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Traffic Incident Management Quick Clearance Guidance and Implications

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LANCE E. DOUGALD
Research Scientist

NOAH J. GOODALL, Ph.D., P.E.
Research Scientist

RAMKUMAR VENKATANARAYANA, Ph.D.
Research Scientist

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530 Edgemont Road, Charlottesville, VA 22903-2454
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16. Abstract:

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The purpose of this study was (1) to investigate traffic incident management initiatives including quick clearance practices and policies used by other state departments of transportation; (2) to assess the feasibility of adopting strategies that are not currently implemented in Virginia; and (3) to provide emergency responders and VDOT staff with a tool to estimate the benefits of clearing an incident quickly, individualized for a particular incident, location, and time. The tool would provide an incident commander with real-time information on the costs to the traveler from extended lane closures.

The guidance and data tool developed in this study will provide VDOT with additional mechanisms to broaden and strengthen its outreach to the responder community and improve real-time awareness of incident lane closure costs. The guidance on quick clearance is intended to support statewide implementation of strategies to improve incident response and clearance times. Implementing this guidance will provide strengthened interagency coordination and cooperation resulting in measurable benefits for traffic incident management.

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Lance E. Dougald
Research Scientist

Noah J. Goodall, Ph.D., P.E.
Research Scientist

Ramkumar Venkatanarayana, Ph.D.
Research Scientist

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ABSTRACT

Improving traffic incident management is one means to help reduce congestion, as traffic incidents account for approximately 25 percent of total congestion on U.S. highways. Between July and September 2012, 330 collisions were recorded for the I-66 corridor in Northern Virginia alone, of which 82 required more than 1 hour to clear. To improve its incident management efforts, the Virginia Department of Transportation's (VDOT) Northern Region Operations recently piloted a quick clearance policy called Operation Instant Tow. With an instant tow concept, a tow truck and a Virginia State Police trooper are dispatched simultaneously to the site of specific incident types (e.g., lane blocking events), thus reducing clearance time. VDOT's Operations Division is interested in the potential expansion of this initiative to other operations regions and the employment of other quick clearance initiatives currently not executed in Virginia.

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Lance E. Dougald
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INTRODUCTION

Traffic congestion and safety on U.S. roadways are issues that receive significant and continual attention from transportation professionals. The economic impacts of congestion are clear and have been documented in numerous publications—most recently in the *2015 Urban Mobility Scorecard*[1] in which the total financial cost of congestion in the United States in 2014 was reported to be $160 billion, or $960 per commuter. Improving traffic incident management (TIM) is one way to reduce congestion as traffic incidents account for approximately 25 percent of total congestion on U.S. highways.[2] TIM combines public safety and traffic management functions to help reduce the detection, response, and clearance times of incidents on roadways. The Federal Highway Administration (FHWA) continues to support and champion laws, policies, and practices that speed up the clearance of major and minor incidents.[3]

States are also collaborating to address issues related to incident management. The American Association of State Highway and Transportation Officials' (AASHTO) National Traffic Incident Management Coalition (NTIMC) is a multidisciplinary partnership forum spanning the public safety and transportation communities to coordinate experiences, knowledge, practices, and ideas. NTIMC's commitment statement and objectives are proposed as a National Unified Goal that speaks specifically to promoting, developing, and sustaining multijurisdictional TIM programs to achieve (1) enhanced responder safety; (2) safe, quick traffic incident clearance; and, (3) prompt, reliable, and interoperable communications.[4] In this broad TIM context, *quick clearance* is the practice of rapidly responding to and removing temporary roadway obstructions including disabled or wrecked vehicles, debris, and spilled cargo. Quick clearance directly increases the safety of incident responders by minimizing their exposure to adjacent passing traffic, reduces the probability of secondary incidents, and relieves overall congestion levels and delay.[5]

Between July and September 2012, 330 collisions were recorded for the I-66 corridor in Northern Virginia alone, of which 82 required more than 1 hour to clear.[6] Such high incident occurrences and durations coupled with heavy daily traffic volumes are primary reasons the

Washington, D.C. / Maryland / Virginia metropolitan region has the highest levels of congestion of any urban area in the United States.[1] To mitigate this congestion through improved incident management efforts, VDOT's Northern Region Operations (NRO) initiated a quick clearance policy called Operation Instant Tow (OIT)[7] (see Appendix A). In the instant tow program, a tow truck is dispatched simultaneously with the initial Virginia State Police (VSP) trooper to specific incident types, thus saving critical clearance time. Prior to OIT, tow dispatch occurred after a VSP trooper responded to and verified the incident. The simultaneous dispatch is also used by the state of Washington and has been found to reduce incident clearance times by an average of 15 minutes.[8]

VDOT's Operations Division (OD) is interested in developing a more robust statewide TIM toolbox to include OIT and other quick clearance initiatives not currently used in Virginia. In addition, VDOT is seeking a data analysis tool to quantify and communicate clearly the benefits of quick clearance to primary incident responders.

PURPOSE AND SCOPE

VDOT's stated mission is to operate a transportation network that is safe and enables easy movement of people and goods. When an incident requires closure of one or more travel lanes for an extended period of time, motorists encounter greater delay and there is a higher risk of secondary crash occurrence. To support VDOT's mission through improved TIM, this study had two objectives:

1. Investigate TIM initiatives including quick clearance policies and practices used by other state departments of transportation (DOTs), understand their advantages and disadvantages, and assess the feasibility of adopting strategies that are not currently implemented in Virginia.

2. Provide emergency responders and VDOT staff with a tool to estimate the benefits of clearing an incident quickly, with benefits individualized for a particular incident at a specific time. This tool would provide an incident commander with real-time information on the costs to the traveler of lane closures.

These objectives were intended to provide VDOT with potential strategies to help clear incidents more quickly, thereby reducing motorist delay and improving safety by reducing queues and secondary crashes. The scope of the study was limited to clearance operations on interstate highways within Virginia. The literature review consisted of a scan of international and domestic programs, and best practice interviews were limited to programs within the United States.

METHODS

To achieve the study objectives, four tasks were performed:

1. Review the literature and best practices.
2. Conduct best practice interviews.
3. Develop quick clearance best practices guidance.
4. Develop the Incident Impact Estimator (IIE) tool.

Review Literature and Best Practices

Literature pertaining specifically to how agencies monitor and reduce the time it takes to respond to and clear major incidents was reviewed. This included a review of policies and legislative statutes designed to assist TIM programs with quick clearance initiatives. Topics were investigated by reviewing literature regarding research and best practices across the responder community, both within and outside the United States, to identify key issues with respect to the following TIM initiatives.

- *Towing and recovery initiatives.* Topics examined included quick clearance initiatives and incentives, statewide or regional contracts (including compensation mechanisms), and various response and on-scene protocols.

- *Driver removal laws.* These are commonly referred to as "Fender Bender," "Move It," or "Steer It / Clear It" laws and are currently enacted in approximately one-half of all states to encourage or require drivers involved in incidents to move their vehicle out of the travel lanes if they can do so safely.

- *Authority removal laws.* Authority removal laws provide authorization to law enforcement or state DOTs to remove damaged or disabled vehicles and/or spilled cargo determined to be a hazard from the roadway. About one-half of the states have these laws, but designation of authority varies. Liability concerns are often raised with respect to damage to vehicles or cargo attributable to removal procedures. To address this concern, some states have enacted "hold harmless" provisions that protect responders from liability resulting from clearance activities.

- *Abandoned vehicle legislation.* A high percentage of roadway incidents are classified as shoulder disablements. In some instances, motorists abandon the vehicle to reach services. Abandoned vehicles are considered roadway hazards, and responders with authority "tag" the vehicles. From the time a vehicle has been tagged, a motorist is often allowed to leave the vehicle in excess of 24 and up to 72 hours before the vehicle is towed. This period increases the exposure time of the roadway hazard.

- *Expedited crash investigation.* Some states have developed photogrammetry programs/systems to expedite on-scene crash investigations. These systems use photography, laser scanning, and specialized software for accident reconstruction.

- *Interagency coordination and cooperation.* The FHWA Focus States Initiative (FSI)[9] was reviewed to obtain a better understanding of how participating states are integrating and coordinating TIM operations among multiple agencies and how

outreach plans and products can be used to promote TIM performance measures and integrated TIM programs. Initiatives have also been developed by other states. Kentucky developed a Highway Crash Site Management Workshop, which has been very effective in getting the message of quick clearance to emergency responders.[10] Illinois developed a Highway Management and Operation Training Guide for Incident Responders with the objectives of keeping responders safe, preventing secondary incidents, and reducing fatalities while reducing non-recurrent congestion caused by incidents.[11] These types of initiatives, in addition to cross-cutting challenges specific to interagency coordination, cooperation, and communication, were explored. The scope and nature of after-action reviews were also explored.

- *Virginia-specific laws and TIM initiatives.* Existing Virginia laws and policies were reviewed; they encompassed towing and recovery statutes and initiatives; driver and authority removal legislation; and agency coordination, cooperation, and communication.

- *Incident modeling techniques.* For the IIE tool development, literature that described methods to forecast and predict incident durations was reviewed. Of particular interest were reports on hazard-based duration models using traffic flow data, roadway geometry information, and incident databases to describe incident clearance data; adaptive models to forecast the clearance time of real-time traffic incidents; and procedures and methodologies for effective use of historical incident data for incident impact estimation, incident duration prediction, and incident-induced congestion clearance time prediction. These topics and others were investigated to help provide a sound basis for the IIE tool.

Conduct Best Practices Interviews

Based on the findings of Task 1, representatives from TIM agencies in Virginia and other states were contacted through email, teleconference, or in-person meetings to determine each stakeholder's current best practices in further detail. To help guide the interview process and facilitate a transition between topic areas, the incident timeline shown in Figure 1 was followed. The structure of the interviews was intentionally malleable, allowing the responder interviewees to speak candidly about their roles, responsibilities, and areas of needed improvement throughout the incident timeline.

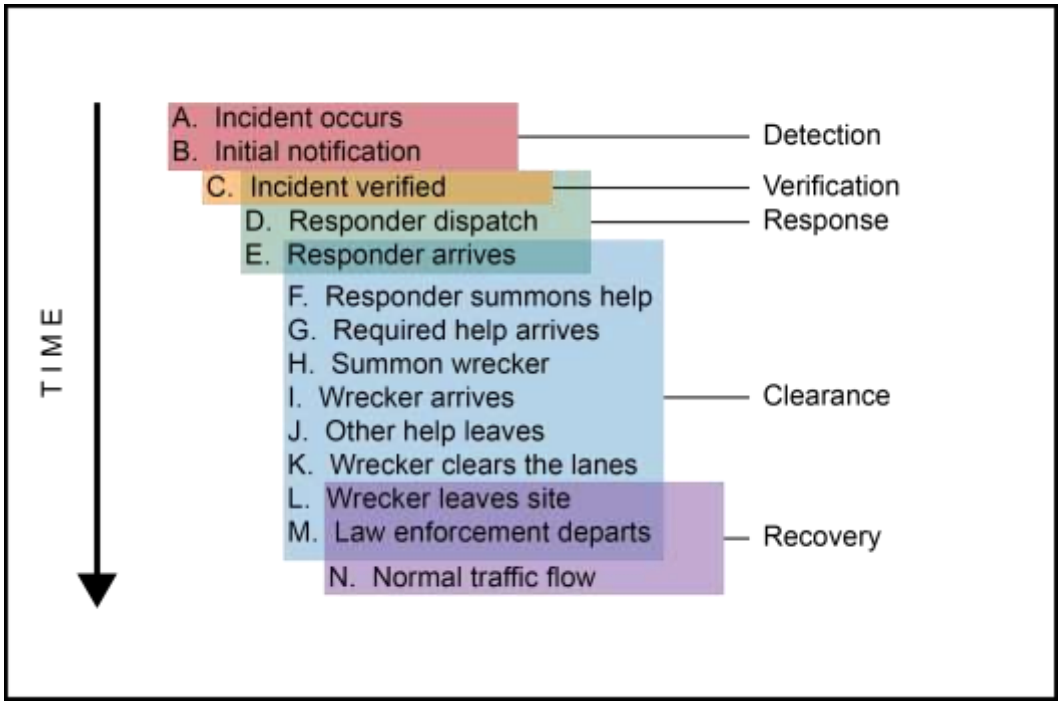


Figure 1. Incident Timeline. Adapted from I-95 Corridor Coalition, *Coordinated Incident Management Toolkit for Quick Clearance*, Rockville, Md., 2007.[12]

Virginia TIM Interviews

VDOT central office staff, regional incident management coordinators, and members of Virginia's Statewide Traffic Incident Management (TIM) Committee were engaged to help develop a list of TIM agencies and contact persons for the interviews. The goal of this subtask was to interview TIM agency representatives in each of Virginia's five operations regions (Southwest, Northern, Central, Southeast, and Northwest) to capture responder experience and identify existing challenges and potential solutions to achieving quick clearance objectives. Table 1 shows the agency/company, title/function of the persons interviewed, and dates of the interviews. The majority of the interviews were conducted in person, and a few were conducted by telephone or email.

TIM Interviews of Other State DOTs

Based on findings from the best practices literature review, a list of state DOTs that employed innovative quick clearance strategies was compiled. As with the Virginia TIM interviews, the structure of these interviews followed the incident timeline shown in Figure 1 with emphasis placed on the unique strategies not currently employed in Virginia. Table 2 shows the state DOT/agency, title/function of the persons interviewed, and dates of the interviews. All interviews were conducted by telephone.

Table 1. Virginia TIM Interviewees by VDOT Region, Agency/Company, Title/Function, and Date

Region	Agency/Company	Title/Function	Date(s)
ERO	VDOT	IMC	4/7 and 4/11/14
	VSP	Sergeant	5/1/14
	Towing, Newport News	Owner; Tow Operator; Tow Dispatcher	
	York County	Chief, Fire	5/12 and 5/15/14
	VSP	Dispatch Supervisor	4/24/14
NRO	VDOT	IMC; TOC Manager; Operations Staff	5/30/14
	Serco	SSP Manager	
	VSP	First Sergeant; Area Commander	
	Stafford County	Deputy Chief, Fire	
	Towing, Sterling	President, Vice President	6/9/14
	Fairfax County	911 Dispatch Assistant Director	
	Towing, Arlington/Lorton	President	6/19/14
NWRO	Towing, Woodstock	Owner	6/9/14
	VDOT, Edinburg	Assistant Residency Administrator	6/18/14
	VSP	Sergeant	6/25/14
	VDOT	IMC	07/01/14
	Augusta County	Chief and Battalion Chief, Fire	6/18/14
CRO	VDOT	IMC; ROD	08/14/14
	Chesterfield County	Captain and Shift Chief, Fire	
	VSP	Lieutenant	08/12/14
	Towing, Richmond	President	
SWRO	VDOT	IMC-Bristol, Lynchburg, Salem; RTOM	07/30/14
	VSP	Trooper	
	Towing, Salem	Owner	
	Botetourt County	Division Chief, Fire	
Other	Department of Motor Vehicles	Deputy Director, Program Development and Implementation	10/06/14
	TIM Best Practices Workgroup	Representatives from OEMS, OCME, VDOT, VSP, Stafford Sheriff's Office, VDFP	

TIM = traffic incident management; ERO = Eastern Region Operations; ; VDOT = Virginia Department of Transportation; IMC = Incident Management Coordinator; VSP = Virginia State Police; NRO = Northern Region Operations; TOC = Traffic Operations Center; SSP = Safety Service Patrol; NWRO = Northwest Region Operations; CRO = Central Region Operations; ROD = Regional Operations Director; SWRO = Southwest Region Operations; RTOM = Regional Traffic Operations Manager; OEMS = Office of Emergency Medical Services; OCME = Office of Chief Medical Examiner; VDFP = Virginia Department of Fire Programs.

Table 2. TIM Interviewees by State DOT/Agency, Title/Function, and Date

State DOT/Agency	Title/Function	Date
NCDOT (North Carolina DOT)	State Traffic Operations Engineer	06/24/14
	Traffic Operations Engineer	
	TIM Specialist	
WSDOT (Washington State DOT)	IMC	07/01/14
TxDOT (Texas DOT)	Austin IMC	09/09/14
Caltrans (California DOT)	Chief, TMC Operations and Incident Management	09/04/14
FDOT (Florida DOT)	Incident Manager—Road Rangers	09/22/14
GDOT (Georgia DOT)	Incident Management Manager	09/18/14
IDOT (Illinois DOT)	Operations Manager and Emergency Traffic Patrol Staff	09/26 and 10/03/14
Pennsylvania Turnpike (Pennsylvania)	Safety Trainer	07/10/14

TIM = traffic incident management; IMC = Incident Management Coordinator; TMC = Traffic Management Center.

Development of Quick Clearance Best Practices Guidance

Based on the results of Tasks 1 and 2, specific quick clearance strategies were identified for potential implementation in Virginia. As part of this task, meetings were held with relevant project stakeholders. Topics of discussions included current Virginia experiences with quick clearance, towing, relationships with other responders, incident command, formal and informal protocol, and best practices from other states. The stakeholders were briefed on findings from Tasks 1 and 2 with the goal of identifying additional agency needs with respect to quick clearance initiatives. Representatives from the following entities were involved in the meetings:

- VDOT's Transportation Emergency Operations Center
- VDOT's OD
- VDOT's Safety Service Patrol (SSP)
- VDOT's Regional Traffic Operations Managers
- VSP.

Development of Incident Impact Estimator Tool

Currently, there is a gap or bias in the quantified information received by an incident commander on the scene. When a commercial truck has crashed, the owner may disagree with the incident commander over whether to push the damaged truck to the roadside—possibly damaging the truck further—or wait for a wrecker than can remove the commercial vehicle. Although the commercial vehicle owner can cite the cost of potential truck damage, the incident commander does not have the competing information on the cost of congestion that waiting for removal will incur to the economy or the traveling public. As part of this study, a prototype web-based tool to help users estimate the potential cost and safety impacts of an incident and different lane clearing strategies was to be developed based on input from VDOT staff and other emergency responders.

The IIE tool was to calculate the expected traffic and safety conditions based on an incident both at a current place in time and as projected into the future and was to allow users to quantify the benefits of quickly clearing an incident in terms of cost to the traveler, queue length, and risk of secondary crashes. This information would provide incident responders with a better understanding of the real costs of lane closures and ideally act as an incentive for quick clearance. The functional specifications for the IIE tool were to be determined based on feedback from stakeholders throughout the development process.

The tool development had three main components: (1) determination of functional specifications and potential use cases, (2) development of a new model for secondary crash probability, and (3) development of the prototype tool itself.

Determination of Functional Specifications and Potential Use Cases

Initial functional specifications in terms of desired inputs and outputs and potential use cases were determined by the study's technical review panel and the research team. These

functional specifications and use cases were further refined through interviews with key stakeholders.

Development of a New Model for Secondary Crash Probability

As part of this study, a new study of secondary crashes was initiated using incident data from the Regional Integrated Transportation Information System (RITIS)[6] database and speed data from the RITIS Vehicle Probe Project. The study covered the I-66 corridor over all of 2014. During the study period, 8,772 incidents were recorded, of which 2,466 were crashes.

To identify secondary crashes, the techniques developed by Yang et al.[13] were used with a few variations. For example, Yang et al. required that non-recurring congestion be present in all time-space intervals between the secondary crash and primary incidents. In this study, only 90 percent of the time-space intervals between the secondary crash and primary incidents were required to show non-recurring congestion. This approach captures secondary crashes that may occur at the tail-end of a primary incident's queue.

The second difference between the approach used in this study and that used by Yang et al.[13] involves the incident duration. In the study by Yang et al., the secondary crash was required to be "linked" by congestion to the beginning of an incident. Secondary crashes might be miscategorized if the corresponding primary incident did not generate congestion immediately. In the approach used on the current study, the secondary crash could be connected to the primary incident at any point along the primary incident timeline. This allowed the identification of secondary crashes where a primary incident might not have generated congestion until later in the incident timeline. An example of this approach is shown in Figure 2.

Real-time volumes were collected as part of this study to determine the effect of the number of vehicles encountering non-recurring congestion on secondary crash occurrence. Annual average daily traffic (AADT) values were obtained from VDOT for each link along the corridor.[14] As continuous volume measurements are collected only at select links, some extrapolation was required to determine the hourly traffic volumes at each link.

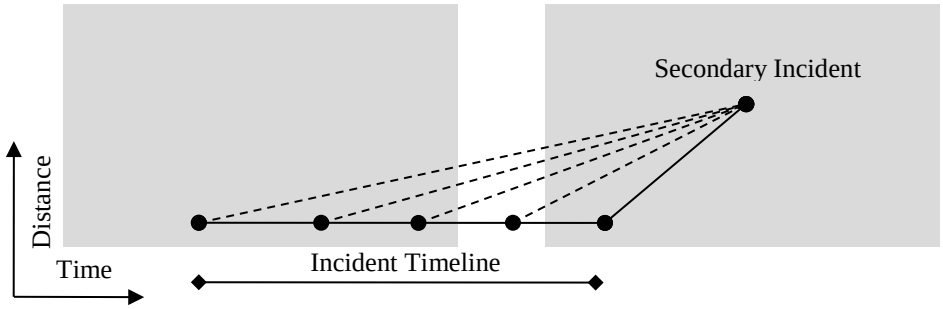


Figure 2. Identifying Secondary Incidents From Multiple Points Along Primary Incident Timeline. Gray areas represent non-recurring congestion.

Two continuous count stations deployed on I-66 were used in this study. One was located at mile marker (MM) 72, approximately 2 miles from the eastern terminus of the study area. The other was located at MM 30, approximately 6 miles beyond the western terminus. I-66 is restricted to high-occupancy vehicles only on all lanes during peak hours on sections east of I-495. Therefore, hourly volumes often decrease during peak hours, in contrast to sections of I-66 west of I-495. The continuous count station at MM 72 was used to estimate hourly adjustment factors for sections of I-66 east of MM 65 (I-495), and the station at MM 30 was used to develop factors for I-66 west of MM 65. The AADTs and hourly adjustment factors were used together for developing cost estimates, queue length estimates, and crash probabilities for any location within the corridor.

A model was developed to determine the probability of a secondary crash occurring over time. The model considered three factors: (1) whether the incident was creating a queue or not, (2) the duration of the incident in minutes, and (3) the estimated number of vehicles that had encountered the incident and therefore been exposed to the queue. The factors were fitted to a binary logistic regression model using Minitab software.

Development of Prototype Tool

The prototype IIE tool was developed using PHP and MySQL to serve on a web-based platform. MySQL was used as the data query and calculation engine. PHP was used for the user interface to gather inputs and display analysis results. The traffic volume AADT and hourly adjustment factor data were stored in the MySQL database.

