# Traffic Incident Management and Reducing Secondary Crashes in Arizona

**SPR-740**
**November 2018**

18-386

ADOT Arizona Department of Transportation Research Center

# Traffic Incident Management and Reducing Secondary Crashes in Arizona

**SPR-740**

**November 2018**

**Published by:**

Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007
In cooperation with
U.S. Department of Transportation
Federal Highway Administration

This report was funded in part through grants from the Federal Highway Administration, U.S. Department of Transportation. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data, and for the use or adaptation of previously published material, presented herein. The contents do not necessarily reflect the official views or policies of the Arizona Department of Transportation or the Federal Highway Administration, U.S. Department of Transportation. This report does not constitute a standard, specification, or regulation. Trade or manufacturers' names that may appear herein are cited only because they are considered essential to the objectives of the report. The U.S. government and the State of Arizona do not endorse products or manufacturers.

This report is subject to the provisions of 23 USC § 409. Any intentional or inadvertent release of this material, or any data derived from its use, does not constitute a waiver of privilege pursuant to 23 USC § 409, which reads as follows:

***23 USC § 409 — Discovery and admission as evidence of certain reports and surveys***

> Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 148 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

## Technical Report Documentation Page

| | | |
|---|---|---|
| 1. Report No. FHWA-AZ-18-740 | 2. Government Accession No. | 3. Recipient's Catalog No. |
| 4. Title and Subtitle Traffic Incident Management and Reducing Secondary Crashes in Arizona | | 5. Report Date November 2018<br>6. Performing Organization Code |
| 7. Author Eric Rensel, Peter Rafferty, and Charles Yorks | | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>Gannett Fleming<br>207 Senate Avenue<br>Camp Hill, PA 17011-2316 | | 10. Work Unit No.<br>11. Contract or Grant No. SPR 000-1(184) 740 |
| 12. Sponsoring Agency Name and Address<br>Arizona Department Of Transportation<br>206 S. 17th Avenue<br>Phoenix, AZ 85007 | | 13.Type of Report & Period Covered<br>14. Sponsoring Agency Code |
| 15. Supplementary Notes Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration | | |

16. Abstract

Arizona's current traffic crash data collection system including data for secondary crashes positioned the state to make significant advancement toward understanding the nature and impacts of those crashes. This study concentrated on identification of the benefits of effective Traffic Incident Management (TIM) practices on secondary crashes in terms of improved safety for motorists and first responders. The study begins the process of developing an assessment model that examines a well-defined situation and a known threat, and estimates the relative risk. Based on the findings, recommendations were made to establish several action items for statewide TIM implementation and relationship building. The study resulted in identification of opportunities to collect additional data that will help better understand the time and spatial relationships of secondary crashes, linked to the time and spatial relationships of TIM tactics engaged in primary crashes. This has the potential for enhancing the recommended risk model that considers a number of factors and necessary data that would become available.

| | | | | |
|---|---|---|---|---|
| 17. Key Words Traffic incident management, secondary crash, risk model, roadway safety, performance measures | | 18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161 | | 23. Registrant's Seal |
| 19. Security Classification Unclassified | 20. Security Classification Unclassified | 21. No. of Pages 23 | 22. Price | |

# SI* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yard | 0.836 | square meters | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | milliliters | mL |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| | | NOTE: volumes greater than 1000 L shall be shown in $m^3$ | | |
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| | | **TEMPERATURE (exact degrees)** | | |
| $^oF$ | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | $^oC$ |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-Lamberts | 3.426 | candela/$m^2$ | cd/$m^2$ |
| | | **FORCE and PRESSURE or STRESS** | | |
| lbf | poundforce | 4.45 | newtons | N |
| lbf/$in^2$ | poundforce per square inch | 6.89 | kilopascals | kPa |

## APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.202 | pounds | lb |
| Mg (or "t") | megagrams (or "metric ton") | 1.103 | short tons (2000 lb) | T |
| | | **TEMPERATURE (exact degrees)** | | |
| $^oC$ | Celsius | 1.8C+32 | Fahrenheit | $^oF$ |
| | | **ILLUMINATION** | | |
| lx | lux | 0.0929 | foot-candles | fc |
| cd/$m^2$ | candela/$m^2$ | 0.2919 | foot-Lamberts | fl |
| | | **FORCE and PRESSURE or STRESS** | | |
| N | newtons | 0.225 | poundforce | lbf |
| kPa | kilopascals | 0.145 | poundforce per square inch | lbf/$in^2$ |

