM Performance Measurement
 - 20.2: Emergency Transportation Operations for Disasters
 - 20.3: Road Weather Management (RWM)
 - 20.4: Work Zone Traffic Management
 - 20.5: Planned Special Event Management

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