RESULTS

Literature Review

This section describes the findings from the literature in which specific towing and recovery strategies; driver and authority removal laws; abandoned vehicle legislation; expedited crash investigations; and TIM agency coordination, cooperation, and communication were explored.

Towing and Recovery

With increased national scrutiny on incident-related congestion and associated costs, transportation agencies are focusing more than ever on the strategies to expedite the removal of incidents from the roadways. States looking for ways to improve incident management have found towing programs to be successful in reducing incident clearance times.[15] Tow companies have an extremely important role in TIM, and their response to incidents and on-scene activities is critical to realizing clearance time objectives.

Training to improve TIM and specifically towing response so that TIM is not learned on the job helps to create standardization in the towing industry.[16] Professional certification denotes

an effective means of ensuring that private towing operators have complete knowledge of equipment operation and procedures. As an example, the Towing and Recovery Association of America (TRAA) sponsors a national driver certification program consisting of the following three levels:[17,18]

- *Level 1:* light-duty towing and recovery
- *Level 2:* medium-duty towing and recovery
- *Level 3:* heavy recovery specialty.

The need to remove damaged vehicles from the roadway quickly necessitates that it is the government agencies that will enter into service agreements with towing and recovery based on capabilities, geography, and regulated pricing. The agreements should consider towing and recovery capabilities to guarantee that only the most qualified companies are used to remove damaged commercial vehicles and cargo quickly and efficiently from the roadway.[19] Virginia's previous version of its Statewide TIM Committee, i.e., the Statewide Seaboard Incident Management (SIM) Committee, developed a template for local agencies to use to review and evaluate towing and recovery operators objectively. This can be used as a means to ensure that operators involved in major incidents are qualified and have the proper equipment.[20]

In Florida, the wrecker industry has worked with the legislature to regulate operations and to ensure that wrecker companies are adequately equipped, operators are properly trained, and companies are properly certified to recover heavy vehicles. The rationale for this action is first to ensure public safety but second to create an industry base for heavy towing in which only qualified firms with the ability to invest in the necessary equipment and training can participate. The legislative action would not prevent small firms with limited resources from handling small towing jobs; it would, however, discourage tow companies to operate without meeting a baseline level of safety and training.[20]

A survey of towing and recovery representatives found that overall, the industry is not averse to more government regulation as long as such regulation is geared toward protecting the towing community and improves recognition by state DOTs and law enforcement of the towing industry's important role in TIM.[21] The inclusion of "Towing Companies" as on-scene responders places a burden on the towing industry such as being held liable for damage to equipment and cargo after being instructed by a government entity to clear the public roadway. An example of legislation that protects the towing industry is Georgia Code OCGA 32-6-2(1):[22]

> . . . and any person or towing service that is removing an obstruction, cargo, or personal property at the location of such obstruction, cargo, or personal property upon instruction by a law enforcement officer, an official of a fire department acting under the authority of paragraph (1) of Code Section 25-3-1 or paragraph (3) of Code Section 25-3-2, or an official of the department shall be liable only for gross negligence.

Response

Getting to the incident scene in a timely manner is widely considered as one of the biggest obstacles for the towing industry. Therefore, improvements must be made in developing

methods to get tow trucks to the scene faster.[23] There are typically three types of dispatch strategies with respect to tower response:

1. *Typical.* Tow trucks are dispatched after on-site verification.
2. *Staged.* Tow trucks standing by at a strategic location are dispatched.
3. *Instant.* Tow trucks are dispatched immediately after an incident is reported.

Tow trucks being dispatched after on-site verification can lead to response delays, particularly in urban areas where high traffic volumes lead to large incident-induced traffic queues. Staged and instant tow dispatch mechanisms are aimed at alleviating the response delays that typical dispatch strategies encounter. The instant tow dispatch approach originated in the state of Washington, where tow truck, police, and incident response vehicles are simultaneously dispatched to all incidents. Participating tow companies must be on the police rotations list to be eligible, but participation is voluntary. In cases in which an incident is unfounded, the Washington State DOT (WSDOT) pays tow companies a flat fee for dry runs, typically $35. Studies have shown that this dispatch mechanism saves an average of 15 minutes of lane blocking congestion each time it is used and can save approximately $20,000 to $30,000 in delay costs per incident depending on the location and traffic conditions.[16] An alternate approach to the dry run fees is to keep the tower on top of the rotation list for the next call.

In Oregon, a study that evaluated the three towing strategies (typical, staged, instant) on the I-5 / I-405 loop in downtown Portland found that implementing the instant dispatch system increased capacity on the most congested corridor by decreasing towing response times by 30 percent at an annual cost of under $2,000.[24]

Occasionally, tow companies will dispatch the wrong type of towing and recovery vehicle to an incident, resulting in additional delay as the correct equipment must be re-dispatched. This is often caused by the tow companies receiving incorrect or incomplete information from on-scene responders. To remedy this situation, responders should be educated regarding proper identification of vehicle classes involved in an incident so that tow companies receive relevant and accurate information to determine the correct recovery equipment to dispatch.[25]

In an effort to provide such education:

> The Towing and Recovery Association of America, Inc.® (TRAA) produces and distributes a Law Enforcement Vehicle Identification Guide© to assist responders who are requesting towing and recovery services. The guide [shown in Figure 3] provides the information required by tow operators prior to dispatch. Any reprint, reproduction of any part or use of the Law Enforcement Vehicle Identification Guide© is strictly prohibited without the express permission of TRAA. For more information or to obtain this product, visit www.traaonline.com/products or contact the TRAA Office at contact@traaonline.com.[26]

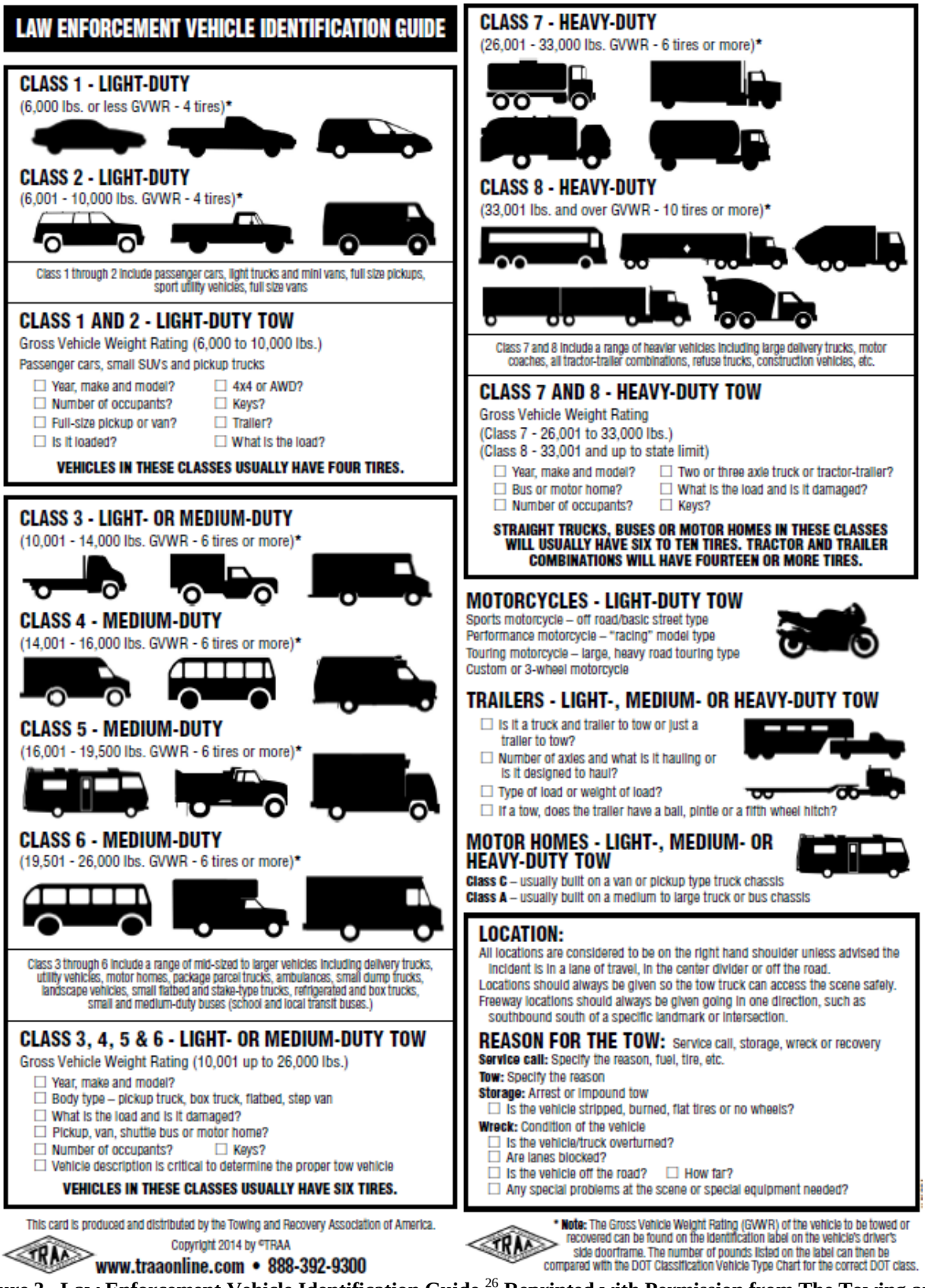


Figure 3. Law Enforcement Vehicle Identification Guide.[26] Reprinted with Permission from The Towing and Recovery Association of America, Inc. Any reprint, reproduction of any part, or use of the Law Enforcement Vehicle Identification Guide© is strictly prohibited without the express permission of TRAA.

Incentive-Based Programs

Traditionally, tow companies have been compensated on an hourly basis rather than per job. Some TIM stakeholders thought that this compensation scheme hinders the goal of quick clearance, as more efficient recovery and removal efforts resulted in less pay. Thus, this compensation practice has been considered a disincentive to perform quick removals. To address this, some states have configured contracts to pay by the pound of material hauled from the roadway.[20] Although this practice removes the disincentive to clear the roadway quickly, it does not provide a performance-based quick clearance incentive.

Georgia and Florida are two states that have developed quick clearance incentives to speed the clearance of major incidents through the provision of financial rewards and/or penalties tied to performance for participating towing and recovery agencies.[16] In Georgia, the Metro Atlanta Traffic Incident Management Enhancement (TIME) initiative is the Towing and Recovery Incentive Program (TRIP) that provides monetary incentives to the towing industry for clearing roadways in 90 minutes or less.[15] The program contracts with qualified heavy-duty towing and recovery companies and pays monetary bonuses for the quick clearance of large commercial vehicle incidents in the greater Atlanta area. The purpose of TRIP is to make clearing roadways more profitable for the towing industry and to promote safe, fast, and efficient management of commercial vehicle incidents in an effort to reduce congestion and secondary incidents. Towing and recovery companies have open invitations to participate in the program if they meet specific equipment and training requirements. The specifics of TRIP are provided by the Metro Atlanta TIME Task Force.[27] In order for an incident to qualify for TRIP activation, the incident must occur within TRIP activation zones and involve FHWA Vehicle Classes 5 through 8, aircraft, or a major transportation emergency. Qualifying incident types include the following:[28]

- rollover blocking any travel lanes
- multiple truck crash
- jackknifed and not drivable
- lost load on or affecting travel lanes
- load shifted on or affecting travel lanes
- lost tandems/axle or buckled trailer affecting travel lanes
- fire with tires burned off or cargo spilled
- major impact with guard rail, bridge support, or structure on top of barrier wall
- bus crash with multiple injuries.

The TRIP incentive requires that the Georgia DOT pay $600 to the wrecker service if response time requirements are met but the service ultimately is not needed. If wrecker services are needed, the tow company is paid $2,500 if response requirements are met and the roadway is cleared and opened to traffic within 90 minutes after the tow company received the notice to proceed. An extra $1,000 is paid if additional or special equipment is required and provided and clearance time requirements are met. TRIP contracts also require liquidated damages to be paid by TRIP-enrolled wrecker companies that do not clear the roadway in 3 hours when it is determined to be the fault of the wrecker company. In these cases, the wrecker company is fined

$600 in liquidated damages and an additional $10 for each minute over 3 hours that the lane is blocked.[29]

TRIP was initiated in 2008. Figure 4 shows the significant impact the program has had on roadway clearance through 2014. Since TRIP began, average clearance times have drastically reduced upon notice-to-proceed instruction. A detailed study using 2 years of data from 2008 and 2009 found that TRIP resulted in a $456,396 cost savings per incident and had an overall benefit-cost ratio of 11:1.[29,30]

Florida has a program similar to Georgia's TRIP called the Rapid Incident Scene Clearance (RISC) program. Towing contracts in the RISC program stipulate that towing companies respond to major incidents with two certified heavy-duty wreckers and a support vehicle carrying cleanup and traffic control equipment. Bonuses are rewarded for faster clearances, and penalties administered for slow clearances.[16] The RISC program supports Florida's Open Roads Policy, which establishes a 90-minute goal for the clearance of a motor vehicle crash or incident. As with Georgia's TRIP, towing and recovery programs must meet equipment and training standards developed to ensure the safe and efficient clearance of major incidents.[32] Figure 5 shows the RISC program's monetary incentives and penalties in relation to the incident clearance timeline. Yearly RISC program performance measure reports are developed to help identify areas for improvement. Details are provided in the program's annual reports.[33]

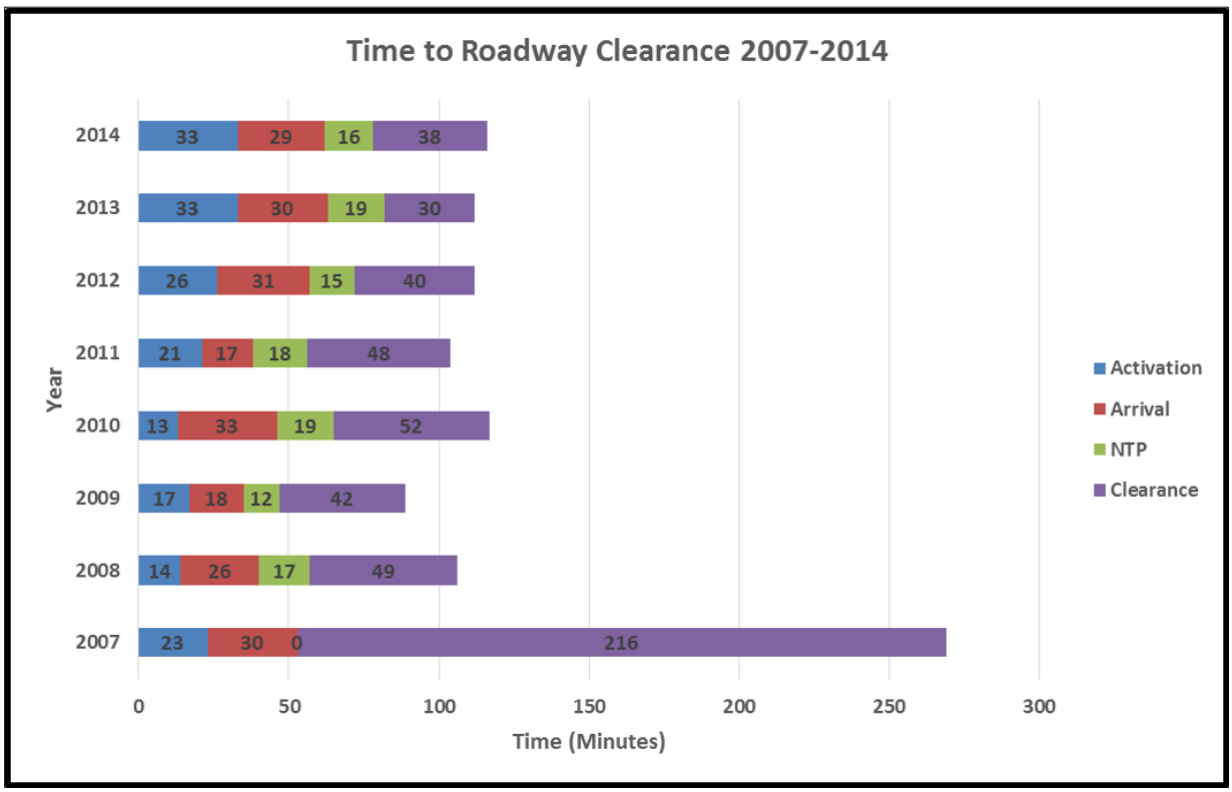


Figure 4. TRIP Activation Zone Time to Roadway Clearance From 2001-2014.[31] NTP = notice to proceed. From Metro Atlanta TIME Task Force, Towing and Recovery Incentive Program (TRIP)—TRIP Event Time Savings. Reprinted with Permission.

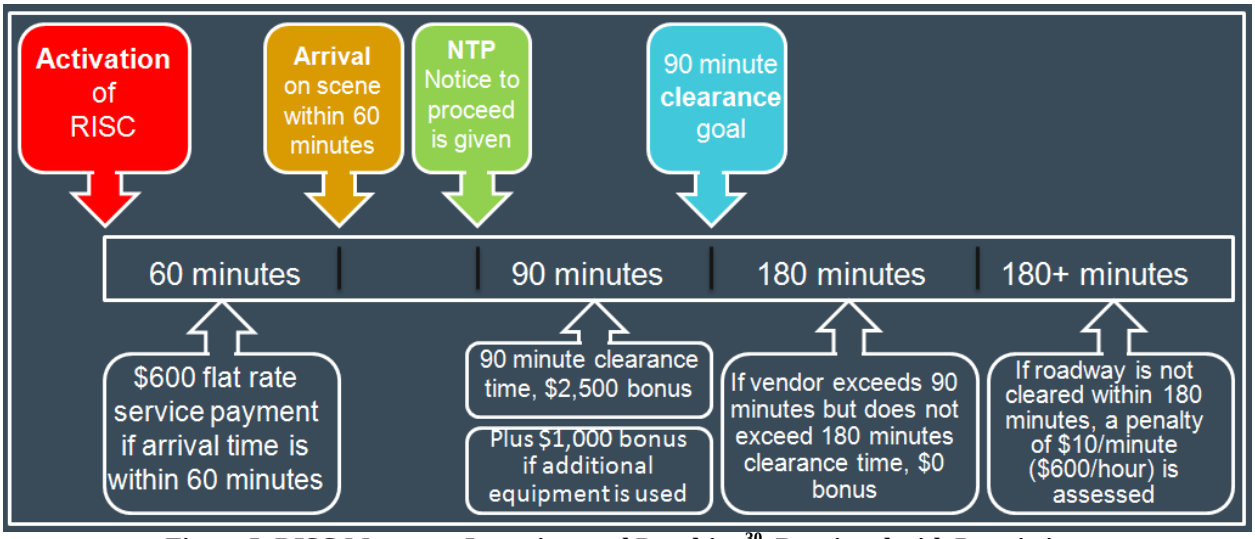


Figure 5. RISC Monetary Incentives and Penalties.[30] Reprinted with Permission.

Zone-Based Contracts

Two of the most common contracting mechanisms are rotational lists and zone-based licensing. In rotational contracting, state police, counties, or cities maintain a list of approved towing companies and select the next tow company in the list when services are needed. Zone contracting typically involves the selection of one or several tow companies through a bidding process to serve a predefined geographical area. Tow companies must meet certain requirements to bid, such as proximity to the area and minimum equipment and training standards.[16] One of the earliest zone-based, open bid contracts for towing and motorist assistance services was the Parkway Towing Program created by the New York Parkway Commission in the 1950s. Today, this program awards a single 1-year contract for each zone, with the potential of a 1-year extension.[23]

The Specialty Towing and Roadside Repair (STARR) program was developed and implemented in Florida in 2009. The incentive-based 1-year contracts are regionally segregated, with Florida's Turnpike system divided into 10 sectors ranging from 23 to 56 miles in length. Each sector is awarded to a single tow company through a competitive process.[34] The zone-based program provides consistent service to the turnpike—something that rotational systems were unable to do.[35] The STARR program provides light- and medium-duty towing and minor vehicle repairs on the turnpike for a fee to the customer as set by the turnpike. A study of the STARR program found that its implementation has saved more than $16.5 million in congestion delay and an estimated 560 hours in traveler delay since its inception in June 2009 through calendar year 2010.[34]

New York State DOT TIM Regions 8 and 10 have a high-bid contract towing program that assigns contracts for towing services under strict qualifications and guidelines. The tow companies agreed to provide towing services on designated segments of limited access highways in the regions within a specified rate schedule and response time of 30 minutes. The program is administered by the New York State DOT, supervised by the New York State Police, and

awarded on the basis of competitive bidding. Towing agencies that have been assigned contracts are subject to regular inspections, and the specified rate schedule is required to be posted on every authorized tow vehicle.[35]

Houston, Texas, created a Safe Clear Towing Program (SAFEClear) in 2004 that provides for the immediate clearance of stalled or disabled vehicles on Houston's freeways. SAFEClear was created by the Mayor's Office of Mobility, members of Houston TranStar, law enforcement agencies, and the towing industry. Towing companies bid to provide exclusive towing services on designated sections of freeways. Currently, awarded contracts have a performance requirement of 6 minutes to respond to calls and are paid $50 for a tow, $160 if a vehicle is blocking a lane, and $30 to provide gas or do very minor repairs.[35] These payout amounts were previously funded by the City of Houston but are now charged to the vehicle owner directly.[36]

Driver Removal Laws

Driver removal laws, often called Move It or Steer It, Clear It laws, as discussed previously, encourage or require drivers involved in incidents to move their vehicle out of the travel lanes if they can do so safely. This type of law, which exists in approximately one-half of U.S. states, essentially eliminates the detection and verification stages for minor incidents, thereby drastically reducing incident clearance time. The response stage is also not a factor for travel lane blockage, because the clearance could be performed before the response personnel arrived.[37]

There is variability in the strength of the language in Move It laws. Some state statutes stipulate that a driver *shall* remove his or her vehicle from the roadway with the caveat that the vehicle is able to be moved (i.e., not disabled) and there is no apparent injury to a person. Examples of states using the "shall" statement include Arkansas,[38] Connecticut,[39] Indiana,[40] Michigan,[41] and New Hampshire.[42] Missouri and Virginia use the term "should," and Florida law states: "if a damaged vehicle is obstructing traffic, the driver of such vehicle must make every reasonable effort to move the vehicle or have it moved so as not to block the regular flow of traffic."[43]

There is some uncertainty as to how this law might be interpreted by drivers and by law enforcement personnel. The New Hampshire law states that a driver "shall" move a vehicle "without risk of further damage to the vehicle." This language may preclude a driver from voluntarily moving a vehicle based on assessment of risk. Concurrent legislation or language that protects drivers from liability resulting from their actions (in the absence of gross negligence) or that waives at-fault determination regarding the cause of the incident as a result of moving their vehicle is often included to encourage drivers to move their vehicle expeditiously.[16] Implementation challenges or shortcomings when driver removal laws are introduced and enacted include the following:[5]

- Driver removal law provisions may be limited to metropolitan areas.
- Vehicles on the shoulder are not considered a hazard.
- Drivers may be reluctant to move vehicles.