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

# CONTENTS

## LIST OF ACRONYMS

| | |
|---|---|
| AASHTO | Association of American State Highway Transportation Officials |
| ADOT | Arizona Department of Transportation |
| CMF | crash modification factor |
| DPS | (Arizona) Department of Public Safety |
| ELG | executive leadership group |
| EPDO | equivalent property damage only |
| FHWA | Federal Highway Administration |
| KABCO | scale of injury severity |
| MSELG | multi-state executive leadership group |
| RAM | risk assessment methodology |
| TIM | traffic incident management |
| TraCS | Traffic and Criminal Software |
| TRB | Transportation Research Board |

As defined by the Federal Highway Administration (FHWA), traffic incident management (TIM) consists of a planned and coordinated multi-disciplinary process to detect, respond to, and clear traffic incidents so that traffic flow may be restored as safely and quickly as possible. Effective TIM reduces the duration and impacts of traffic incidents and improves the safety of passing motorists, initial crash victims, and emergency responders. Besides emergency responders — law enforcement, fire and rescue, hazardous material units, medical transport, and towing and recovery companies — TIM stakeholders also include the public safety dispatchers, traffic management communications staff, and technical experts such as traffic engineers and emergency management officials.

The concern in controlling and decreasing traffic congestion due to an initial roadway incident is that a related traffic incident, termed a secondary crash, may occur. A secondary crash may have even more serious, sometimes deadly, consequences than the original incident. This study defines a secondary crash as any crash that follows an initial crash or other reportable roadway incident. A secondary crash may occur either in traffic moving in the same direction as the original incident or in traffic moving in the opposite direction on the same roadway.

Add to the above list of emergency responders all those motorists affected by initial crashes, other roadway incidents, and the resulting traffic congestion, and every person on the road is at risk from a secondary crash.

Interagency cooperation in the use of advancing technology was seen as key to meeting public safety risks. Led by the Maricopa County Department of Transportation (MCDOT) and the Arizona Department of Transportation (ADOT) in 1996, AZTech formed as a unique partnership of public agencies, including the Arizona Department of Public Safety (DPS), that operate with a regional traffic management approach in the Phoenix Metropolitan area. AZTech guides the application of intelligent transportation system (ITS) technologies for managing regional traffic. As such, TIM was identified as a regional issue deserving of attention, and DPS has chaired the AZTech TIM Coalition since it was established in 2010 (see the coalition charter in Appendix A). The coalition is a joint TIM endeavor in metropolitan Phoenix involving state and local police, fire agencies, state and local transportation agencies, metropolitan planning offices, and towing companies. The coalition is dedicated to multi-disciplinary collaboration for safer and more efficient management of roadway incidents. The main operational principles are the following:

- Responder safety: Reducing risks to the safety of first responders means reducing the number and duration of traffic incident responses that expose the responder to roadway/traffic hazards.
- Safe and quick clearance: The TIM standard “Every 1 minute of blockage results in 4 minutes of delay” emphasizes the need to educate the driving public on Arizona’s Quick Clearance Law and the Move Over Law, as well as to encourage first responders in mitigating traffic congestion through quick, effective clearance practices.
- Prompt, reliable, interoperable communications: Safer, faster clearance times are enabled by better onsite communications among different agencies responding to the same incidents, as well as between responding agencies and the traffic operations centers.

Keeping this in mind, DPS and ADOT partnered to prioritize the issue of secondary crashes and their causes. Data collection was key to a better understanding of contributing factors in secondary crashes and what TIM countermeasures were effective. In October of 2010, DPS officers began collecting basic data to support the TIM initiative. Using available data fields on the DPS electronic crash reporting system, Traffic and Criminal Software (TraCS), DPS entered data on roadway clearance time, incident clearance time, whether the crash was secondary, if the primary incident was a crash, and if the secondary crash involved a responder.