- Law enforcement personnel may be reluctant to have drivers move vehicles.

Several states have developed publicity materials to raise awareness of driver responsibilities under driver removal laws including the installation of "Move-It" signs near high-crash locations.[25] The Tennessee DOT installed more than 100 signs at key locations along the state's urban freeway system with the message "Move Damaged Vehicles to Shoulder If No Serious Injury."[16] The I-95 Corridor Coalition recommended a model "Move-It" law with the following provisions:[20]

- Any driver able to do so safely and who is physically able to do so shall move a crash vehicle (and debris) off the traveled way (and if possible the shoulder or median) on any class of highway as quickly as possible so long as further risk of injury is not imposed.

- If the driver cannot move the vehicle, he or she shall seek assistance in doing so.

- Any traffic or public safety responder shall be empowered to move any disabled vehicle and debris from the traveled way in a safe and efficient manner possible.

- In all such cases, if a frontage road, cross street, accident investigation site, or other safe haven is available, these are preferable to the median, shoulder, sidewalk, or clear zone.

- In all such cases, both drivers and responders shall be immune from liability for the lawful and conscientious execution of these actions.

- Similarly, when such actions are not prudent, drivers and responders shall be immune from liability for deliberately not undertaking such action when the risk of further damage or injury dictates.

Maryland's Move It law is part of Maryland's Transportation Code, Section 20-103, which states in part:[44] "The driver of each vehicle involved in an accident that results only in damage to an attended vehicle or other attended property immediately shall stop the vehicle as close as possible to the scene of the accident, without obstructing traffic more than necessary." The Move It law applies to drivers involved in collisions in which there are no injuries and vehicles can be moved. As part of Maryland's public information campaign, flyers with information and tips for motorists involved in a collision are published and distributed. The flyer has a Collision Information Exchange Form to be kept inside the vehicle and used as a checklist for information needed for insurance claims. Maryland state law requires the driver of each vehicle involved in a collision to provide his or her name, address, and license number; the name and address of the vehicle's owner; the insurance company name and policy number; and the name and address of the local insurance agent if available.[45]

Hamlin et al.[46] considered the benefits attributable to South Carolina's Steer It and Clear It program. Microscopic simulation analysis estimated that implementation of the related legislation resulted in an 11 percent reduction in delay for minor incidents with one lane blocked.

This reduced delay would translate into an average cost savings of $1,682 per incident, which is significant when the number of minor incidents occurring on a daily basis in large metropolitan areas is considered.[5,46]

Authority Removal Laws

Authority removal laws provide authorization to a designated set of public agencies—typically state, county, and local law enforcement agencies or state DOTs—to remove from the roadway damaged or disabled vehicles and/or spilled cargo determined to be a hazard.[16] Under this type of law, authorities may require or perform removal without the consent of the owner. Approximately one-half of all states have enacted authority removal laws. States that designate authority to law enforcement personnel include only Colorado, Georgia, Idaho, Iowa, Kentucky, Nevada, New Jersey, Oklahoma, Ohio, Pennsylvania, Rhode Island, Virginia, Wisconsin, and Wisconsin. States that designate authority to both law enforcement personnel and state DOTs include Arizona, California, Florida, Illinois, Missouri, New Mexico, Oregon, South Carolina, Tennessee, Texas, and Washington.[5]

Approximately one-half of all states with authority removal laws have concurrent hold harmless provisions.[16] Under these provisions, incident responders can take an active and immediate role to restore the roadway to normal conditions without fear of damage liability claims since these laws indemnify the agency for damage caused in the removal process.[47] Even with hold harmless provisions, the effectiveness of authority removal laws may be compromised if response personnel are reluctant to exercise their full authority under this law.[16]

Pennsylvania's authority removal law states that immediately following an accident, a police officer may remove or direct removal of spilled cargo from any roadway to the nearest point off the roadway where the spilled cargo will not interfere with or obstruct traffic. In carrying out the provisions of this section of the law, no liability shall attach to the police officer or absent a showing of gross negligence to any person acting under the direction of the police officer for damage to or loss of any portion of the contents or load or spilled cargo.[48] Further, the law states that the driver or any other person who has removed a vehicle from the roadway as provided in this section of the law before the arrival of a law enforcement officer shall not be considered liable or at fault regarding the cause of the accident solely by reason of moving the vehicle pursuant to this section of the law.[48]

According to Dunn and Latoski,[17] an authority tow law accomplishes the same goal as an authority removal law with regard to the maintenance of open roads. However, an authority tow law emphasizes the removal of driver-attended disabled or wrecked vehicles from the highway right of way to a legal parking area or other area of safe refuge. Some states, such as Pennsylvania, have expanded the law to include the removal of spilled cargo from a highway right of way. In certain cases, incident responders may apply an authority tow law when drivers or cargo owners cannot provide for the timely removal of an incapacitated vehicle or spilled cargo located on, and perhaps previously moved to, the shoulder.

In Colorado, legislation has been modified to overcome the removal and liability limitation contained in its original statute, which stated that law enforcement "has the authority

to remove motor vehicles from the highway right-of-way." The definition of *motor vehicle* was interpreted as "any self-propelled vehicle which is designed primarily for travel on the public highway and which is generally and commonly used to transport persons and property over the public highways." This definition does not address the authorization of law enforcement to remove non-motorized vehicles, trailers, cargo, or debris associated with an incident. To address this limitation of the law, the Colorado legislation was modified to allow law enforcement to remove "a motor vehicle, cargo, or debris, attended or unattended, standing upon any portion of a highway right-of-way in such a manner as to constitute an obstruction to traffic or proper highway maintenance."[5] This revision enhances safety and delay-related benefits attributable to authority removal laws and provides protection against liability to law enforcement agencies acting in good faith to restore the flow of traffic.[5]

Authority removal law language should also address resistance from commercial interests that may be concerned with protecting its spilled cargo. This can be accomplished by allowing either certain exceptions for commercial motor vehicles or a reasonable opportunity for the owner to contact his or her preferred towing company. In general, effective authority removal laws meet the following objectives:[5]

- applying the law consistently statewide (not just in the metropolitan areas of a state)
- defining incidents as occurring both "within the roadway right-of-way" and on the median, shoulder, and adjacent areas
- applying consistently to both attended and unattended (abandoned) vehicles
- authorizing removal if the vehicle/cargo "constitutes a hazard or obstructs traffic"
- authorizing removal by law enforcement or state DOT personnel
- authorizing removal of the vehicle, as well as any associated appurtenances, cargo, and debris that poses a hazard
- promoting off-site vehicle/cargo removal locations such as "an exit ramp shoulder, the frontage road, the nearest suitable cross street, a designated crash investigation site, or other suitable location"
- limiting delayed removal activities until after the crash investigation of incidents involving serious injury or fatality has been completed
- directly assigning "all costs incurred in the removal and subsequent disposition" of incident-involved vehicles/cargo to the owner
- including concurrent hold harmless legislation or language that protects responders from liability "in the absence of gross negligence" as a result of their actions.

Abandoned Vehicle Legislation

Abandoned vehicle legislation typically addresses the length of time vehicles may be left unattended within the roadway right of way before being considered "abandoned." The legislation and its enforcement vary greatly by jurisdiction. Legislation allows disabled vehicles to remain on the shoulder of freeways in the metropolitan area of Columbus, Ohio, for not more than 3 hours, with strict enforcement, [20] whereas most states have either 24- or 48-hour rules concerning such vehicles. More aggressive abandoned vehicle laws are employed by the New York State Bridge Authority[49] and the state of Illinois, where a vehicle is considered abandoned and subsequently towed if unattended for more than 2 hours.[50]

Louisiana state law allows 72 hours for motorists of disabled or abandoned vehicles to remove their vehicles from the shoulder. However, a judge citing case law resulting from a previous motor vehicle fatality noted that any vehicle on a shoulder can be considered hazardous and immediately removed in the interest of public safety. The Louisiana State Police's approach of aggressively removing vehicles from shoulders as a means of preventing potential incidents is considered a best practice.[20]

A Texas law states that the DOT can remove cargo or other personal property on the right of way without the consent of the owner and that the DOT is not liable for any damages. Further, the owner or carrier must reimburse the DOT for costs.[20] In most states, the owner or last registered owner of a vehicle is responsible for towing and storage charges. Michigan[51] and Connecticut[52] charge a fine of $50 and $85 for abandonment, respectively. Maine[53] and Massachusetts[54] apply a fine of $250 for abandonment, with Massachusetts charging a $500 fine for subsequent abandonments.

The state of Washington has documented several statistics regarding the hazards associated with abandoned vehicles, including the following: [22]

- 500 shoulder collisions a year statewide, with an average of five fatalities
- blocking of law enforcement and emergency vehicle access to collisions
- being frequent targets of vandalism, which causes unnecessary 911 calls
- reduced capacity and increased congestion.

North Carolina has documented similar statistics. For example, in 2005, North Carolina completed a 5-year study of abandoned vehicle crash involvement and found that a total of 1,300 abandoned vehicles were struck, resulting in 47 fatal crashes and more than 500 injuries.[12] In the same year but on a national level, the National Highway Traffic Safety Administration reported an estimated 500 fatalities resulting from multiple vehicle incidents occurring on the roadway shoulder and median, respectively (300 fatalities on the shoulder and 200 fatalities on the median).[12] Such safety-related statistics from damaged, disabled, or abandoned vehicles on the shoulder or median were presented as the basis for strengthening abandoned vehicle legislation. North Carolina legislation was subsequently changed so that vehicles can be removed from the roadway in 24 hours, down from 48 hours.[12]

Expedited Crash Investigation

Law enforcement investigates crashes and collects evidence where needed. Carson, in *Best Practices in Traffic Incident Management*,[16] and Dunn and Latoski, in NCHRP Synthesis 318,[17] mention three main approaches to collecting physical evidence at an incident scene: (1) the traditional methods (the base-tape method, coordinate method, or triangulation method); (2) the total station surveying equipment method; and (3) photogrammetry. In the traditional methods, distances to key objects are measured off a central baseline. In the total station surveying equipment method, survey equipment is used to get the same kind of measurements as with the traditional methods. Photogrammetry uses off-site triangulation from crash scene photographs, a single accurately pre-measured distance, and objects marked with simple markers. Table 3 compares the advantages and disadvantages of these three most commonly used crash investigation techniques.[17]

The Washington State Patrol (WSP) uses the total station surveying equipment method, and WSDOT has reported an average of a 51-minute faster investigation using this method. WSDOT provides the equipment and training to the WSP.[20]

Recognized in the literature as best practice states for using photogrammetry in crash investigations are Florida, Indiana, and Utah. The Florida DOT (FDOT) procured the photogrammetry systems for the Florida Highway Patrol (FHP) statewide. The FHP had the goal of converting to a complete photogrammetry-based investigatory process by the end of 2010. Indiana has 23 photogrammetry systems. They were funded cooperatively by the Indiana DOT, Indiana Department of Revenue, FHWA, and Indiana Toll Road.

Table 3. Advantages and Disadvantages of Three Crash Investigation Techniques

Method	Advantages	Disadvantages
Traditional (coordinate method)	• Well known and familiar	• Time and labor intensive (needs 2 or 3 people)
Total station	• Transportation agencies have experience using total stations and could share knowledge/skills • Takes less time than traditional method	• Labor intensive (needs 2 people)
Photogrammetry	• On-scene time is generally less than with the other two methods • Requires only 1 investigator • Provides permanent pictorial evidence • Documents environmental evidence that may not be captured otherwise • Permits estimation of locations of other items not included in original survey, after the fact • More cost-effective than total station method • More accurate than tape measurements	• Method does not have widespread use;[17] costs of procurement, training, use, and maintenance are likely some of the reasons • More processing time needed in office • Difficulty photographing long scenes • Difficulty seeing skid marks and other evidence at scene without enhancing scene photos • For nighttime, enhancement of marks or other evidence may be necessary; fog, smoke, and rain are other issues • Easier to convince judge/jury with simple measurements as opposed to complex analyses

The Utah Highway Patrol sometimes uses aerial photogrammetry, in which crash scene photos are taken with a camera mounted on a small, low-flying, remote-controlled helicopter.[16,35] According to a Utah Highway Patrol interview in 1999,[55] photogrammetric investigations required more time for off-site analysis than total station investigations but required only about one-half of the on-scene time, thus reducing lane closure times and delays to motorists. Although off-site analysis requires more detailed training, the on-scene investigators need to understand only how to take photos correctly. Arizona, California, Australia, Japan, and Germany are also documented to have used photogrammetry for crash scene investigations to varying degrees, and Oregon and Hawaii at one point experimented with the technology. The current status of usage in these locations, however, is unknown.

The photogrammetry training courses offered by the North Central Texas Council of Governments (NCTCOG) are particularly noteworthy.[16] NCTCOG offers these courses free of charge to approved agencies as a complement to the region's Freeway Incident Management series.[56] A training flyer[56] states that the agencies should use the equipment or return it to NCTCOG, potentially implying that NCTCOG furnishes the equipment.

The I-95 Corridor Coalition documented[20] that "the Dallas County Sheriff's Department Traffic Section has been trained in and uses photogrammetry for major crash scene investigations. They developed a comprehensive field manual for the use of photogrammetry and have had tremendous success in reducing the time spent for crash scene documentation." The same report documents several other approaches to expediting crash investigations:[17,20]

- The Nashville Police Department and the Tennessee DOT have signed a joint operating statement that reads: "Wherever practical, accidents will be removed to off ramps or other areas for completion of investigations to reduce the delays associated with motorists slowing to 'gawk.'"

- In the Delaware River and Bay Authority jurisdiction, the police have several accident reconstruction teams that are available to respond to incidents and conduct thorough and rapid investigations in an effort to clear the tolled bridge facility. They use electronic total station technology to speed their efforts in investigating the scene. This rapid response on the part of the DOT and police is a 24/7 operation. As their roadways are limited access toll roads with few shoulders and areas to relocate damaged or disabled vehicles, their operations can be considered best practices for a closed facility.

- In addition to technologies for expediting crash investigation, some states have designed accident investigation sites, also called crash investigation sites. An accident investigation site is a facility off the main highway near an exit ramp or off a parallel low-traffic facility that law enforcement can use for investigating minor crashes. Drivers involved in minor crashes could also pull over in this secluded area. Wisconsin District 2 is a noted example for using these sites.

Interagency Coordination, Cooperation, and Communication (3Cs)

This section contains four subsections: (1) promoting performance measures and integrated TIM programs; (2) training; (3) cross cutting challenges and solutions to interagency coordination, cooperation, and communication (3Cs) among agencies; and (4) after-action reviews. The literature on 3Cs is vast, and the purpose of the review was to capture a snapshot of best practices.

Promoting Performance Measures and Integrated TIM Programs

FHWA's TIM Self-Assessment Guide[57] provides an explanation of the benefits and challenges of TIM performance measurement:

> Performance measurement is key to targeting limited resources and measuring TIM program performance is the means for documenting program value, identifying areas for improvement and justifying program continuation and expansion. However, measuring program performance is challenging; the program is the result of the efforts of many agencies and the data necessary to evaluate program performance resides with those multiple agencies.

Through a series of workshops in 2005, the FHWA FSI[9] involved 11 participating states and included both the transportation and the law enforcement agencies to identify appropriate TIM performance measures . A stated objective for the FSI was "to help FHWA Division Offices move key decision-makers in State transportation and law enforcement agencies from 'awareness' through 'comprehension,' 'conviction,' 'desire,' and finally 'action' to learn more about and implement TIM performance measurement." The participants reached consensus on the following three performance measures:[8]

1. *Roadway Clearance Time.* This interval is defined as the time between the first recordable awareness of an incident (detection, notification, or verification) by a responding agency and the first confirmation that all lanes are available for traffic flow.

2. *Incident Clearance Time.* This interval is defined as the time between the first recordable awareness of the incident and the time at which the last responder left the scene.

3. *Secondary Incidents.* These incidents are identified as the number of unplanned incidents beginning with the time of detection of the primary incident where a collision occurs either within the incident scene or within the queue, including the opposite direction, resulting from the original incident.

A number of states track the performance of clearing incidents. The performance measure describes what the state is trying to accomplish, and the target describes how much (usually, in minutes or percentage of time) accomplishment the state is striving to achieve given its resources. Table 4 lists TIM performance measures and targets used by some states.[15]

Table 4. Performance Measures and Targets Used by Some States

State	Performance Measure	Target
California	Clearing major incidents	Less than 90 minutes
	Percent of major incidents cleared in less than 90 minutes (major incidents are defined as those to which both CHP and Caltrans respond)	60%
Connecticut	Average highway incident duration time	Cars: less than 45 minutes
		Jackknifed tractor-trailers: less than 3 hours
		Overturned tractor-trailers: less than 5 hours
Florida	All incidents cleared from roadway	Within 90 minutes of arrival of first responding officer
Georgia	Clearance of incidents with significant impact on roadways	Within 90 minutes
Idaho	Period from incident detection to when traffic is fully restored	Response A: Up to 30 minutes; includes stalled vehicles, minor traffic accidents, or any impacts to traffic that can be safely moved to shoulders
		Response B: 30 minutes to 2 hours; includes most severe traffic accidents that require investigation or cleanup
		Response C: More than 2 hours; includes catastrophic traffic accidents, hazardous materials, or local disasters
Minnesota	Clearance time for incidents on urban freeways	35 minutes or less
Utah	Clearing incidents	Non-injury incidents in 30 minutes or less
		Serious injuries in 60 minutes or less
		Fatalities in less than 2 hours
Washington	Clearing highway traffic incidents	90 minutes
	Average length of time to clear major incidents lasting more than 90 minutes on key highway segments	155 minutes

CHP = California Highway Patrol; Caltrans = California Department of Transportation.

The FHWA initiated a Traffic Incident Management Self-Assessment (TIMSA) program in 2002[57] to survey metropolitan areas and has been publishing national summary reports each year since 2003. According to the latest national summary report in 2013,[58] tracking TIM performance measures continued to score the lowest among all areas; however, progress from previous years was notable and promising. Perhaps several agencies and locations are tracking these measures internally but not publishing them publically.

Training

In response to Congress' directive to improve the efficiency and safety of the U.S. highway system, in 2012, a Strategic Highway Research Program 2 (SHRP 2) project developed a national, multidisciplinary TIM process and training course detailed in a report titled *Training of Traffic Incident Responders*.[59] These training programs are currently being implemented across the United States via the FHWA's Every Day Counts initiative. Using a multidisciplinary perspective, responders within states, regions, and localities learn how to operate more efficiently and collectively. The training covers many topics including recommended TIM procedures and techniques.[60] Two important objectives of the SHRP 2 project are to improve TIM core competencies and to increase coordination among multidisciplinary response teams. Responders who attended the courses indicated a better understanding of each agency's roles and

responsibilities at an incident site. The training includes interactive seminars, case study analysis, tabletop role-play and scenarios, and field practicums.[59]

Figure 6 shows the most recent update of responders trained in each of the 50 states. In Virginia, 7,676 responders had been trained as of March 2015, and the training sessions were well attended and well received by the responder community. The training is endorsed by the International Association of Fire Chiefs, the International Association of Chiefs of Police, the National Volunteer Fire Council, the Towing and Recovery Association of America, and the International Association of Directors of Law Enforcement Standards and Training. An e-training module supplementing this in-class training has been released by SHRP 2.[61]

Some states have developed their own TIM training regimens. For example, in Washington State, WSDOT; WSP; and fire, towing, and other incident responder representatives and stakeholders are partners in the Washington Traffic Incident Management Coalition that oversees implementation of the NTIMC's National Unified Goal. The coalition's website provides information about regional conferences and training that are presented to and by all three disciplines (WSDOT, WSP, and fire). The goal for the training is to initiate communication within these groups and work together with unified command.[15]

In Minnesota, DOT officials have developed specialized presentations and training to private towing and recovery operators to communicate incident management procedures and the importance of rapidly removing incidents. DOT officials have found that these training activities have enhanced the responsiveness of tow operators at incident sites.[17] Zhou et al.[63] performed a methodical study of a large body of literature and conducted several interviews to develop an incident management program for Illinois. Their report also provides a good example of the process of developing a training program.

Cross-cutting Challenges and Solutions to 3Cs

As explained in the *Traffic Incident Management Handbook,*[19] although each responder agency has a specific role to play in incident clearance, a shared understanding of the roles and responsibilities of the other agencies is essential for the effectiveness of the incident response. The report about the FHWA FSI[9] mentions development of a memorandum of understanding (MOU) as a way to define roles and responsibilities for establishing a working relationship for data exchange. The report also mentions that establishing cost-sharing agreements is critical to successful interagency relationships.

The literature contains several examples of different agencies responsible for incident management in a region executing joint policies, agreements, and MOUs and establishing common goals and understanding. A report prepared for the I-95 Corridor Coalition, *Best Practices for Border Bridge Incident Management,*[64] and NCHRP Synthesis 318[17] contain a number of useful examples.

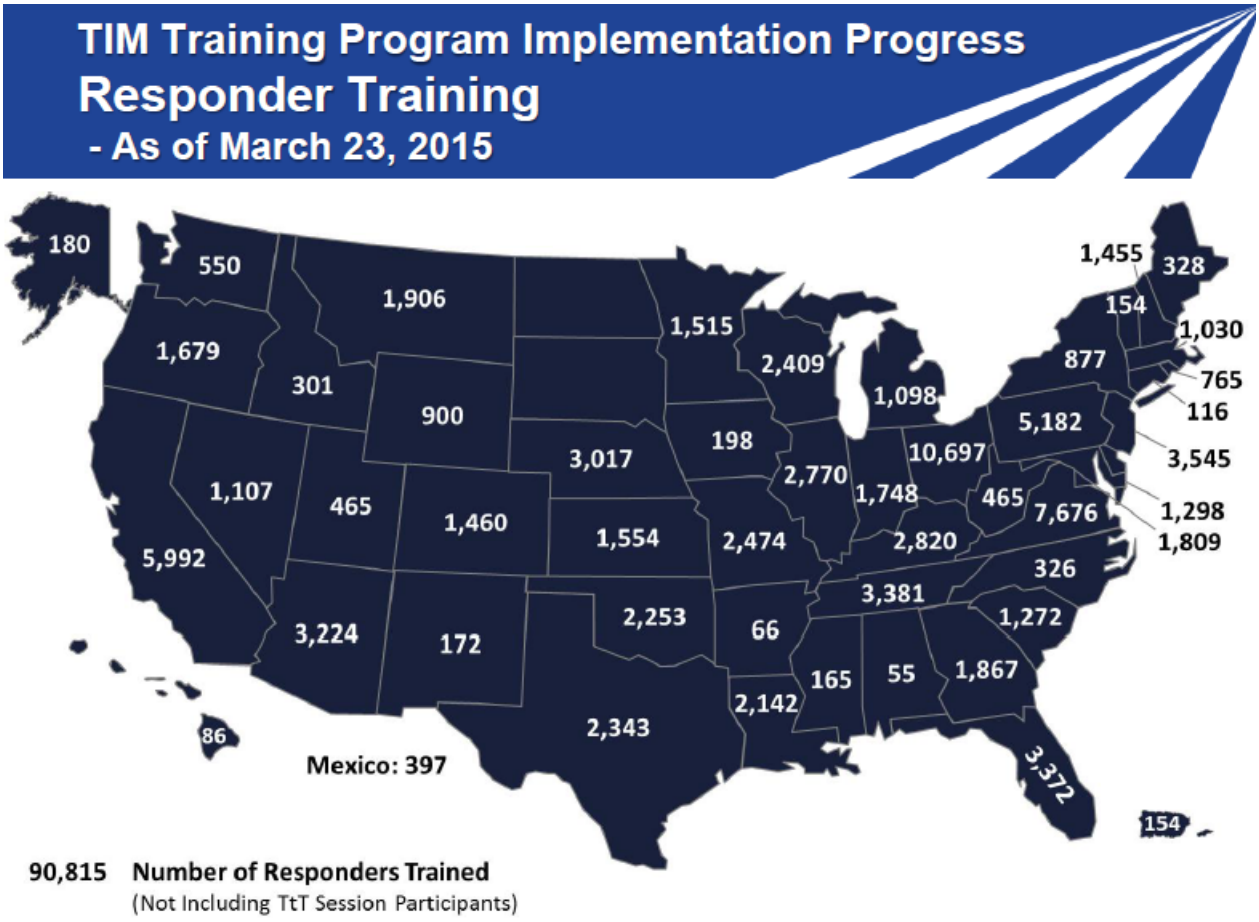


Figure 6. National TIM Responders Trained as of March 23, 2015. Source: Federal Highway Administration.[62]

These reports document setting TIM goals and formalizing different 3C approaches, such as establishing an interdepartmental committee with specific charges, sharing data, sharing resources, training, providing technical support, procuring equipment for one agency by another agency, establishing a chain of command, defining roles and responsibilities of different agencies, and defining the liabilities of different agencies. Where a region lies at the border of two jurisdictions, a joint agreement among all the agencies from all of the jurisdictions enhances clear communication and coordination. The agencies mentioned in these reports include cities, counties, DOTs, DOT maintenance units, and the police.

Several states have established working groups that meet on a regular basis to discuss TIM operations and policies as a means to identify areas for improvement and to exchange information and lessons learned.[8] The report prepared for the I-95 Corridor Coalition titled *Quick Clearance and "Move-It" Best Practices*[20] emphasized the importance of strong regional and statewide TIM plans:

> One major key to a well-organized incident management program is to have groups and practices in continuous communication cooperation and coordination—not only at incident scenes, but also in long range and operational planning. Statewide teams are great for developing broad policies and strategies, but they do not deal directly with incidents. Smaller, more regionally focused groups can be an effective 3-C mechanism, but they may also, in the case of major incidents, take on the role of an inter-jurisdictional operations team.

MOUs or joint policies among major responder agencies from the states of Washington, Tennessee, Florida, Connecticut, Wisconsin, and Maryland are mentioned.

Florida's Open Roads Policy states it is the goal of "all agencies that all incidents be cleared from the roadway within 90 minutes of the arrival of the first responding officer" and that "this goal [is] being made with the understanding that more complex scenarios may require additional time for complete clearance."[65] In 2014, FDOT and the FHP renewed their Open Roads Policy. The renewal mainly re-emphasized the continued focus of the responder agencies and the new personnel to those same original goals and visions. Developing such statewide and regional MOUs among all incident responders helps bring together the commitments and energies of all the agencies.

According to Dildine,[66] the Roadway Operations Patrol (referred to in other literature as the SSP or Freeway Safety Patrol) in the District of Columbia has been banned from using flashing lights and sirens to reach the bottlenecks swiftly because of an accusation of reckless driving by the District Police. As a result, the Roadway Operations Patrols are now delayed in the same congested traffic that they are charged to clear quickly. Although citing only two minor breakdown incidents, Dildine noted that the backups were as long as 10 miles and lasted more than 5 hours. Such drastic policy changes that hinder quick clearance could possibly be avoided through better coordination and communication.

After-Action Reviews

Post-incident debriefs, after-action analyses, after-incident reviews, critical incident reviews, hotwashes, and tailboard critiques are other commonly used names for after-action

reviews (AARs). Hotwash and tailboard critique describe the immediate quick assessment that is made after the incident is cleared but before the responders leave the scene. The other terms describe more formal reviews done later and off-site after additional relevant data are gathered and analyzed. More than a response to a single incident, effective AARs involve establishing regular meetings between incident responders to review and discuss coordination and tactical issues associated with responding to incidents. These meetings increase trust and respect among responders. The *Traffic Incident Management Handbook*[19] recommends conducting reviews soon after the incident, ensuring the discussion includes what was done well at the incident scene, and ensuring the review discussions are well documented so that the lessons learned can be used at future incidents.

In Dallas, Texas, a debriefing is conducted if the clearance time exceeds the maximum time limits defined. The stakeholders in Dallas find the reviews very beneficial to maintain current yet ever-changing operating procedures stating: "in an environment of mutual professional respect, hold meetings after major traffic incidents to review performance, decisions, policies or procedures that conflicted with the goal of efficient incident management."[20]

Challenges with AARs include "some responders viewing it as a personal attack on performance" and "difficulty getting all field personnel together at same time because of shifts."[67] To minimize the former, use of third party facilitators is often recommended.[20] Appendix D of a report prepared for the I-95 Corridor Coalition titled *TIM Best Practices Report*[35] contains a useful implementation checklist for AAR. NCHRP Synthesis 318[17] mentions that 20 percent of surveyed jurisdictions "do not meet at all" and provides the percentages of times different agencies are commonly represented at such meetings across the country.

Virginia-Specific Laws and TIM Initiatives

This section provides information on Virginia legislation that relates either directly or indirectly to TIM. This includes laws and/or TIM practices specific to towing, driver removal, authority removal, abandoned vehicles, and coordination, cooperation, and communication.

Towing

Most legislation directed toward towing operations is in Virginia Code, Title 46.2: Motor Vehicles. In Chapter 12, Article 2 (§ 46.2-1209 to § 46.2-1215) covers immobilized and unattended vehicles, and Article 3 (§ 46.2-1216 to § 46.2-1239) covers trespassing vehicles, parking, and towing. Prior to 2013, the Board of Towing and Recovery Operators established minimum requirements for Class A and Class B towing operators in Virginia including qualifications, standards, and necessary equipment. During its 2012 Session, the Virginia General Assembly passed legislation eliminating the board and the towing regulations it managed. Under this legislation, tow operators and companies are no longer licensed or regulated by any state entity.[68] However, this legislative action did not impact any local governance or oversight of the towing industry where county tow advisory boards set regulations with respect to towing directed by law enforcement. Virginia Code § 46.2-1217 affords

localities the option to regulate towing services rendered within jurisdictional boundaries. It states the following:

> The governing body of any county, city, or town by ordinance, may regulate services rendered pursuant to police towing requests by any business engaged in the towing or storage of unattended, abandoned, or immobile vehicles.

The majority of counties in Virginia use a towing rotation system. Placement on the rotation list is usually by alphabetical order, and when a tow is needed, the police dispatcher will call the next authorized tow service provider on the county-maintained rotation list. There are concerns within the TIM community in Virginia about the towing rotation system, as some towing and recovery companies are not trained or equipped to handle large scale operations in a timely manner yet are still called to the scene as the next on a rotating list. Further, depending on the location of the tow responder with respect to the location of the incident, response times can vary. In the incident timeline, the tow company is called only after response vehicles have arrived and assessed clearance needs. The current practice for dispatch order to an incident is as follows:

- VSP
- SSP (if not already on-scene)
- fire/rescue (if needed)
- tow truck (once a VSP trooper is on scene and determines if vehicles need to be towed).

In locations with high traffic volume, a lane blocking incident can result in quick queue propagation adding to the arrival delay of towing and recovery equipment. Unless provided with alternative routes or police escorts, tow companies are hesitant to use the shoulders because they are not indemnified from incidents they may cause en route to an incident scene. In an attempt to address the issues with delay associated with the arrival of towing and recovery equipment, VDOTs NRO initiated an instant tow policy. The objective of Operation Instant Tow is to reduce incident clearance time by 15 minutes by dispatching a tow truck and a VSP trooper simultaneously. Currently, the NRO is the only VDOT region operating an instant tow program.[7]

Under Operation Instant Tow, the towing company will be reimbursed by VDOT for any dry runs. *Dry runs* are defined as arriving at the incident scene and not towing. Any other scenario will be covered by existing contract terms according to the costs that are defined in the contracts. The cost of a dry run is estimated to be $35 to $45. VDOT estimates that of 1,000 incidents per month, only 5 percent will be dry runs, and this would cost VDOT an estimated $2,000 per month.[7]

Stafford, Arlington, and Fairfax are the only counties in Virginia that use zone-based contracts for towing services. Under these contracts, towing companies bid to render services within predetermined zones. Virginia Code § 46.2-1212 provides the authority for the governing

body of any county, city, or town to remove vehicles that impede the orderly flow of traffic. It specifically states the following:

> The governing body of any county, city, or town may provide ordinance that whenever a motor vehicle, trailer, or semitrailer involved in an accident is so located as to impede the orderly flow of traffic, the police or other uniformed employee of the local law-enforcement agency who specifically is authorized to do so by the chief law-enforcement officer or his designee may (i) at no cost to the owner or operator remove the motor vehicle, trailer, or semitrailer to some point in the vicinity where it will not impede the flow of traffic or (ii) have the vehicle removed to a storage area for safekeeping and shall report the removal to the Department and to the owner of the vehicle as promptly as possible. If the vehicle is removed to a storage area under clause (ii), the owner shall pay to the parties entitled thereto all costs incidental to its removal and storage.

County-regulated towing rotation lists and zone-based contracts are the primary police-directed towing mechanisms in Virginia. Discussions are currently being held to expand the instant tow concept to other regions, initiate more zone-based (or segment-based) contracts, and incorporate other quick clearance strategies such as incentivized towing.

Driver Removal

Virginia Code § 46.2-888 addresses what is commonly known as the "driver removal" law and states that drivers may move vehicles to the shoulder whenever possible and activate emergency flashing lights. Specifically, it states the following:

> No person shall stop a vehicle in such manner as to impede or render dangerous the use of the highway by others, except in the case of an emergency, an accident, or a mechanical breakdown. In the event of such an emergency, accident, or breakdown, the emergency flashing lights of such vehicle shall be turned on if the vehicle is equipped with such lights and such lights are in working order. If the driver is capable of safely doing so and the vehicle is movable, the driver may move the vehicle from the roadway to prevent obstructing the regular flow of traffic; provided, however, that the movement of the vehicle to prevent the obstruction of traffic shall not relieve the law enforcement officer of his duty pursuant to § 46.2-373. A report of the vehicle's location shall be made to the nearest law-enforcement officer as soon as practicable, and the vehicle shall be moved from the roadway to the shoulder as soon as possible and removed from the shoulder without unnecessary delay. If the vehicle is not promptly removed, such removal may be ordered by a law-enforcement officer at the expense of the owner if the disabled vehicle creates a traffic hazard.

Authority Removal

Virginia Code § 46.2-1212.1 provides law enforcement with the authority to remove and dispose of vehicles involved in accidents and their cargo without the consent of a vehicle's owner. Further, the law requires the owner or carrier to reimburse whichever public agency removes the property. The law states:

> A. As a result of a motor vehicle accident or incident, the Department of State Police and/or local law-enforcement agency in conjunction with other public safety agencies may, without the consent of the owner or carrier, remove:
>
> 1. A vehicle, cargo, or other personal property that has been (i) damaged or spilled within the right-of-way or any portion of a roadway in the primary state highway system and (ii) is blocking the roadway or may otherwise be endangering public safety; or

> 2. Cargo or personal property that the Department of Transportation, Department of Emergency Management, or the fire officer in charge has reason to believe is a hazardous material, hazardous waste or regulated substance as defined by the Virginia Waste Management Act (§ 10.1-1400 et seq.), the Hazardous Materials Transportation Act (49 U.S.C. § 1808 et seq.) or the State Water Control Law (§ 62.1-44.2 et seq.), if the Department of Transportation or applicable person complies with the applicable procedures and instructions defined either by the Department of Emergency Management or the fire officer in charge.
>
> B. The Department of Transportation, Department of State Police, Department of Emergency Management, local law-enforcement agency and other local public safety agencies and their officers, employees and agents, shall not be held responsible for any damages or claims that may result from the failure to exercise any authority granted under this section provided they are acting in good faith.
>
> C. The owner and carrier, if any, of the vehicle, cargo or personal property removed or disposed of under the authority of this section shall reimburse the Department of Transportation, Department of State Police, Department of Emergency Management, local law-enforcement agency, and local public safety agencies for all costs incurred in the removal and subsequent disposition of such property.

A hold harmless clause is given in Virginia Code § 46.2-1231.1, which protects towing operators from civil damages when operating under the direction of law enforcement or in certain emergencies. The law states:

> No towing and recovery operator shall be liable for damages in any civil action for responding in good faith to the lawful direction of a law-enforcement or, in the case that life, limb, or property is endangered, a fire or rescue agency to tow, recover, or store any vehicle, combination of vehicles, their contents, or any other object. The immunity provided by this section shall not extend to the liability for negligence in the towing, recovery, or storage carried out by the towing and recovery operator.

Authority to remove vehicles is also afforded to VDOT under limited circumstances in Virginia Code § 46.2-1210 and § 46.2-1223. Section 46.2-1210 states:

> Whenever any motor vehicle, trailer, semitrailer, or combination or part of a motor vehicle, trailer, semitrailer, is immobilized on any roadway by weather conditions or other emergency situations, the Department of Transportation may move or have the vehicle removed to some reasonably accessible portion of the adjacent right-of-way. Disposition thereafter shall be effected as provided by §46.2-1209.

Section 46.2-1223 states:

> Except as otherwise provided in this article, the Commissioner of Highways may, by regulation, regulate parking on any part of the primary and secondary systems of state highways.

VDOT uses its own wreckers to support emergency relocation of immobile vehicles that are impeding a travel lane and/or the normal flow of traffic. These wreckers are typically assigned at or near restricted lanes, bridges, construction areas, extended work zones, and tunnel facilities. However, use criteria for agency-owned wreckers vary across VDOT districts. For example, the Lynchburg, Culpeper, Staunton, Richmond, Salem, and Fredericksburg districts use assigned wreckers to retrieve state-owned assets deemed operationally immobile, but these wreckers are not used to participate in accident recovery operations of privately owned vehicles.

Only NRO supports emergency relocation of privately owned immobile vehicles on the interstates in the Northern Virginia and Fredericksburg districts. However this has been discontinued as a routine practice.

VDOT also operates an SSP program on many segments of its interstate system. These vehicles patrol predefined routes or segments either continuously 24 hours a day (in urban corridors) or during peak travel times (in rural corridors) and are typically the first responders to freeway incidents. The vehicles are equipped with a push bumper to assist with moving vehicles out of travel lanes but will not engage in clearance activities unless directed to do so by law enforcement (see Virginia Code § 46.2-1212.1).

Abandoned Vehicles

When an abandoned vehicle is not impeding the flow of traffic and is deemed positioned safely on a shoulder or off the paved roadway, the vehicle is tagged by either law enforcement or VDOT. Virginia Code § 46.2-1209 states:

> No person shall leave any motor vehicle, trailer, semitrailer, or part or combination thereof immobilized or unattended on or adjacent to any roadway if it constitutes a hazard in the use of the highway. No person shall leave any immobilized or unattended motor vehicle, trailer, semitrailer, or part or combination thereof longer than 24 hours on or adjacent to any roadway outside the corporate limits of any city or town, or on an interstate highway or limited access highway, expressway, or parkway inside the corporate limits of any city or town.

When an abandoned vehicle requires immediate removal because it is impeding the flow of traffic or has exceeded the 24-hour time limit, removal is conducted under the direction of law enforcement in accordance with Virginia Code § 46.2-1213:

> B. Removal shall be carried out by or under the direction of a law enforcement officer or other uniformed employee of the local law-enforcement agency who specifically is authorized to do so by the chief law-enforcement officer or his designee.

Coordination, Cooperation, and Communication

Virginia's Statewide TIM Committee is chaired by the Superintendent of the VSP, with members representing all major incident responders. The committee's current members include the following:

- Superintendent, VSP (Chair)
- Commissioner, VDOT
- State Coordinator of the Virginia Department of Emergency Management
- Executive Director, Virginia Department of Fire Programs
- Director, Department of Criminal Justice Services

- Representative, Virginia Department of Health, Office of Emergency Medical Services
- Executive Director, Virginia Association of Chiefs of Police
- Executive Director, Virginia Sheriffs Association
- President, Virginia Association of Volunteer Rescue Squads
- President, Virginia Fire Chiefs Association
- President, Virginia Professional Fire Fighters Association
- President, Virginia Association of Towing and Recovery Operators
- President, Virginia Association of Public-Safety Communications Officials
- Representative, Department of Motor Vehicles.

Virginia's Statewide TIM Committee has workgroups that focus on specific areas with respect to incident management. Currently, there are four workgroups:

1. *Responder Safety*: tasked with identifying roadway hazards with emphasis on using proper safety equipment
2. *Best Practices*: tasked with implementing best practices for TIM in Virginia
3. *Communications*: tasked with identifying and resolving issues related to communications and dispatch
4. *Training Oversight*: tasked with ensuring that SHRP 2 training is effectively implemented and managed.

In 2010, Virginia's Statewide TIM Committee held meetings to discuss strategies to reduce traffic congestion and secondary crashes by better managing incidents when they occur. One of the strategies related to coordination and cooperation was to establish or re-establish regional and local TIM committees. These local TIM groups are made up of first responders who are charged with looking for ways to manage traffic-related incidents better in their respective jurisdictions and have provided an effective way for Virginia's Statewide TIM Committee to promulgate initiatives and scene strategies, communications, and individual stakeholder procedures.[69]

The Regional Concept of Transportation Operations (RCTO)–TIM working group in the Hampton Roads region developed a Hampton Roads RCTO Resource Guide in 2008[70] that documented six objectives that have implementable action items and performance measures. Although the objectives are specific to the Hampton Roads region, they reflect goals of statewide

TIM working groups with respect to performance measures, training, coordination and cooperation, and incident after-action reviews.

Objective 1: Increase Responder Safety by Eliminating Struck-By Incidents and Fatalities. The two action items associated with this objective are (1) to start regional public awareness campaigns concerning the "Slow Down, Move Over" law and the Move It law, and (2) to encourage optimal lighting and traffic control equipment for secondary responder vehicles. The performance target is zero injuries or fatalities occurring during the incident management process.

Objective 2: Decrease Incident Clearance Time. The action items for this objective include (1) implementing the use of intermediate reference location signs for easier points of reference, and 2) pursuing the use of incentive-based towing contracts or other innovative towing strategies. The performance target is to reduce incident clearance times annually by 5.5 percent or 1.5 minutes.

Objective 3: Decrease Secondary Incident Occurrences. This objective has the following action items: (1) provide regional entities information regarding incidents in Hampton Roads, and (2) enhance the dissemination of incident-specific information to the motoring public. The performance measure target is to reduce secondary accidents by 25 percent over 3 years.

Objective 4: Improve Inter-agency Communication During Incidents . The action items for this objective include (1) using the Hampton Roads Traffic Management Center as a contact point for multiple agencies, and (2) exploring the possibility of multiple agencies being co-located at the center. Currently, the McConnell Public Safety and Transportation Operations Center in Fairfax County (see Figure 7) is the only fully co-located facility in Virginia and is considered a model for multiagency coordination and cooperation.[71] It houses the following agencies:

- Department of Public Safety Communications (Fairfax County)
- Office of Emergency Management (Fairfax County)
- Fire and Rescue Department (Fairfax County)
- Police Department (Fairfax County)
- VDOT
- VSP.

Although a specific quantifiable performance measure is not established with this objective, an annual communications survey of TIM stakeholders is conducted to generate input on communication deficiencies and proposed improvements to correct deficiencies.