In 2014, the Arizona Traffic Records Coordinating Committee (TRCC), part of the Governor's Office of Highway Safety, officially adopted a revised statewide crash report form that incorporated the same fields — incident clearance time, roadway clearance time, and if the crash was a secondary one — already being collected by DPS. That meant data previously collected only by DPS was now being collected by law enforcement agencies statewide on all crashes. The amount of crash detail collected was seen as a topic for further study, prompting this research project. (Note that in late 2017, while this study was concluding, additional revisions were made to the crash report form to identify when responder disciplines were involved in a secondary crash, again reflecting what DPS had been already collecting.)

DPS knows first-hand the impact secondary crashes have on safety, congestion, and responder resources. Between 1958 and 2015, the department lost 29 officers in the line of duty; of the 17 officers who were killed in traffic-related incidents, 11 died in secondary crashes. This ADOT research project used crash data collected and provided by DPS for 2011-2015 from the state highway system to serve as the basis for analysis in this report.

More than half — approximately 67 percent — of secondary crashes on the state highway system from 2011 through 2015 involved two vehicles, while 24 percent involved three or more vehicles; 9 percent involved only one vehicle. Throughout Arizona, most of the secondary crashes (85 percent) occurred in Maricopa County, the most populated Arizona county. Looking at the reported time of day for crashes, 86 percent of secondary crashes occurred between 0600 hours (6 a.m.) and 2000 hours (8 p.m.). In short, most of Arizona's secondary crashes occurred in populated areas during times when the largest proportion of traffic was active on the transportation network, but secondary crashes still occurred on uncongested rural roadways as well, including seven of the DPS officer fatalities mentioned above.

An increasing trend for total crashes is evident across the data time period. (The documentation used did not include some data for January and February 2011, and thus 2011 should not be interpreted as having unusually low crash occurrences.) The graph in Figure 1 shows the annual trend of both total and secondary crashes.

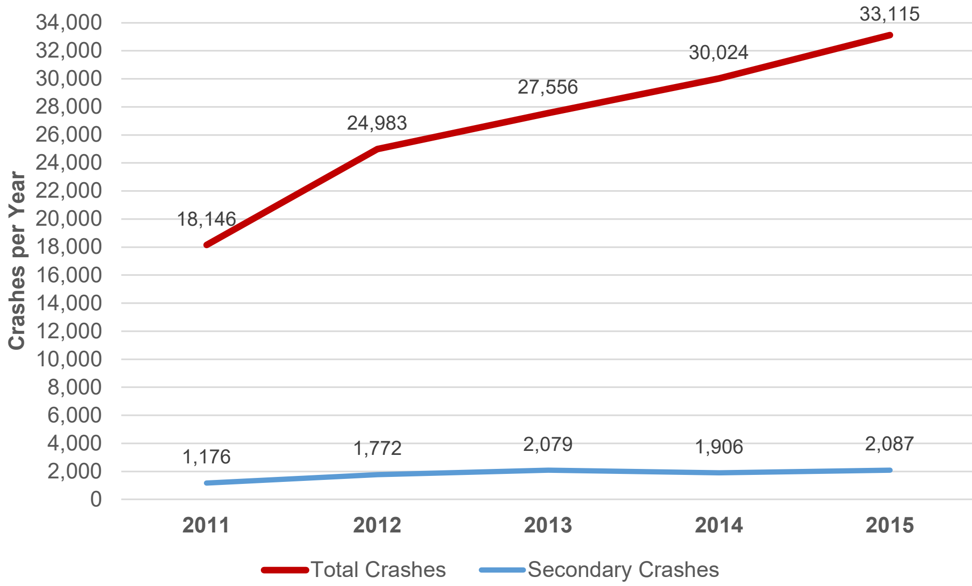


**Figure 1. Comparison of Total and Secondary Crash Investigations by DPS on the Arizona State Highway System 2011-2015***

*Not included are data for several days from January and February of 2011.

The next steps toward increased TIM effectiveness may lie in the ability to better predict when and where secondary crashes are expected and then implement proven TIM strategies following data-driven evidence of safety improvement. One idea at the core of this study was that a risk assessment model might be a suitable tool for doing such analysis based scientifically on available data. A risk assessment model examines a well-defined situation and a known threat or hazard and then estimates the relative risk.