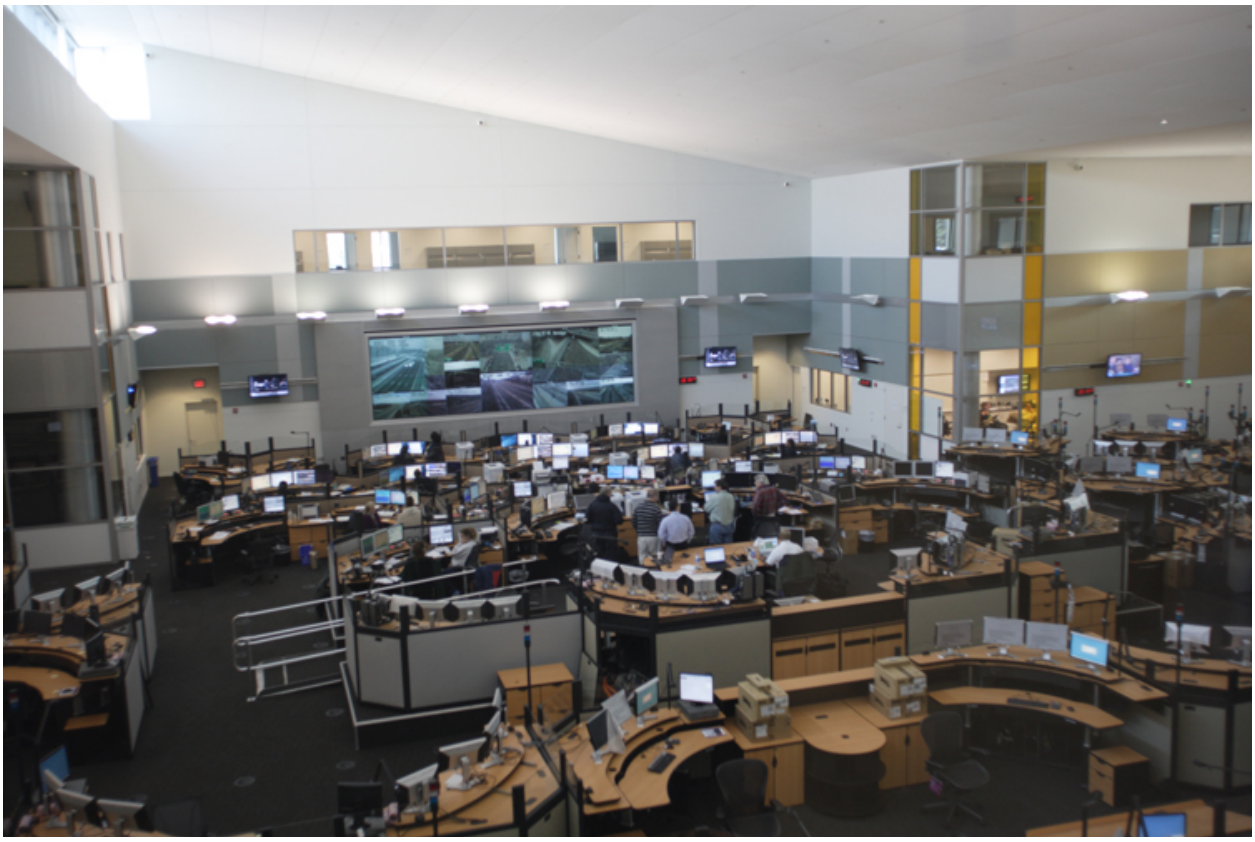


Figure 7. McConnell Public Safety and Transportation Operations Center, Fairfax County. *Source:* Virginia Department of Transportation.

Objective 5: Identify Existing Regional Incident Management Resources and Plans for Inter-agency Utilization and Acquisition. The two action items for this objective are (1) to conduct cross-agency training, and (2) to provide more total station equipment to be used in investigations. Under this objective, goals of the RCTO-TIM working group are (1) to ensure that cross-agency training of all response agencies reflects national trends and policies regarding TIM, the National Unified Goals, and the National Incident Management System, and (2) to use and make available more total station survey equipment for the purpose of reducing accident investigation times. The performance target is to identify resource arrangements, mutual training agreements, and information sharing components annually for all stakeholder agencies.

Objective 6: Establish a Regional Incident Management Proactive and Post Incident Review Consortium. The two action items under this objective are (1) to hold meetings of the post-incident review consortium following any problematic incidents where everyone involved with response, management, and recovery supply input, and (2) to create and maintain a Hampton Roads Incident Responders Contact, Jurisdiction, and Resource Guide. The performance target is to maintain a multiagency major post-incident review process, and to schedule routine regional incident management awareness committee meetings.

Incident Modeling Techniques

The literature review for the development of the IIE tool focused on three major areas of interest: the estimation of the cost of incident delay to road users, the probability of secondary crash occurrence, and the growth rate of queue length attributable to incidents.

Cost Estimates of Incidents in U.S. Dollars Based on Delay Costs to Motorists

In order to provide responders with financial justification for quickly clearing an incident, the IIE tool provides a method to estimate the delay costs of an incident for a traveler. Costs per hour of delay were obtained from the *2015 Urban Mobility Scorecard,*[1] which used $17.67 per hour for passenger vehicles, and $94.04 per hour for commercial vehicles. AADT and truck percentages were obtained from VDOT traffic counts.[14] The delay was calculated using the following equation:

$$D = \frac{(v_h - c_a)\frac{T^2}{2}}{v_h}$$

where

D = total delay due to excess demand for analysis period *T* (hr)
v_h = demand volume in hour *h* (veh/hr)
c_a = adjusted incident capacity (veh/hr)
T = duration of analysis period (hr).

The cost of delay was then calculated by multiplying the portion of traffic in each vehicle class by its respective delay cost and then summing the costs. The cost of delay can be calculated using the following equation:

$$Cost_T = D \times [P_T \times \$94.04 + (1 - P_T) \times \$17.60]$$

where

$Cost_T$ = delay cost over analysis period *T* ($)
P_T = truck portion of vehicle demand.

Secondary Crash Classification

Secondary crashes are defined as crashes that are an indirect result of another crash or incident. They can occur in a primary incident's queue, as vehicles encounter unexpected congestion and are unable to brake in time. They can also occur in the immediate vicinity of a crash, as drivers become distracted by the incident scene.

Several studies have attempted to measure the rate and characteristics of secondary crashes. The studies differ on how they define and classify *secondary crashes.* The main approaches are to classify only crashes occurring within a predefined time and distance of a

primary incident;[72-75] to consider in addition crashes occurring within a deterministic queue of a primary incident;[76-78] and to consider crashes occurring within a directly measured queue.[13,79,80] No studies investigating the prevalence of secondary crashes considered both empirical queues and incident duration.

Previous studies have used different strategies to identify secondary crashes, and the definitions were largely dependent on the available data. The most sophisticated approach was used by Yang et al.[13] In their approach, an *incident queue* was defined as speeds that were 30 percent of the historical average speed for that segment at that time and day of the week. All incidents were then plotted on a time-space diagram. A crash was considered secondary to another incident if a line could be drawn between them on the time-space diagram passing only through incident queue segments.

There are two major shortcoming of this approach. First, if the line between the primary incident and secondary crash passing through even a single segment not considered as non-recurring congestion, the incidents are considered unrelated. In practice, however, there may be small segments within the time-space diagram where speeds do not meet the definition for non-recurring congestion yet are clearly within the larger queue. Second, only the beginning of the incident is used to connect the primary incident and the secondary crash. For incidents that do not cause congestion until later in their duration, the connecting line between the primary incident and the secondary crash may not show much non-recurring congestion.

In addition to crashes that occur in the incident queue, secondary crashes may also occur in the physical proximity of a primary incident because of rubbernecking. To capture these incidents, Yang et al. classified any crash occurring within 30 minutes of the start of the primary incident and within 0.5 mile in the upstream direction when the crash occurred in the same direction as a secondary crash.[13] They further defined *secondary crashes* as occurring in the opposite direction within 1 hour of the start of the primary incident and within 1 mile upstream. Yang et al. were forced to use a time window as they did not have access to incident duration data. For the analysis presented herein, the definition of *secondary crashes occurring within proximity of a primary incident* is any crash within 0.5 mile and within the duration of the primary incident.

There are several factors that can contribute to the risk of a secondary crash and influence the model of secondary crash probability. For example, as upstream vehicles approach an unexpected queue, sudden braking behaviors may increase the crash risk for distracted drivers. With each driver that encounters this queue, the risk for a secondary crash may increase slightly. The number of vehicles encountering the end-of-queue has been investigated in simulation as a surrogate measure for freeway safety.[76] Several studies of secondary crash occurrence have investigated the effect of volume, but only using surrogate measures for volume such as time of day[76] or unadjusted AADT.[74,78] No studies have investigated the relationship between empirical demand and secondary crash rate.

Queue Length Estimates

The estimation of queue length that is due to an incident involves the comparison of the volume of traffic on the roadway (demand) and the volume that can pass the incident (capacity). A road's capacity is reduced during an incident, and the 2010 *Highway Capacity Manual*[81] provides estimates for the remaining capacities that are due to incidents, re-created in Table 5.

Table 5. Proportion of Freeway Capacity Remaining During an Incident

Number of Lanes (One Direction)	Shoulder Disablement	Shoulder Accident	One Lane Blocked	Two Lanes Blocked	Three Lanes Blocked
2	0.95	0.81	0.35	0.00	N/A
3	0.99	0.83	0.49	0.17	0.00
4	0.99	0.85	0.58	0.25	0.13
5	0.99	0.87	0.65	0.40	0.20
6	0.99	0.89	0.71	0.50	0.26
7	0.99	0.91	0.75	0.57	0.36
8	0.99	0.93	0.78	0.63	0.41

Source: Federal Highway Administration. *2010 Urban Congestion Trends: Enhancing System Reliability with Operations.* FHWA-HOP-11-024. Washington, D.C., 2011. [82]

Using a default freeway capacity of 2200 vehicles per hour per lane, and multiplying by the appropriate factor in Table 5, the IIE tool determines the expected capacity of the roadway during an incident. Further, by multiplying the freeway segment's AADT by the correct adjustment factor to account for seasonal, daily, and hourly fluctuations in demand, the demand at the incident location and time is estimated. The queue length calculation assumes that any demand that cannot be served by the current capacity will add to the queue length and that any situations in which capacity exceeds demand will subtract from the queue length. From guidance in the 2010 *Highway Capacity Manual*,[81] passenger vehicles are assumed to require 20 feet of roadway per lane when queued and trucks are assumed to require 75 feet. For example, when demand exceeds capacity by 200 vehicles per hour on a three-lane interstate with 5 percent trucks, the queue length grows at the following rate:

$$\frac{[200(.05)(75) + 200(1 - .05)(20)]}{5280 \text{ x } 3} = 0.287 \text{ mi/hr}$$

If capacity were instead to exceed demand by 200 vehicles per hour, the queue length would decrease at the same rate. The following equation shows the change in queue length per hour:

$$QL_h = \frac{(v_h - c_a)[P_T \times 75 + (1 - P_T) \times 20]}{5280 \times N_{original}}$$

where

QL_h = queue length change (mi) for hour h

v_h = demand volume in hour h (vph)

c_a = adjusted incident capacity (vph)

P_T = percentage of trucks

$N_{original}$ = base number of lanes before the lane closure. In the case of a work zone, the total number of lanes available before the incident should be used.

Best Practices Interviews

Findings from the Virginia interviews for each response agency were categorized into specific topic areas including dispatch, response, scene management, 3 Cs (coordination, cooperation, and communication), training, compensation (for tow companies), and general operational protocols. For each category, a list of agency concerns, issues, and/or practices was populated. This list is provided in Appendix B.

Appendix C shows the interview notes on programs from other state DOTs. Of particular interest were high-impact programs such as Georgia's TRIP and Florida's RISC program. Other programs of interest were incident response patrols operating in Illinois, Washington, and California and clearance practices and policies in Texas, North Carolina, and Pennsylvania.

An itemized list of problems and potential solutions was created from the Virginia responder and other state DOT interviews and the reviewed literature. This list was presented to VDOT and VSP staff at project stakeholder meetings. Stakeholder feedback and the potential solutions and possible challenges to implementing the solutions were incorporated in the following consolidated documentation of critical quick clearance problems encountered in Virginia. The problems, potential solutions, and challenges are divided into categories of response, clearance, and 3Cs.

Response

Towing Equipment and Training of Operators

A common theme from VSP interviews was related to tow lists. In Virginia, most counties have established tow lists whereby tow companies are dispatched to incidents in the order of rotation. Some of the VSP complaints are that the requirements to get on a county tow list with respect to equipment and training are not as strong as they should be to support incident

quick clearance. An example of this problem is a tow company showing up at an incident site with improper or inadequate equipment and/or tow operators lacking the necessary training to handle complex recovery efforts. Potential solutions to address this problem include the following:

- *Tightening equipment and training requirements to get on tow lists.* Enact tighter standards on wrecker fleet inventories and classifications for light, medium, and heavy-duty towing operations, and require yearly equipment and facility inspections. Uphold training and certification requirements for tow truck operators (TRAA's National Driver Certification Program[18] is an example). Because this may be politically difficult to accomplish as a statewide mandate, changes in equipment and training requirements may have to be made on a county-by-county basis.

- *Tightening requirements to remain on tow lists.* Objectively review and evaluate towing companies on tow lists, and remove those that are underperforming. This would involve developing and tracking performance measures for towing programs; a possible undertaking by the VSP. Example evaluation criteria are provided in Appendix C of *Quick Clearance and 'Move-It' Best Practices Final Report.*[20]

- *Creating separate heavy-duty tow lists in areas that do not have them.* In addition to creating separate lists, require companies on heavy-duty tow lists to own their equipment rather than subcontract for equipment. This will minimize the delay that occurs when tow companies must subcontract certain tasks.

Incident Information and Descriptions Provided to Tow Companies

A collective concern heard from the towing company interviews is that incomplete information about an incident can lead to the dispatching of improper equipment and that often the VSP will specifically request certain equipment rather than provide a description of what needs to be recovered and letting tow companies decide what equipment to bring. Obtaining proper information and descriptions of the incident on a consistent basis is an area of high interest for tow companies, especially if TIM performance is to be tracked and measured. Potential solutions to address this problem include the following:

- *Encouraging the VSP to describe the incident more completely for the benefit of tow companies.* This includes additional information such as the size, position, and location of the vehicle(s) to be recovered; the load spilled; and the weight of the spill. VDOT could alternately provide this information through the Traffic Operations Center (TOC) or SSP. To assist with providing proper descriptions, the towing and recovery vehicle identification guides should be referenced.

- *Providing images of the incident to tow companies.* A possible means of accomplishing this is to take photographs of the scene with a cell phone; however, VSP troopers are not issued cell phones with a camera. Occasionally, VSP troopers use personal cell phones with a camera, but this is not a consistent practice. Alternatively, VDOT may have closed-circuit television coverage of an incident and

may be able to pan to an incident and briefly take a screenshot that can be emailed to a tow company; or the VDOT SSP could be equipped with dashboard cameras or cell phones with a camera. There are potential issues with privacy as static images can be stored on government servers and subjected to requests under the Freedom of Information Act or may be subject to discovery in a trial. Potential ways to navigate around this are to send "self-destructing" static images (e.g., via Snapchat) or streaming video (e.g., via FaceTime).

Towing Response Time

The response time for towing companies was identified in the interviews as an area in need of improvement. VDOT's NRO initiated OIT in an attempt to address this concern: with OIT, emergency dispatchers dispatch the tow company next in line on the tow list immediately along with other responders without first confirming whether towing is needed. For VDOT regions that do not have OIT, tow companies are dispatched by the VSP after first responders arrive at an incident. In congested corridors, traffic queues will quickly grow the longer travel lanes remain closed, further prolonging towing response times. Towing operators often encounter these queues en route to an incident and are reluctant to use shoulders and crossovers because of liability concerns, even if given permission from the VSP. In addition, depending on the nature of the incident, the dispatched tow company may not be provided the proper information about equipment needs or, as discussed previously, may not have the proper equipment to manage towing needs, which further adds to delays in response. Potential solutions to address towing response time problems include the following:

- *Developing zone-based contracts.* Zone-based towing contracts, developed through a competitive bidding process, provide for a single tow company to respond to incidents within a defined boundary or roadway segment. Successful examples of zone-based towing contracts include the New York Parkway Commission, Georgia's TRIP, and Florida's RISC program. An alternative to establishing single contracts for specific roadway segments is developing shared contracts in which tow companies alternate management of a zone weekly or monthly.

- *Promoting more efficient dispatch protocols.* Response times can be reduced by initiating more instant tow programs in which wreckers are dispatched simultaneously with VSP troopers. In addition, regions can initiate "next-in-line" notifications, which will improve preparedness by alerting tow companies that they will be called next on the rotational tow lists. Another problem commonly encountered with tow lists is the lack of proximity of a dispatched company to a freeway recovery job. In some cases, tow companies are on tow lists for a particular geographical area even though they may be stationed more than 30 miles from a freeway incident site. By either requiring tow companies to be positioned within a certain distance of the incident before dispatching or initiating next-in-line notifications, tow companies are afforded the ability to prepare or even pre-position equipment near incident "hot spots."

- *Providing more efficient en route mechanisms.* Permit towing operators to use crossovers and shoulders, and enact legislation that indemnifies tow operators from liability. Alternatively, provide police escorts on shoulders (or through traffic).

Clearance

Opening of Travel Lanes

A common problem heard in the interviews relates to the inefficiencies of on-site clearance activities. The contributing factors that result in clearance delays are numerous as response agencies/companies attempt to work together seamlessly in dangerous and stressful conditions. The most important primary task for first responders at an incident site is to create a safe environment for response personnel, crash victims, and the traveling public. A secondary but equally important task is the re-opening of travel lanes since prolonged clearance activities will result in added safety risk within and around the initial incident site and add to motorists' delay and frustration. Implementable means to expedite the re-opening of travel lanes include the following:

- *Initiating towing incentive programs*. Florida, Georgia, and Washington have had success with significantly improved clearance performance by developing monetary incentive programs for towing companies. These programs typically use a 90-minute threshold to clear after given notice to proceed. Additional aspects to be included in a towing incentive program or instituted separately where incentive programs are not implemented include (1) strengthening hold harmless laws to protect tow companies from damage liability; (2) ensuring that other responding agencies provide sufficient access to the incident scene for vehicle/cargo recovery upon giving notice-to-proceed instruction; and (3) developing multiagency procurement lists allowing TIM responders (including tow companies) to purchase traffic control equipment at group discounts, as done in Wisconsin.

- *Endorsing emergency relocation and/or "instant push" practices.* This would initiate relocation practices whereby VDOT tows or pushes a lane blocking vehicle to a ramp, shoulder, or designated area. Tow companies can then recover the vehicle upon their arrival. The Illinois DOT uses this aggressive practice, and it is endorsed by Illinois TIM agencies. Currently, the VSP must authorize VDOT to push a vehicle to the shoulder. Granting VDOT authority to push vehicles and/or spilled cargo would expedite the opening of travel lanes in instances in which SSPs arrive on-scene before the VSP. Two important aspects of such an initiative are (1) to include hold harmless laws to protect VDOT from liability when moving vehicles, and (2) to compensate tow companies the same as if recovery was performed from travel lanes, since relocation mitigates but does not fully remove the travel hazard.

- *Strengthening and promoting driver removal laws.* Virginia Code § 46.2-888 states: "If the driver is capable of safely doing so and the vehicle is movable, the driver *may* move the vehicle from the roadway to prevent obstructing the regular flow of traffic (emphasis added)." Strengthening the language to "shall move" as opposed to "may

move" and promoting the law through educational campaigns would enhance the quick clearance of moveable obstructing vehicles. In addition, the law could authorize any occupant with a valid driver's license to move a vehicle rather than just the driver. Laws in Arizona, Michigan, and Kentucky support this practice.

- *Instituting consistent compensation mechanisms that require towing companies to charge by the pound instead of time.* Some tow companies charge according to time spent, which can create less urgency at incident sites. As an incentive to encourage tow companies to change compensation practices, VDOT could consider paying tow companies a fixed cost for the removal of uninsured vehicles on interstates (since tow companies do not receive compensation for removal of uninsured vehicles) and could take on the responsibility for recovery of these charges from liquidation of the vehicle or simply absorb the costs (responsibilities currently imposed on tow companies).

Extra Lane Closures

Fire departments often have a "lane plus one" policy for traffic control (including speed reduction) and scene protection and will often remain on-scene while the VSP and tow companies finish their work. This can lead to additional congestion and rubbernecking. Instead of using an expensive fire truck as a scene barrier that, by protocol, takes an extra lane, VDOT may be able to assist with traffic control and protection using truck mounted attenuators (TMAs), allowing the fire truck to leave the scene sooner. Possible means to do this include the following:

- *Forming incident response teams (IRTs).* These IRTs would consist of a response vehicle and a crash-cushion truck. This would be an on-call team to provide traffic control support. These IRTs would be especially helpful in rural locations and during off-peak incidents and would include a resident engineer as part of the team. Funding challenges may be met by allowing IRT sponsorships. Georgia and Florida have had success with this approach.

- *Promoting Slow Down / Move Over laws.* Fire departments will occasionally creep into additional lanes beyond the standard extra lane if they observe that passing vehicles are going too fast. The current Virginia Slow Down / Move Over law does not provide a speed reduction threshold as this would be difficult to enforce. However, by promoting the law through more awareness campaigns, the traveling public would be more educated about the importance of adhering to this regulation.

Crash Investigations

For major incidents and those involving fatalities, the VSP may close all lanes to perform crash investigations. These investigations typically involve surveying skid marks and all crash debris for the purpose of crash reconstruction. Depending on the severity of the incident and resulting debris field, these investigations can close the roadway for hours. Certain procedural and investigative protocols must be followed with crashes that involve fatalities; however, there are methods to expedite the re-opening of lanes, which include the following:

- *Providing more mobile crash investigation teams, equipment, and trained personnel.* When crash investigations are needed, this often involves travel to a particular VSP office to retrieve the proper equipment. By having crash investigation equipment staged at strategic or crash hot-spot locations, crash investigations could begin much sooner. In terms of survey methods, the VSP typically uses total station equipment. However, other surveying techniques such as photogrammetry and laser scanners require less time on-scene than total stations. Factors that inhibit these quicker survey methods are lack of inventory and lack of trained personnel. VDOT could provide training and funding for these more expensive non-traditional survey tools. The VSP might also investigate the use of aerial photogrammetry. The Utah Highway Patrol has used aerial photogrammetry for crash investigations using a remote-controlled, low-flying helicopter.

- *Clarifying the medical examiner's (ME) procedures statewide.* The ME has some discretion regarding when a body can be moved and whether the ME must be present prior to the moving. This creates a source of confusion as to when an ME is needed on-scene. In addition, there needs to be clarification of mechanisms to move a fatality from the incident scene. For example, there may be certain provisions that allow the VSP to move a body to an off-site location, without removing the body from the vehicle, prior to the arrival of the ME.

Interagency Coordination, Cooperation, and Communication (3Cs)

Establishing quick clearance initiatives and practices cannot be done without cooperative relationships across the responder community. These relationships are typically cultivated through interactions that occur beyond the collaboration at incident scenes. The following are actionable items that are critical to facilitating interagency 3Cs:

- *Promote regular, facilitated TIM meetings at the local level.* These local level meetings should include all responders including the towing community.

- *Promote joint in-class training (SHRP 2).* This training should be mandated across all responders. Members of volunteer fire departments should be especially encouraged to attend, as they typically operate in rural areas with limited opportunities for joint training. The training should be repeated periodically even for those who have already attended. Through development of a TIM statewide task force as a non-profit organization, funds can be raised to provide training and award certifications. Georgia has had success with this approach.

- *Establish joint open road policies / MOUs among all response agencies.* By developing and agreeing to joint operational policies, agencies across jurisdictions can establish a cohesive vision of quick clearance objectives and strategies. Washington, Georgia, Florida, and Illinois have had success with this approach.

- *Promote and mandate AARs.* AARs are meetings held to discuss successes, challenges encountered, and lessons learned during major incidents that lead to

prolonged lane closures. However, there is no consistency across the state as to when AARs are to be initiated. Establishing minimum clearance time thresholds for the initiation of mandatory AARs would create more consistency. Funding challenges for these meetings and shift scheduling challenges need to be overcome by all response agencies. For example, tow companies could be given an incentive of redistribution of their calls to the following day.

- *Establish more collocated facilities*. Northern Virginia, Florida, Texas, and North Carolina have had success with this approach.

Development of Best Practices Guidance

Upon meeting with project stakeholders and reviewing the list of problems and potential solutions, the researchers synthesized common themes from the literature and interviews, and identified high-interest topics as potential pilots. Discussions were held about the political, financial, legal, and staffing realities of establishing the pilots and identifying pilot project locations and oversight. The proposed pilots combine the problems heard from various responders regarding incident clearance, the frequency and intensity of the problems, and the availability of feasible solutions to address those problems. Pilot projects are not exclusive, and in many cases, multiple pilots can be deployed by a single region. As presented to the stakeholders, the following pilots are considered tools within a toolbox to realize safe quick clearance. The following sections provide a description, example programs, necessary components, and optional components of each pilot.

Towing and Recovery Incentive Program

In this pilot project, tow companies would receive financial incentives for quick response and clearance of an incident for heavy-duty towing in an urban corridor. Tow operators would be required to clear an incident in less than 90 minutes once the VSP provides the notice to proceed. Disincentives could be applied for excessively slow clearances.

Example Programs: Georgia, Florida

Necessary Components:

1. identification of interstate mile markers zone for piloting
2. identification of appropriate tow companies and execution of contracts
3. criteria/standards for tow lists (equipment, distance)
4. yearly inspections of equipment/yard
5. tow staff training/certifications
6. heavy-duty and light-duty lists
7. extension of the VSP's hold harmless clause to towing companies
8. tow list performance reviews
9. after action reviews.

Additional Options:

1. VSP/VDOT/tow direct communication link
2. next-in-line notification to towers
3. sending of incident scene images to tow companies.

Zone-Based Towing Contracts

Instead of the conventional single tow rotation list covering a large region, this pilot project would use competitive bidding to assign each road segment to a single towing company. This would allow companies to stage on a segment, with the knowledge that it is always "next on deck." Tow companies would have to meet requirements to be allowed to bid, and contracts would include minimum performance criteria and standards. Pilots could be interspersed throughout the state.

Example Programs: Fairfax, Prince William, Arlington, City of Richmond, New York, Georgia, Florida

*Necessary Components**:***

1. identification of interstate, mile markers zone for piloting
2. county/city board approvals
3. criteria/standards for contracts (equipment, distance)
4. execution of zone-based towing contracts for the pilot.

Additional Options:

1. regular inspections of equipment/yard
2. tow staff training/certifications
3. instant tow
4. evaluation of tow companies / review of performance on a regular basis
5. requirement for tow companies to own equipment
6. shared zone-based contracts—alternating management of a zone weekly/monthly
7. sending of incident scene images to tow companies
8. VSP/VDOT/tow direct communication link.

VDOT Emergency Relocation

In this pilot project, VDOT's tow equipment would be pre-staged at strategic locations, similar to current operations at special facilities such as bridges and tunnels. Staging could occur in advance of expected congestion such as that which occurs with storms, special events, or bottlenecks or as a general precaution with vehicles parked at the TOC or area headquarters. In the event of an incident, VDOT tow equipment would relocate crashed vehicles and debris to designated drop points near ramps. Private tow companies, which might arrive later, could then clear this debris from the drop point. Tow companies would be paid the same rate as for clearing the incident scene itself.

Example Programs: Illinois, Washington

*Necessary Components**:***

1. VDOT towing equipment staging for emergency relocation

2. identification of interstate, mile markers zone for piloting

3. designated drop-off points for vehicle relocation

4. agreements and policies necessary for extending the hold harmless clause from the VSP to the VDOT operator

5. identification and training of VDOT operators.

Additional Options:

1. VSP/VDOT/tow direct communication link
2. instant push for SSP
3. hold harmless clause for SSP
4. next-in-line notification for tow companies
5. sending of images to tow companies.

Rural Incident Response Teams

This pilot project would designate VDOT staff in rural areas as members of IRTs. The IRTs would be equipped with SSP trucks with arrow boards and a TMA. Team members would take turns and provide 24/7 coverage to respond instantaneously to incidents. In order to minimize response times outside business hours, members would be allowed to take these trucks home. Providing additional traffic control in this manner is expected to minimize the use of traditional lane-plus-one approaches common among traditional responders.

Necessary Components:

1. identification of interstate, mile markers zone for piloting

2. VDOT SSP trucks equipped with an arrow board, a TMA, and other necessary incident management equipment (such as cones, flares, and incident management signs)

3. modification of VDOT policy to allow SSP (or other designated operator) to take vehicle home and be on call to respond directly to incidents 24/7

4. identification and training of operators.

Additional Options:

1. VSP/VDOT/tow direct communication link
2. instant push for SSP
3. emergency vehicle classification (red lights) for SSP trucks
4. next-in-line notification for tow companies
5. sending of incident scene images to tow companies
6. instant tow
7. SSP sponsorship.

Discussion

By implementing a project as a targeted pilot first, VDOT could evaluate its strengths and weaknesses and learn valuable lessons before implementing a full rollout. These pilots and their components form the primary new "tools in the TIM toolbox." Each region needs to customize a chosen pilot to fit its needs. A one size fits all solution will likely not work for all types of incidents and situations across the state, since TIM is an inherently complex topic involving several jurisdictions; responding agencies; their missions and training needs; and the diverse political, financial, legal and staffing realities. For example, rural and urban areas differ in the number and type of incidents, amount of traffic impacted by the incidents, availability and proximity of towing options, etc.; whereas a 24/7 SSP program is often essential for an urban area, it is impractical in a rural area.

In addition to these targeted pilot projects, several other immediately implementable TIM tools (hereafter referred as second category tools) were identified in the literature and interviews. Although some TIM tools (such as performance measures program) could be fully implemented by VDOT alone, others (such as legislative changes) would require cooperation, communication, coordination, and collaboration with other responder agencies. Select second category tools include the following:

- *Performance monitoring.* Data collection and performance monitoring are essential for proper implementation of all the tools in the TIM quick clearance toolbox, although not mentioned explicitly in any of the pilot projects. Accurate and timely monitoring of activities and results will inform stakeholders about the costs and benefits of specific TIM quick clearance tools. Performance monitoring also helps to identify improvements needed in operations and policies and to gain further support and investment from the legislature and the public.

- *Towing industry certification and equipment inspection.* Achieving any minimum quality and performance standards for TIM towing and recovery requires strengthening these activities.

- *On-scene communication with tow companies.* Technologies such as smart phones and cellular communications can help provide tow companies with detailed incident information (possibly including photos or videos).

- *Open roads policy, SHRP 2, and additional joint training for incident responders.* They help generate and maintain consensus and clarity among all incident responder agencies on TIM roles and goals.

- *Continued support of TIM efforts in the state including the following:*

  — establishing consistent ME protocols across the state (Statewide TIM Best Practices Working Group in lead)

  — developing TIM website for all responders to use (VDOT in lead)

  — implementing public education campaigns and public safety announcements (various responder agencies currently in lead)

  — scheduling, organizing, and hosting regular local TIM meetings for incident responders independent of other after-action reviews.

- *Standardize incident criteria for holding after-action reviews, with VDOT taking the lead in scheduling, hosting, and conducting after-action reviews.*

Some TIM tools fall in the third category of potential future implementation. They cannot be implemented currently for reasons such as financial constraints or lack of political support or technology. VDOT and other TIM agencies will benefit from periodic reviews of such tools to determine if the constraints have changed since the last review. Select third category tools include the following:

- *Strengthen legislative language for driver removal, changing "may" to "shall" in Virginia Code § 46.2-888.* This would be combined with a strong public safety announcement program to reach out to current and new drivers.

- *Add legislative language to extend hold harmless protection to other incident responders.*

- *Identify funding sources to procure and maintain technology (such as photogrammetry) for reducing on-scene crash investigation times and for training VSP personnel.*

Given the diversity of responder roles and the large number of personnel involved, new TIM quick clearance implementations, including the pilot projects, would benefit immensely from strong leadership, project champions, and the 3Cs among the agencies. To help focus all stakeholders on the quick clearance needs and to persuade changing from the status quo, principles of change management and learning organizations may be helpful for implementing the pilots.

Incident Impact Estimator Tool

This section describes the results of the interviews regarding TTE tool specifications and use cases, model development, contents, and lessons learned.

Use Cases and Functional Specifications From Stakeholder Interviews

Based on discussions with stakeholders, the researchers considered several potential use cases in the design of the IIE. Incident scene responders noted that there was a financial component to the decision to clear some incidents, particularly when deciding to push cargo to the shoulder. Commercial vehicle operators may want to delay pushing cargo to the shoulder in order to avoid damage. If delay costs to the traveling public can be estimated, this value could be weighed against the cost of potential damages to cargo in decisions regarding how best to clear an incident.

A different use case was developed from discussions with the Virginia Chief Medical Examiner's Office. In a fatal crash, typically a coroner must arrive on the scene to confirm a fatality before the body may be moved and the scene cleared. In some situations, however, the coroner may allow on-scene responders to move the body before the coroner's arrival if they are able to identify the body themselves. The decision to allow responders to move the body is partly a factor of the congestion generated by the incident and the time required for the coroner, who could be delayed by the same queue, to travel to the scene. If a coroner could estimate the future traffic conditions from the incident over the time period required to travel to the scene, the coroner might allow responders to move the body and clear the incident more quickly at high-congestion incidents.

Another use case involves first responder training. In many training classes, there is a high-level discussion of the risk of additional crashes that are directly or partly due to the congestion caused from the first, or primary, incident. These additional crashes, called "secondary crashes," are related to the primary incident and are more likely to occur during longer primary incidents and during severe congestion. Although current training covers the factors leading to secondary crashes, the discussion is very high level and relies on out-of-date and generalized metrics. A tool to estimate the secondary crash probability of a specific incident and a specific location and time could provide responders with a better understanding of the relationship between secondary crashes and quick incident clearance. This would provide an additional incentive to responders to clear an incident quicker to improve public safety and reduce the responders' own time on-scene.

A final use case came out of discussions with VDOT incident managers. For managing major incidents, contractors are used to provide traffic control and advanced warning for motorists. In addition, traffic may be diverted onto parallel routes. Both of these situations could benefit from estimates of queue length based on current and expected conditions, so that contractors could position warnings at appropriate locations and diversions are positioned at relevant off-ramps.

Based on the discussion findings, the initial prototype of the IIE tool was designed with the following characteristics:

1. *Simple user-interface to input incident location and characteristics.* As the IIE tool is expected to be used by non-traffic professionals in both office and field environments, its user interface was designed to be as simple and low effort as possible. In its current design, specifics about the incident in question can be entered using several dropdown menus. The required inputs are number of lanes, number of lanes blocked, interstate number and direction (e.g., I-66E), interstate mile marker, day of the week, month, and time of day.

2. *Platform-neutral, with ability to work on smartphones, tablets, and desktop/laptop computers.* Incident responders are equipped with different mobile devices running different operating systems. In addition, many potential users of the tool may be accessing it from a desktop or laptop computer, either in an office environment or a training class. The tool was therefore designed to work via a simple browser interface, allowing seamless access from a wide range of devices, while also minimizing potential incompatibilities with various users' operating system and software upgrades. The tool uses the inputs to query an SQL database, hosted on remote servers, so that minimal calculation and storage are required on the user's device.

3. *Cost estimates of incidents in U.S. dollars based on delay costs to motorists.* Cost estimates were developed based on the *2015 Urban Mobility Scorecard* [1] and the delay equations in the *Highway Capacity Manual.*[81] They are displayed in the IIE tool as U.S. dollars over the specified time interval.

4. *Probability of secondary crashes.* Secondary crashes were identified from the RITIS database over a segment of I-66 in 2014. Of the 2,466 crashes, 340 (13.8%) were classified as secondary crashes. Of these secondary crashes, 233 (69%) occurred within the incident queue and 107 (31%) were in proximity. Of those occurring in the queue, 159 (69%) were in the same direction as the primary incident, and 74 (31%) were in the opposite direction. Of those occurring in proximity, 70 (66%) were in the same direction, and 37 (34%) were in the opposite direction. A secondary crash occurred on average once every 24.8 incidents, although this rate varied based on the type of primary incident. For example, a secondary crash occurs on average once every 9.9 crashes, 54 disabled vehicles, and 7.8 vehicle fires. The resulting model of secondary crash probability is shown in the following equation:

$$P(s) = \frac{e^Y}{1 + e^Y}$$

where *P(s)* is the probability of a secondary crash occurring, and *Y* is defined as:

$$\text{For } \begin{cases} C = 0; Y = -4.459 + 0.006985t + 0.000162d \\ C = 1; Y = -2.836 + 0.006985t + 0.000162d \end{cases}$$

and where $C = 1$ indicates congestion, t is incident duration in minutes, and d is the number of vehicles estimated to have encountered the incident. *Congestion* is defined as any period in which estimated demand is greater than or equal to estimated capacity, using the values of v_h and c_a from the queue length calculations. For all model terms, $p < 0.01$. A representation of the probability of secondary crash occurrence for a roadway with an estimated demand of 2,000 vehicles per hour is shown in Figure 8. This model is used in the IIE tool to provide probabilities of secondary incident occurrence at different points in time and in different lane closure scenarios.

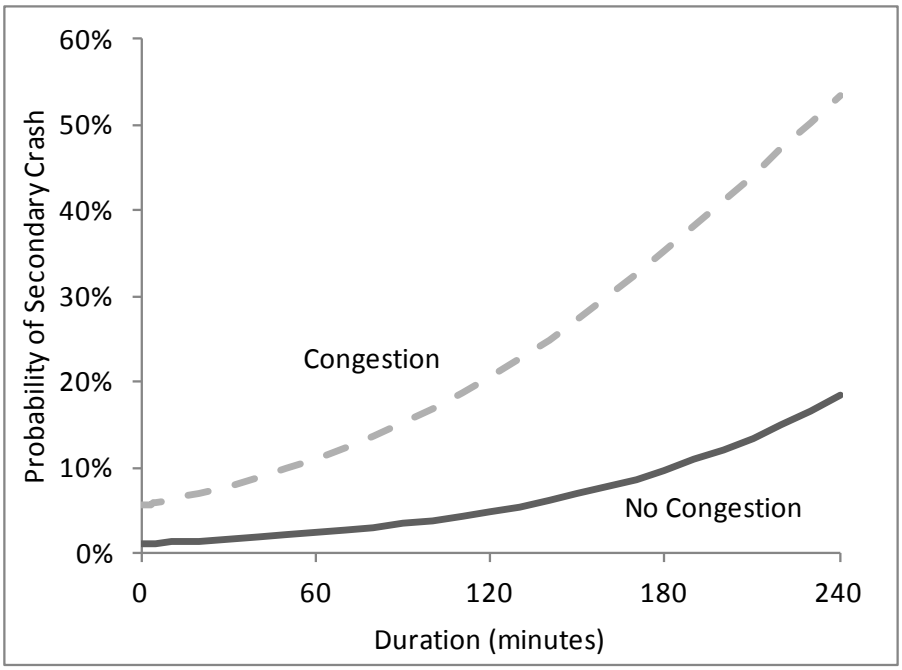


Figure 8. Estimated Probability of a Secondary Crash at 2,000 Vehicle per Hour Demand

5. *Queue length estimates.* The IIE tool calculates the expected queue length at an incident based on expected capacity and demand. Using deterministic queuing theory, the queue length over time can also be estimated.

6. *Display results for different lane closure scenarios.* The stakeholders requested the ability to compare impacts for different levels of lane closures in order to help with decision making in the field. At a three-lane facility, this means the display of impacts for one-lane, two-lane, and three-lane closures over time.

Current Status of Incident Impact Estimator Tool

The IIE tool remains under development. A prototype has been developed, and the application is undergoing final testing while hosted on a local machine. The project team is investigating alternatives for Web hosting. The application is expected to be deployed through Phase II of this study. The application will come with a detailed manual describing its mechanisms, features, and instructions for maintenance and potential expansion. The first

version of the tool will cover the I-66 corridor, with expansion to other interstates in future versions.

Figures 9 and 10 are screenshots of the IIE tool in development. As seen in the figures, the data entry and display of results are intentionally simple to facilitate use in the field and across different browsers and devices. The results page (Figure 11) displays different outcomes for opening one, two, or three lanes. These values are for display only and do not represent calculations described in previous sections.

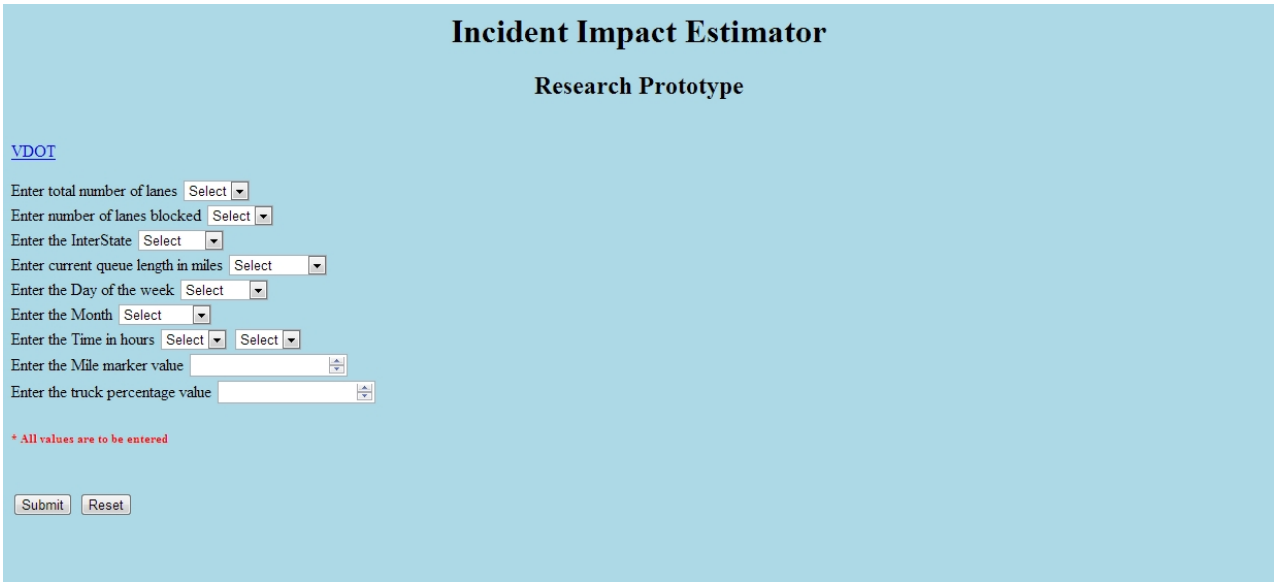


Figure 9. Incident Impact Estimator Main Page

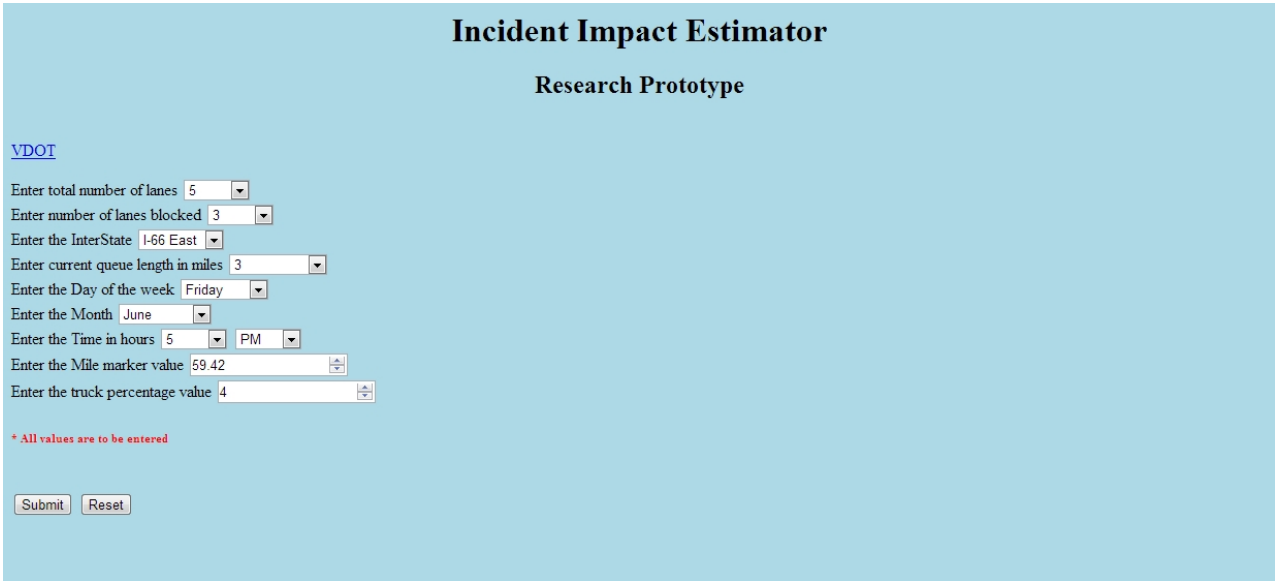
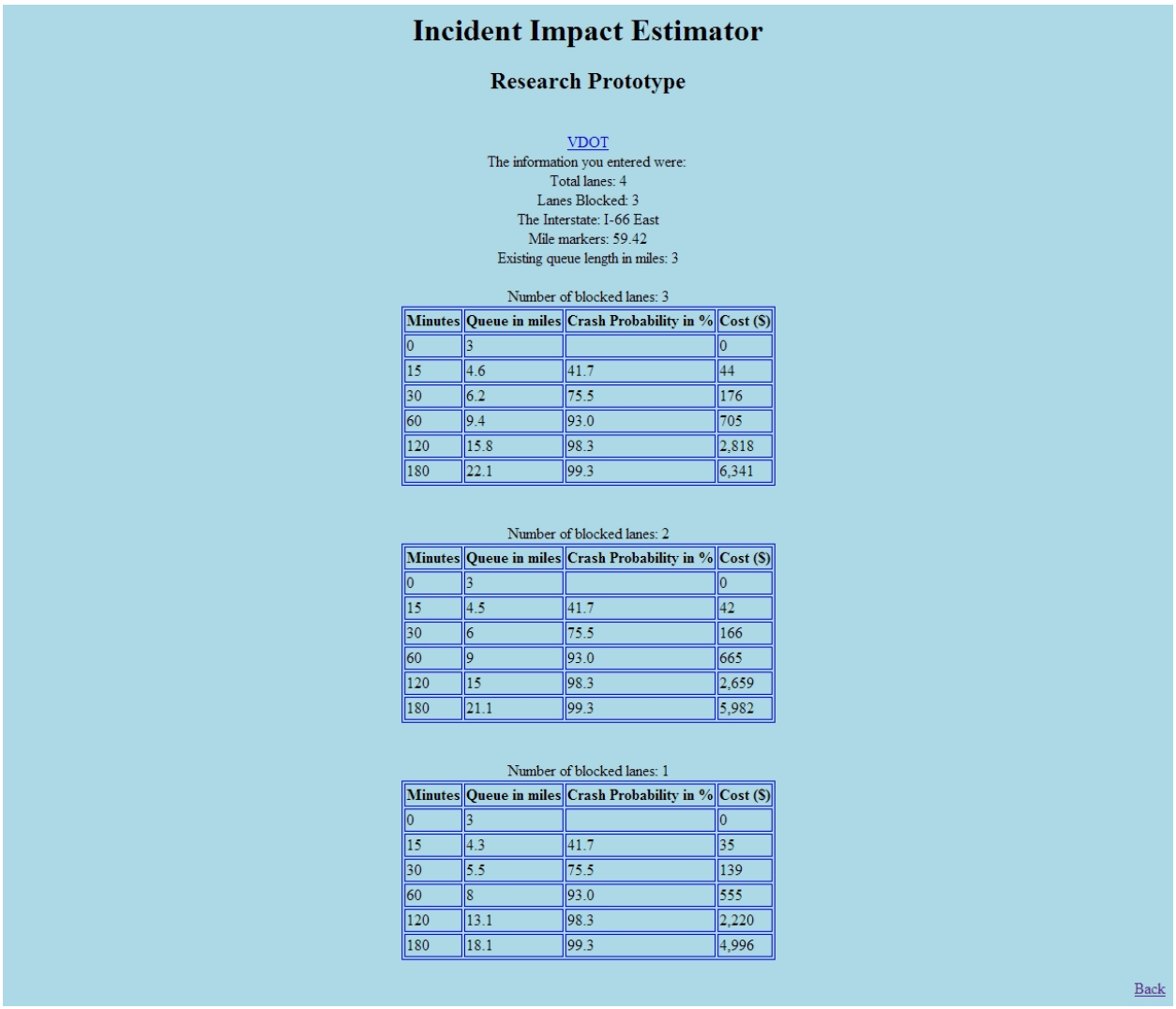


Figure 10. Incident Impact Estimator After Incident Data Inputted



Incident Impact Estimator

Research Prototype

VDOT

The information you entered were:
Total lanes: 4
Lanes Blocked: 3
The Interstate: I-66 East
Mile markers: 59.42
Existing queue length in miles: 3

Number of blocked lanes: 3

Minutes	Queue in miles	Crash Probability in %	Cost ($)
0	3		0
15	4.6	41.7	44
30	6.2	75.5	176
60	9.4	93.0	705
120	15.8	98.3	2,818
180	22.1	99.3	6,341

Number of blocked lanes: 2

Minutes	Queue in miles	Crash Probability in %	Cost ($)
0	3		0
15	4.5	41.7	42
30	6	75.5	166
60	9	93.0	665
120	15	98.3	2,659
180	21.1	99.3	5,982

Number of blocked lanes: 1

Minutes	Queue in miles	Crash Probability in %	Cost ($)
0	3		0
15	4.3	41.7	35
30	5.5	75.5	139
60	8	93.0	555
120	13.1	98.3	2,220
180	18.1	99.3	4,996

Back

Figure 11. Incident Impact Estimator Results Page

Lessons Learned From Prototype Tool Development

A number of lessons were learned in the process of functional requirement determination and tool development. These will be used in Phase II of this study.

- A number of factors such as weather effects, holiday effects, availability of detour routes in the vicinity of incidents, and operational improvements (such as adjusted signal timing) to detour routes are desirable features to be included in the prototype tool but do not have sufficient models in the literature currently. Such specific models have to be developed.

- Typical weekday and weekend traffic will encompass a large number of incidents.

- The accuracy of the model results has to be field tested with the help of responder use and feedback. A lack of accuracy with large scale deployment would prematurely

end tool usability. On the other hand, an iterative cycle of phased deployment, feedback evaluation, and model improvement at select areas before expansion would significantly improve the chances of tool use and success.

CONCLUSIONS

- *A much stronger focus of all responders on the safe and quick clearance of incidents in order to improve responder and motorist safety and to support traveler mobility is possible and is worth pursuing.* Based on the interviews conducted, Virginia TIM responders are clearly passionate about their work and possess the knowledge, skill, ability, and resources to clear incidents safely and quickly. The responders offered many details on the history, existing challenges, and potential solutions with regard to the TIM quick clearance process in Virginia. Some of those solutions can be implemented together, but not all.

- *A stronger TIM performance monitoring and reporting program is necessary in Virginia to continue to garner more support from responders, elected officials, and the public for expanding TIM activities and TIM funding*. Currently, there is no formal performance monitoring mechanism for TIM activities.

- *The incident impact estimator tool will be beneficial for incident responders.* The prototype tool developed in this study received positive feedback from stakeholders. In addition, many responders interviewed thought that real-time and predictive information on the impacts of incident-related lane closures could be used to establish potential strategies during incidents (e.g., route detours) and to assist with post incident reviews and training efforts.

RECOMMENDATIONS

1. *VDOT's OD and regions should further develop and implement one or more of the four targeted pilot projects developed in this study*:

   — Towing and Recovery Incentive Program
   — Zone-Based Towing
   — Emergency Relocation
   — Rural Incident Response Team.

2. *The Virginia Transportation Research Council (VTRC) should assist VDOT's OD and regions in evaluating the implemented pilot projects*. Evaluations would consist of before-after studies of incident durations including response and clearance time comparisons.

3. *VDOT's OD should designate a staff person to identify and track the second category TIM tools worthy of immediate implementation, to coordinate with other responders, and to report annual implementation progress to executive management*.

4. *VDOT's OD should designate a staff person to lead periodic (2 to 4 years) reviews of the third category TIM tools for potential future implementation. This person should keep the third category list updated on an annual basis*.

5. *VTRC should initiate a Phase II of this study to develop the underlying models further, field test their accuracy, and develop the impact estimator tool to field deployment status*.

BENEFITS AND IMPLEMENTATION

Benefits

The benefits of TIM quick clearance initiatives have been well documented. In general, potential benefits include the following:

- decreased motorist delay
- decreased vehicle emissions and fuel consumption
- decreased response time to traffic incidents and other emergencies
- decreased secondary incidents including those involving responders
- decreased negative regional economic impacts.

The benefits of individual TIM program components such as towing and recovery initiatives, driver and authority removal laws, expedited crash investigation, and abandoned vehicle tagging and removal protocols can also be measured. Examples include the following:

- Georgia's TRIP resulting in a benefit-cost ratio of 11:1[29]

- South Carolina's Steer It / Clear It law resulting in an estimated 11 percent reduction in total delay for minor incidents with one lane blocked and an average cost savings of $1,682 per incident[46]

- Indiana's use of photogrammetry at 135 crash sites resulting in an estimated reduction of 1 hour and 47 minutes per road closing scene and more than 900 hours of delay to Indiana motorists[82]

- North Carolina's 5-year study, which found that 1,300 abandoned vehicles were struck resulting in 47 fatality crashes and more than 500 injuries;[12] the benefits are intuitive: there would have been fewer crashes and more lives saved had these shoulder hazards been expeditiously removed.

Every agency involved in the TIM process has a common goal of ensuring the safety of response scene personnel and the motoring public. The guidance and tool developed in this study will provide VDOT the additional mechanisms to broaden and strengthen its outreach to the responder community through the Statewide TIM Committee and other regional initiatives.

Implementing this guidance will provide strengthened interagency coordination and cooperation, resulting in measurable TIM benefits.

Implementation

From the onset of this study, the research team has been working closely with VDOTs OD briefing staff on the findings from the literature and interviews and the prototype IIE tool. The pilots and recommendations have been vetted with VDOT management, and implementation of some of the pilots is underway. Field testing and eventual deployment of the IIE tool will occur in a Phase II study.

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APPENDIX A

VDOT's OPERATION INSTANT TOW POLICY

Source: Virginia Department of Transportation, Operations Division. *Operation Instant Tow.* Richmond. Unpublished Document.

Operation Instant Tow

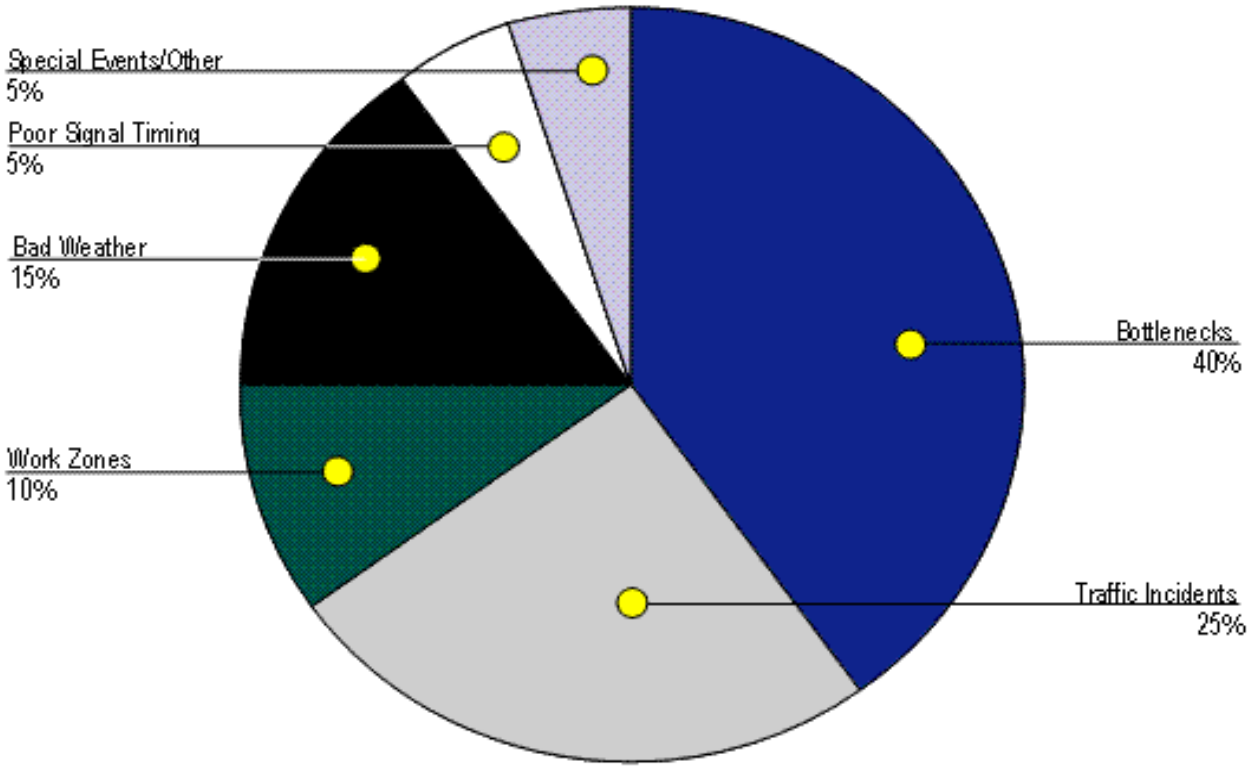
Executive Summary
The goal of this document is to describe Operation Instant Tow and its main objective, which is to create a process that will enable us to reduce incident clearance time by 15 minutes.
Our current practice for responding to an incident is as follows:

- Detect and verify the incident
- Dispatch Virginia State Police
- Dispatch Safety Service Patrol (if not already on scene)
- Dispatch Fire/Rescue (if needed)
- Dispatch Tow Truck (once a Trooper is on-scene and determines if the vehicles need to be towed)

With an "instant tow" concept, a tow truck and the Trooper are dispatched simultaneously. The tow truck does not have to wait for the Trooper to respond and verify the call. The tow truck can save an average of 15 to 20 minutes of time getting to the incident scene. Besides being dispatched faster, this concept further reduces the amount of time that the tow truck is delayed by traffic that is stopped due to the incident.

Instant Towing programs reduce the chances for secondary incidents and can reduce driver frustration associated with being involved in traffic backups. This will also reduce the traffic diversions to the arterial streets and provides a network wide benefit. From an incident response viewpoint, an Instant Towing program is a viable tool in reducing incident-related congestion. Washington State DOT has implemented a successful Instant Tow Program. This Program has shown an average of 15 minutes reduction in incident clearance times.

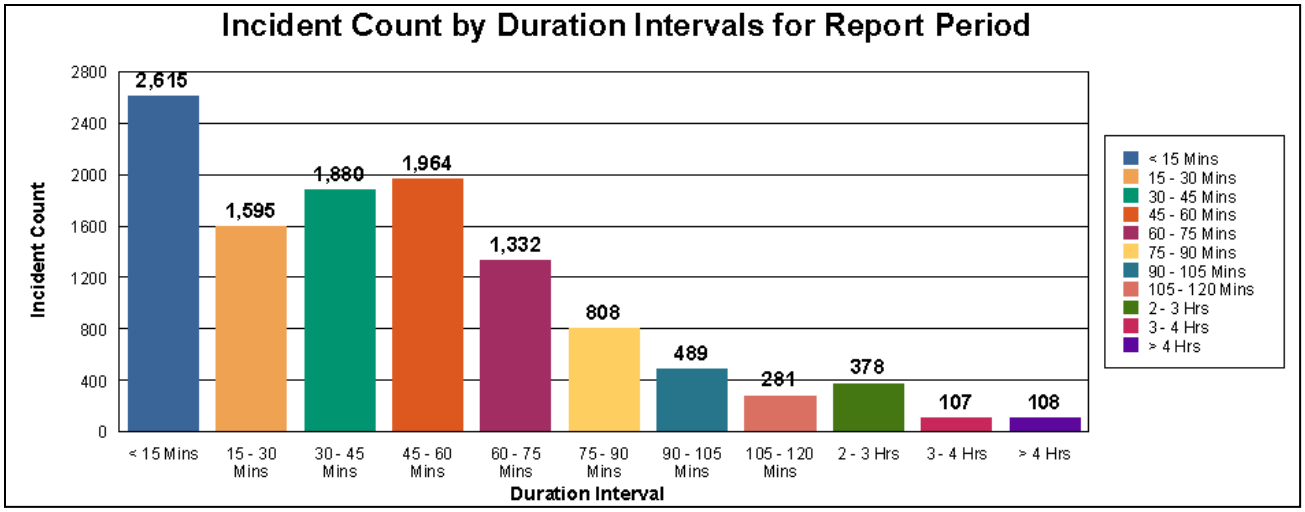
Description of Proposal
The diagram below shows the components of congestion from a national perspective and the percentage of congestion that each source contributes. This information is useful to develop strategies and programs for reducing congestion. Local conditions and percentages can be calculated so that strategies can be tailored to address specific conditions.



In Northern Virginia, the historical data shown below is the number of incidents [in] 2009, 2010, and 2011. The average number of incidents is approximately 12,000 per year and 1,000 per month.

2009			2010			2011		
Events	**Count**	**Minutes**	**Events**	**Count**	**Minutes**	**Events**	**Count**	**Minutes**
Assists	13178	47	Assists	18884	29	Assists	17076	25
Incidents	10681	64	Incidents	13009	52	Incidents	11557	53
Congestion	3440	183	Congestion	3929	167	Congestion	4555	161
Events	118	37	Events	77	34	Events	77	49
Others	2871	59	Others	2400	34	Others	2206	28

The diagram below shows incident count by duration for the year 2011. Eighty-eight percent of all incidents are cleared within 90 minutes.



There are several initiatives that can be taken (or have been taken) to reduce incident clearance time. Instant tow is one component of the overall strategy being developed for NRO. These are:

- Increase Safety Service Patrol to pre-cut levels (completed)
- Create staging areas and move vehicles out of travel lanes (being developed)
- Improve towing contracts and dispatching time (instant tow)
- Dedicate wreckers to each bridge crossing into DC and Maryland from Virginia (similar to previous VDOT program)
- Pre-deploy (heavy duty) wreckers prior to snow storms (similar to Maryland Program)
- Reduce crash reconstruction time with the use of newer technology (similar to program in England)
- Develop a program for major truck crash clearance program (similar to Georgia DOT program)
- Formulate and implement the Operation Instant Tow Pilot Program

The Instant Tow Pilot Program will encompass the following:

- VSP to dispatch tow trucks at the same time as VSP or SSP
- Interstates in NOVA, 5 AM to 9 PM
- Six months evaluation/trial period
- Monthly review of data

The towing company will be reimbursed by VDOT for any dry runs. Dry Runs are defined as arriving at the incident scene and not towing. Any other scenario will be covered by their existing contract terms according to the costs that are defined in the contracts. The cost of a dry run is estimated to be $35 to $45. VDOT estimates that out of 1000 incident per month only 5% will be dry runs and this would cost VDOT an estimated $2000 per month.

For a six-month pilot run this would cost VDOT $12,000.

APPENDIX B

NOTES FROM VIRGINIA TIM RESPONDER INTERVIEWS

The following bulleted notes are key points heard during interviews with Virginia TIM representatives from towing personnel, fire personnel, the VSP, and VDOT. Additional notes from the Virginia Department of Motor Vehicles and the TIM Best Practices Workgroup are also included. These notes include subjective opinions of the interviewees and may not be factually accurate.

Towing

General

- Several areas for improvement have been realized in the towing industry. However, new ideas, such as incentive programs, exclusive zones, and equipment standards, often go nowhere. Funding challenge. Directive needs to come from "feds."
- Recovery is not an exact science—different recoveries for different incidents.
- Cannot envision statewide consistency with the towing industry.
- Fairfax County's exclusive zone contract per tower is conducive to quick clearance, whereas Arlington allows one low bid tow contract for the entire county, which may or may not result in achieving quick clearance.
- Difference between opening lane in rural areas vs. urban. Impacts are very different depending on peak congestion, number of lanes, and available alternate routes.
- Performance reports for towing needed. An agency has to keep track of these data.
- "Spirit of incident management" and "urgency to clear incidents" are more important than always adhering to rigid rules.

Dispatch/Response

- Tow gets informed of an incident from VSP.
- Need to know information ahead of time. Needs: Is load spilled? How heavy? Location, size of truck, position.
- Tow should be called with initial dispatch—could save 30+ minutes.
- Instant tow—prefer to go back to top of list than take $35 for dry run.
- $45 is a better fee for a dry run as it is more in line with insurance company rates.
- Receiving pictures of scene would be good.
- Trouble getting to an incident site because of traffic.
- Can towers use turnaround points / median crossovers? Some say yes, some no.
- "Expedite" authorizes to use shoulders—sometimes this, too, does not help; need escorts with blue lights.

Scene Management

- Push-to-talk phones would be helpful to communicate.

- Need experience running the scene.
- Decisions need to be made by qualified responders at the scene, not those sitting in an office.
- Especially for large incidents, different tow staff needs to work different parts of scene clearance at the same time, including coordinated recovery, cleaning up, and communicating with incident commanders.
- Develop parking schemes so towers have better access to incident vehicles.
- Moving a vehicle with body—appears to be a gray area—need to understand what is covered under law—may have opportunity to save time.

Tow Lists

- Rotation equates to an automatic 15-minute delay (tow lists).
- Small towers without adequate equipment and low-managed tow lists are the problem.
- Heavy tow lists should be different from the small car tow list. Need 2 separate lists.
- Prince William County uses a separate heavy-duty and small car tow rotation. Heavy-duty rotation is performed on a weekly basis, allowing for better preparation during a rotation week.
- Companies on tow list more than once is unfair.
- Beneficial to know where they are on the rotation list.
- Some towers can be on a tow list 30 miles away. No consistency across the state.
- Geography should be a consideration when dispatching tow trucks. Make sure zones are correct size, and update on a regular basis.
- Prefer assigned zones. Exclusive contracts for specific road sections favorable.
- Towing equipment needs to be owned, not borrowed.
- Equipment standards and criteria need to be tightened.
- VSP not managing tow lists/criteria and equipment standards sufficiently.
- Need vehicle inspections to be conducted yearly.
- Need minimum tow operator qualifications.
- Basic standards need to be employed for wrecker staff—Class 3 vest and proper footwear.
- Mandate criminal background checks, and carry a badge (Prince William County requires this).
- Small outfits feel as though bigger outfits trying to "overrun" them.

Compensation

- Tow list is very long—recovery operations used to handle 1-2 heavy crashes a month—now it is 1-2 every 3-4 months. Hard to sustain.
- If a wrecker service has the equipment to clear, they should not be penalized because they can do it faster.
- Interest in incentive program similar to Florida's and Georgia's, and interest from the members of the Major Incident Heavy Recovery Operators Association (MIHROA) in doing a pilot study without money tied to it.

- For incentive—clock should start when all equipment is at scene—do not incorporate response time (incentive).
- For incentive-based program, need to define clearing an incident—is this open lanes or have everything cleared from the roadway?
- Charge by pound instead of time. Time invoicing can lead to abuse.

3 Cs / Training

- SHRP 2 is good, staff attending.
- Towing personnel need to be trained better to handle the wide array of incidents.
- Towers often not part of local TIM committees.
- Certification can be useful. But experience and skill do not always match ability to pass an exam.
- Educating all responders and senior management regarding incident impacts and need for quick clearance is essential to improve TIM.

Fire

General

- Roadways are unsafe environments in which to work.
- Nothing safe about "quick clearance."
- VDOT priority is work zones.
- Fire has mutual aid agreements (MAAs) with neighboring states and localities statewide.

Dispatch/Response

- Inconsistency with median crossovers—some are locked.
- VDOT should dispatch TMAs as soon as engine/Medevac is dispatched.
- Do not see a problem with SSP/IRT trucks using emergency lights (red) to get to the scene quicker. Want VDOT to have a role with traffic control / scene protection. The quicker VDOT can get there, the better.
- Do not understand why fire responds to traffic incidents with the same equipment they respond to house fires. Want TMAs to assist with lane closures, not a fire truck.
- Need fire incident response vehicles.
- Having on-call crash cushion would be very useful.
- Supportive of instant tow.
- Supportive of staging wreckers.
- Mile markers would be beneficial across the state.
- Wreckers bring equipment that does not meet the need.

Scene Management

- Taking only one lane does not slow down traffic. If traffic going too fast past the incident site, fire will take another lane.
- Need to identify ways to slow down traffic prior to site.
- Rollout speed bumps used in Pennsylvania to slow down traffic.
- No VDOT TMA support or resources exist for minor incidents.
- Need teeth behind the Virginia Work Area Protection Manual (VWAPM) —nothing binding.
- Manuals for staging areas, hazards, and detour routes should be pre-identified in each region.
- Fire will stay at incident scene if requested by VSP for safety.
- Clear cut guidelines on HAZMAT cleanup are needed. Who is responsible? How are decisions made?

3 Cs

- No direct communication channel between fire and VSP.
- Common communication channel across responders needed when working incidents.
- Spent millions of dollars for local/regional radio system but it does not include other responders.
- Developing relationships is important for quick clearance.
- SHRP 2 training is a great way to improve relationships.
- Establish forums for responders to talk, beyond the incident scenes.

Incident Impact Estimator Tool

- Tool would be beneficial from a training perspective.

Virginia State Police

General

- Need a consistent statewide policy on towing—interest has existed since 1980s.
- Big fan of SSP—want more coverage.
- Towers are last to get call but first we want on-scene.
- Budgetary constraints always a problem.

Dispatch/Response

- Delays can occur with local dispatch to VSP.
- Like the VDOT IRT proposal.
- In favor of providing visuals to towers, but VSP does not have the capability. Suggest having VDOT help to provide visuals.

- Need to take action to reduce response time for crash investigation teams.
- Gathering equipment and location of crash investigation team creates delay.

Towing

- If tower does not respond in 30 minutes, call-out canceled and another tower dispatched—this leads to delay.
- Rotation different in different parts of the state.
- Towers sometimes get incomplete information from VSP dispatch.
- No channel to call or communicate with towers prior to being on-scene—policy is restrictive.
- VSP goes off the tow list but sometimes does not know if the tower at the top of the list has the right equipment to handle job.
- Sometimes cringe when they hear who is next on tow rotation.
- Properly trained wreckers should be sent to the scene. Currently there is no mandate for recovery certification.
- No checks currently made on driver qualifications—tow companies taken at their word.
- Proper attire (vests/shoes) should be required for towers.
- Positive on incentives—respond and clear quickly.
- Like instant tow but not sure how it would be financially feasible since costs in Virginia are born by operators/owners—maybe Virginia Department of Emergency Management?
- OIT is automatically dispatched in Northern Virginia when vehicle is blocking lane. OIT seen as favorable among towers.
- Towing sends bill to owner/operator, not to the state. If Virginia had a coffer to distribute money, it would be a big incentive to the towers to open roadways sooner.
- Towers bringing more equipment than needed and billing for it.
- Towers taking more time to clear and charging for time.
- No industry standard for tower billing (charge by pound or time).
- No regulation on tower billing—if motorists feel they have been charged unfairly, they can complain to Office of Attorney General, civil court, or Better Business Bureau.
- Performance measure reporting needed for towing—VSP dispatcher should log dispatch/arrival information.
- Trust issues seen between towers and VSP.

Scene Management

- Scene protection with fire truck is favorable for VSP.
- Need VSP trooper or other service to be active in providing queue warning.
- In favor of moving vehicles/cargo to median/gore area, opening lanes, and retrieving at night with a work zone established.
- Crash investigation/reconstruction takes a lot of time—need to find ways to speed up the process.

- Need to update policies and procedures along with technology and training so data are not collected in both old and new ways, which can increase on-scene crash investigation times.

3 Cs

- Favor having a talk around channel (TAC) to communicate on-scene.
- Need interoperable communications—most direct access by radio.
- Would like SSP to have STARS (Statewide Agencies Radio System) for communication.
- Trust crucial between VSP and Serco/VDOT/contractors and other responders.
- Fire/VSP relationships at scene can be strained because of different views regarding clearing roadway and scene safety.
- TIM meetings help nurture trust. But typically not well attended.
- SHRP 2 training helps build relationships.

Training

- High turnover creates problems because of the need to train people constantly.
- Incident command system (ICS) can be problematic because of the erratic nature of fire response with volunteers and experienced personnel.
- Photogrammetry has helped with clearance time in Northern Virginia. Training an issue.

Incident Impact Estimator Tool

- Tool will be useful for detour decisions.

Virginia Department of Transportation

General

- VDOT catches the grief with incident-related congestion.
- Other responders perceive VDOT as inconsistent across the state (e.g., SSP schedule, Turnkey Asset Maintenance Services [TAMS] contractors).
- Towing industry thinks VDOT wants to single source heavy-duty towing.
- Have IRTs all around the state. Fire always has the tools ready. They do inspections. They could support our work zone trainings, inspections, and outreach. Local area headquarters are stretched so thin. To have one per county would help.
- VDOT needs legislation to support quick clearance, to make progress.
- Need a revenue stream for towers to participate actively in quick clearance. Georgia has a very strict stopwatch. It is a good model.
- VDOT should not be funding a quick clearance program. The tow program is under VSP—maybe they should pay for it. May need a rainy day pool. VDOT's focus is to build, operate, and maintain the transportation network.

- HAZMAT is rare and generally not an issue for quick clearance.

Dispatch/Response

- VDOT does not always get notified in a timely manner.
- SSP is next best thing to motorist calls for incident detection.
- 90% of time, SSP is first on-scene in some areas.
- Without full SSP coverage, TOC is hindered.
- Some local 911s do not use mile markers and this can create a problem.
- Response to incidents and expectations—from TAMS—is not consistent across the state.
- In rural areas without SSP, VSP is often the only responder.
- In rural areas, need IRTs 24/7 that can take vehicles home. One truck with fire/rescue and VSP monitor, the other a crash cushion.
- Towers get hung up in the queue. Need to be certified on equipment and trained—and be allowed to use red lights along with yellow. Need Code changes.
- When people start taking the shoulders, tows cannot get in.
- VDOT IRT should have red lights.
- Instant push/pull from VDOT is a big item needed to be looked at—even if just getting vehicle off the road to the shoulder/median—pushback from towers because they lose money once vehicle is off the road.
- Open to looking into providing images to towers.
- One major incident capacity constraint is the Fire 1+1 policy. If VDOT can get to the scene to set up crash cushion, fire can leave.
- Fairfax has only 1 tow company [per zone]. No rotation. The police love it.
- County tow boards can be a challenge in achieving statewide consistency with OIT.
- Removing inefficient towers from the rotation may have happened one or two times. It should be more often.

Scene Management

- VSP troopers are busy on-scene, VDOT can have a more active role with towers—providing visuals, descriptions, etc.
- SSP do not have the training to be incident commander.
- Not having the right authority on-scene from VDOT to make decisions slows the clearance process—closure, detour, traffic control decisions, clearance at night with a work zone.
- SSP needs a hold harmless clause.
- SSP make the motorist sign the waiver and then keep it on file; but this may not hold up in court. Only forepersons can now move vehicles. Wish SSP could also push vehicle to the side of the road. Major scenes last for several hours anyway. Pushing would significantly help in small incidents. VSP has its own 1-hour training.
- VSP and fire do not have liability waivers to push.
- VDOT needs to engage responders actively in detour plans.
- At the minimum, the detour should be a joint decision of VDOT and VSP.

- At a construction project, VDOT has a traffic control specialist. He or she has the expertise needed to do the job. Need someone like that for TIM.
- VDOT makes sure infrastructure not damaged and detours are set up.
- VDOT communicates with VSP a lot.
- SSP role is to secure scene.
- If a vehicle is in the lane, then VSP should call the tow. New VSP troopers who do not know this allow car owners to use their own tower. Much quicker for VSP to call.
- Queue management critical to preventing secondary incident—TAMS major responsibility.
- Towers are not the last to leave. They get hit a lot. VDOT gives them protection.
- Number one challenge to quick clearance is being able to push a vehicle out of the travel lanes. Towing concerns are second, and communication is third.
- Photogrammetry is used in Northern Virginia and has helped with clearance times but involves a lot of training. Getting the equipment to the scene is a hassle.
- Variability in practices/rules for moving deceased persons—some state police personnel seem to be able to do it; some do not and wait for coroner.

3 Cs

- Need champions at the top level to promote AARs and to make recommendations happen. Need trusted, skilled, local facilitators to bring people together, extract lessons, and avoid finger pointing.
- Need to continue building relationships.
- Pre-planning for major events—detour routes need upgrading.
- VDOT should be bringing options, detour plans, to the table. We know our road network. We can optimize signal timings on detours, make operational/geometric changes, provide traveler information, and perform traffic control.
- Communication is where things break down. Radio systems, personalities, and response agency missions impact that.
- Number one problem is communication. Fire cannot talk to VSP. We can talk to VSP only through portable.
- Communication technology is a big problem.
- No protocols for SSP to talk to VSP trooper or dispatcher. This is done by choice—streamlines communication; control room has to be in the loop.
- There is an interoperability committee. It is going places on the city side, but not on the state side.
- Constant educational effort. VSP troopers are in rotation/turnovers.
- VDOT staff not properly trained.
- VDOT needs to adopt SHRP 2 as a performance standard. Make it mandatory like VSP has done.
- Recovery is a joint effort by VSP, VDOT, and towing. Need some type of formal clarification of roles and responsibilities.
- Some areas have a big problem with undertrained tow truck operators, outdated equipment. So many crashes take far longer to clear than necessary.

Incident Impact Estimator Tool

- We would like to know the hidden costs to the economy and the Commonwealth and the traffic forecast for the next hour. In court, the incident commander (IC) could provide the predicted traffic situations as the rationale for the decisions made.
- Tool providing cost figure, real-time information, where traffic is going would be priceless. VSP could install app on laptop.

Virginia Department of Motor Vehicles and TIM Best Practices Workgroup

General / Response / Scene Management

- There are differences across the state and some confusion in the interpretation of the policies between field and central ME office regarding (1) which road crash fatalities to respond to; (2) moving a body to the side of the road; and (3) communication—who should call who, when, and how often. Office of Chief Medical Examiner (OCME) and the Statewide TIM Best Practices Workgroup are currently working together to understand these topics better and to provide necessary clarifications to all responders.
- Per OCME, moving a body to a shoulder is generally not a problem.
- ME office wants photo document of the field conditions at a crash for records.
- Towing not interested in joint training. They are not making money if they are not working in the field.
- With incentive tow program, asset damage (such as gouging the road) is possible when dragging a vehicle to the roadside. Weighing such consequences of different actions and deciding as a group to follow an incident management plan seem agreeable to all responders.
- Only two ACTAR (Accreditation Commission for Traffic Accident Reconstruction) Level 3 certified officers currently in Virginia for accident reconstruction. Need many more.
- For some crashes, accident investigation has to be done immediately and not postponed, because of defiled scene or potential for washout by rain.
- Some field resistance exists for accident investigation technologies that are vastly different from existing practices.

Incident Impact Estimator Tool

- An understanding of the impacts stemming from a crash, such as congestion delays on the primary and detour routes and secondary incidents, is helpful for an ME to make decisions (to allow moving a body to shoulder), especially for suicide cases.

APPENDIX C

NOTES FROM OTHER STATE DOT INTERVIEWS

Transportation TIM representatives from Georgia, Florida, Illinois, Washington, California, Texas, North Carolina, and the Pennsylvania Turnpike were contacted about specific programs and/or general TIM practices. The following are notes that were documented from the interviews.

Georgia

Towing and Recovery Incentive Program (TRIP)

- Federally funded through a Congestion Mitigation and Air Quality (CMAQ) grant.
- Operates in Metro Atlanta area only.
- Highway Emergency Response Operators (HERO) supervisor typically activates TRIP, monitors the clock, and updates the Traffic Management Center (TMC) to keep the log.
- Time strictly monitored for incentive (even if unusual incident).
- There is no incentive paid if there is no After Incident Review (AIR).
- TRIP activations are typically for commercial vehicle wrecks.
- There are approximately 100 activations per year.
- In 90 minutes, everything has to be off to the shoulder. There is a penalty beyond 90 minutes.
- Monthly inspections for different companies each month.
- Tow companies are under contract for specific zones, and there is no tow rotation.
- Length of TRIP activation zone is not as important as hot spots—try to be fair.
- Every 2 years an evaluation is performed.
- State police is a big ally.
- Benefit-cost ratio is 11:1.

Highway Emergency Response Operators (HERO) Motorist Assist Program

- HERO relocates vehicles to shoulder.
- HERO vehicles can push and pull up to fully loaded 18 wheelers, even if brakes are locked.
- Operators have 300 hours+ of in-class training and 200 hours of ride time. Training includes medical first response, hazardous materials, vehicle extrication, and vehicle relocation.
- They have a special truck equipped with push bumpers and chains.
- The laws assist them in the ability to be aggressive in getting wrecks cleared from the interstate.
- 24/7 operation in Metro Atlanta area.
- Can use shoulders. No state police approval needed.
- Operate red lights and classified as emergency vehicles.

- State Farm sponsorship lasts 5 years. Logo on the vehicles.
- Majority is federal funding. Some state dollars. Not CMAQ.
- No pushback from towing industry.

TIME (Traffic Incident Management Enhancement) Task Force

- Multiple agencies at the state level that have come together to work closely on improving TIM practices.
- It is a non-profit.
- They do fundraising.
- Have sponsors.
- They do all training and evaluation of wreckers for TRIP.
- Open Roads Policy (ORP). Helps focus energies of all responders and formalizes relationships and commitments to efficient traffic incident management.

Additional TIM Note

- None of these was a mandated program. The Georgia DOT, state police, etc., got together and tried these ideas.

Florida

Rapid Incident Scene Clearance (RISC) Program

- Similar to Georgia's TRIP for timelines and incentives.
- Spans both urban and rural areas.
- Rural targets much more difficult to meet because of lack of towers.
- May be several towing vendors on a rotation list.

Road Rangers

- Funded and managed by FDOT.
- One contract per district.
- State Farm sponsors service on the turnpike. Road Ranger vehicles include State Farm logos and color scheme. Currently in the process of expanding State Farm sponsorship to entire state.
- Moving from using assistance comment cards in vehicle to SurveyMonkey online survey.

Additional TIM Notes

- Statewide TIM team and local TIM teams promote coordination, education, and situational awareness; develop and disseminate policies; and address challenges that arise.

- Open Road Policy—between FDOT and the Florida Highway Patrol.
- SHRP 2—focusing on where training is needed most.
- All TMCs are collocated with the police. That has strongly supported coordination and communication.
- FDOT is decentralized—each district may work differently.

Illinois

Minutemen—Emergency Traffic Patrol

- Fleet includes 35 medium-duty patrol units, 11 light 4x4s, and numerous specialty and heavy-duty units: 80 total. The 35 patrol trucks completely upgraded now with advanced technology, hands-free vehicle relocation units.
- Smallest vehicles have capacity of 29,000 GVW. Also have 60 ton and 100 ton capacity rotators.
- All Minutemen are badged—special badge and uniform (not police). Motorists familiar with them.
- Trucks have red lights and blue lights and are classified as emergency vehicles. Red-white-amber light is the legislation. Blue light was an informal agreement between the Illinois DOT (IDOT) and the Illinois State Police (ISP).
- 90% of time they use shoulders (no permission from ISP needed for each incident).
- Will remove shoulder/disabled vehicles. Any vehicle on expressway is dangerous.
- Relocate vehicles on the top of ramps for private towers to pick up—have great relationship with towers.
- IDOT does all the training.
- They are self-insured.
- Do not have sponsors.
- Do not have any incentive program.
- Current operating expenses around $15 million to $18 million/year.
- Rural areas cannot afford Minutemen-type operation. Initial start-up costs are very high.

Additional TIM Notes

- Communication—all responders (ISP and some Chicago Fire) on the same technology: StarComm. Can talk to each other (car-to-car). Have both an in-car unit and a portable radio. Costs millions of dollars. But need the tools to do the job.
- StarComm also has geolocation. Automated vehicle location (AVL) is important so closest truck can be dispatched to an incident.
- All IDOT maintenance vehicles have StarComm too.
- Lane/road closures: IDOT and ISP directors have signed a document together that states unless standard traffic management practice is used, lane closure is illegal. Therefore, the two agencies need each other to close a road properly.
- ISP and IDOT—no joint policy. Great working relationship. Training together.

- It is a long-term process to educate elected officials about the need for red lights and emergency status for patrol. With changes in government policies and governor priorities, may have to start all over again.

Washington State

Incident Response Teams

- Eleven teams operate across the state.
- Staged near hot spots prior to special events and peak periods.
- Dispatched along with WSP.
- 90% of trucks have diesel pump out capabilities.
- IRT can run traffic lights. WSDOT tow trucks cannot.
- Have lights and sirens.
- Hold harmless—have same roadway clearance authority as police and fire.
- Drivers have to pass criminal background check and are vetted through WSP via an Authorized Emergency Vehicle Permit (AEVP).
- Have a set $9 million annual budget, per state law.

Additional TIM Notes

- WSDOT has authority to push, pull, drag anything that is blocking a roadway.
- Rotational tow for state roads, under 26,000 GVW. Major Incident Tow (MIT) are special teams with 2 rotators. They use a flowchart (nine-box) for incident management.
- Bonus, timelines quite similar to Georgia's TRIP and Florida's RISC program, except time frames are different based on the region, and MIT activated by patrol.
- Joint Operations Policy Statement (JOPS): resource sharing agreement with WSP (facilities, wireless, towers, repeaters, etc.).
- AARs are carried out if any responder thinks there is something to learn. Quick 10-minute meetups in a parking lot after the incident also carried out if needed.
- Agreements in place to allow putting a tarp over a fatality and towing the vehicle if it is blocking lanes.
- Relationships are key to effective TIM quick clearance.
- Challenge with getting fire to attend training—Association of Washington Fire Chiefs working to improve attendance.

California

General Notes

- Incident management tool— Bay area doing an app.

- CHP (California Highway Patrol) uses Lidar to make quick measurements on-scene. Photogrammetry is also used.
- Have coordinated with some coroners (of 50 in state) to remove a vehicle when the body is completely inside and CHP has finished their investigation. But not standard practice.
- No MOUs.
- Under law, towing is responsible for protection of the vehicle. Hold harmless holds only for cargo, not for vehicles.
- FHP are all contracted tow companies. Tow only stranded or disabled vehicles—not vehicles involved in crashes.
- Rotation should be used for incidents, but sometimes FHP is called anyway if they are closer.
- FHP requires background checks, SHRP 2 training + additional CHP training; trucks are inspected.
- "Steer clear" laws (for fender benders): maximum $1,000 fine, possible jail time, misdemeanor. Not actively ticketed because the penalty is so severe.
- Move Over law convictions are difficult because "slow down" is not clearly defined.
- Need more communication among responders.
- Do not track secondary incidents well. Each TMC tracks incident times differently—no consistent system currently (trying to get one).

Texas

General Notes

- Austin TMC collocated with police department—good relationships.
- Only experienced police officers respond to highway incidents in Austin.
- Police motorcycle units—able to get in and out of a scene faster. Motor unit will escort tower to scene if needed (stuck in backup).
- Department of Licensing and Regulation has required all the towers to get continuing education credits.
- Texas has a statute that a deceased person can be moved if hazard to traffic. Law enforcement has that authority. Have MOU with ME to invoke this law, if needed.
- Motorists always call City or local sheriff about accidents—not the state police.
- The Texas DOT (TxDOT) has authority to move deceased crash victims but generally does not use that authority.
- Fire is always dispatched. Law enforcement not always.
- TxDOT is not typically on incident scenes anymore—contractors are. However, TxDOT is identified as primary responsible party to remove private automobiles off the road—not contractors.
- HEROs have push bumpers, but high insurance premium, so usually do not push.
- State police involved in investigation only in unusual situations.
- Differences in TIM policies and procedures across the state.
- Decentralized maintenance system with TxDOT.

- Low attendance at TIM meetings—may be afraid of criticism?
- Coordinated response does not meet everyone's requirements.
- Not strong in performance measurement. Typically track response time (not clearance time or secondary incidents).
- Expertise and training are challenges for using photogrammetry.

North Carolina

General Notes

- To push a vehicle to the shoulder, no need to get permission from owner. Have MOU between highway patrol and police, which specifies how the law in quick clearance is carried out.
- Per law, NCDOT is not liable for damage.
- Charlotte County has zone towing. No contract. Rotation everywhere else.
- Specific construction project: SSP/contractor shares incident picture with tower. State agency taking picture would become public record.
- TOC takes closed circuit TV screenshot and sends to tower. So far, the best tool we have to show the scene, overturned vehicle, etc. (no bodies, no IDs, no license plates, etc.).
- Record videos for training. Not hiding. Not advertising.
- Collocated TOC with highway patrol and National Guard. Ideal model going forward.
- Working on joint field training of SSP and highway patrol.
- Statewide HAZMAT cleaning contract where there is no clear responsible party.
- HAZMAT cleaning rates are set in contract. The idea is that NCDOT will get paid by the responsible party, but not easy to get paid.
- Fender-bender law says "shall" not "may." More an issue of education/awareness than enforcement.
- Do not usually hire off-duty state patrol for construction projects. But will hire local police or sheriff.
- In urban areas, SSP dedicated to incident management. In rural areas, may handle signals, pavement markings, etc., as add-on tasks beyond incident management.
- Tried heavy-tow list, statewide, managed by DOT, with equipment specs—shutdown due to lawsuits.
- Tower has to be on-scene in 30 minutes with time restriction; they show up with some equipment, assess the scene, and then decide what more to bring.

Pennsylvania

General Notes

- Turnpike has different legislation, charter, rules, and regulations compared to Pennsylvania DOT. Turnpike could clear incidents.

- No towing rotations. Towing contract used.
- Towing contractors should adhere to minimum equipment requirements and attend training.
- Turnpike has centralized operations and could dispatch towing.
- Central coordination and data collection point is very important. Reports are used to improve incident management system.
- Building relationships with all partners is key.
- All responders used the same radio frequencies. Turnpike gave radios to all responders.
- Maintenance and operations did lot of joint training, along with fire, police, and towing.
- Lot of pre-planning done for construction and events, with different traffic plans.
- A trooper was assigned specifically to the turnpike.
- Turnpike did not close for long hours waiting for tractor-trailer companies to pick up their cargo from incident site. Opening roadway quickly was the focus of the turnpike.
- Coroner policies/approaches on moving a body in a fatal accident were different across the state.
- Turnpike has contract with cleanup companies for HAZMAT incidents.