For TIM practices in Arizona, it was envisioned that a future risk assessment model could be used to assess the secondary crash risk associated with certain locations at a given time. Such risk assessment could give advance notification of responders at the scene and inform more efficient resource allocation for reducing secondary crashes. TIM practitioners would have a tool to develop and refine TIM countermeasures for the most effective approach to minimize secondary crash risk.

This research is the first step in examining what that future risk model might look like and what additional data may be needed. An objective of this research is to begin the process of defining situations presenting the risk of secondary crashes and identify a possible risk assessment model with the ability to accept identified definitions.

Developing a risk assessment model in the future builds on consistent crash data collection such as what DPS has instituted. Enhancing data collection offers opportunities to improve the outputs of the risk model, thereby improving preparedness for secondary crashes. Interagency collaboration enables comprehensive data collection as one of many benefits from coordinated communication, training, and information sharing. Below are a series of interconnected recommendations:

- *Electronically link secondary crashes to their corresponding primary incident.* Documenting this relationship would allow assessment of the effect of primary incident duration and other characteristics on the occurrences of secondary crashes. While it is a common practice in secondary crash reports to identify the primary incident in the narrative, there is no searchable electronic field that links the secondary crash to the corresponding primary crash or incident.
- *Deploy a pilot program to document the use of TIM countermeasures.* Collecting a sample of strategies associated with traffic incidents may be a realistic approach that does not burden the reporting officer. Future research may use this information to assess the effectiveness of the various countermeasures.
- *Contribute statewide data collection toward a national-level effort to develop crash modification factors for preventing secondary crashes.* In Arizona, DPS collected five years of crash data, a considerable body of data which formed the basis for this study. However, the development of crash modification factors (CMFs) for TIM practice in regard to secondary crashes involves extensive modeling and analysis to quantify the benefits of TIM tactics, and depends on the availability of a statistically significant sample of national data from diverse geographical and operating conditions beyond what may developed at a single state level. While CMF research may be most appropriate at a national level, Arizona can contribute through continuing the data collection efforts among partner agencies as has been pioneered by DPS, which was an early leader in documenting secondary crash data.
- *Work toward a statewide system of sharing ideas, developing best practices, and implementing training in TIM practices.* As the AZTech TIM Coalition has demonstrated regionally, blending the resources and efforts of governmental, non-governmental, and private sector organizations can lead to safer, more efficient management of incidents impacting Arizona roadways.

For this ADOT study, the research team conducted four Arizona workshops in 2016 with TIM practitioners from various disciplines and jurisdictions across the state. The team used feedback from those TIM participants to compile suggestions designed to build on established interagency cooperation led by DPS and the AZTech TIM Coalition:

- Beyond the Phoenix metropolitan area, catalog existing responder groups of all disciplines and jurisdictions, and provide a statewide structure as needed.
- Establish a manageable statewide system for sharing TIM information, traffic data, and educational information clearly and promptly among smaller local and regional responder groups.

- Continue the multi-agency operation and training coordination effort through the Arizona Traffic Incident Management website (tim.az.gov) to meet training needs statewide and enable joint training/education efforts at local and regional levels.
- On a systematic basis across the state, positively affect driver actions and responder strategies with simple, clear public messaging that consistently focuses on preventing secondary crashes through defensive practices.
- Develop and clearly communicate the business case for effective TIM practice, sending a consistent, continuous message to the Arizona driving public and decision makers.
- Develop a process for requesting and conducting a post-incident review, which may produce formal documentation informing improved TIM practices.
- On a statewide basis, continue improving coordination of multi-disciplinary, multi-jurisdictional planning for all forecasted events, such as known weather conditions, roadwork projects, and special events.
- Continue active participation in interagency TIM efforts at the state and national levels to advance enhancements to data collection, information sharing, and TIM practice development.

### BACKGROUND

The data provided by the DPS for crashes that had occurred on the state highway system between 2011 and 2015 showed more than 134,000 crashes of which approximately 7 percent (9,380) were secondary crashes.

More than half — approximately 67 percent — of the secondary crashes on the state highway system from 2011 through 2015 involved two vehicles, while 24 percent involved three or more vehicles; 9 percent involved only one vehicle. Throughout Arizona, most of the secondary crashes (85 percent) occurred in Maricopa County, the most populated county in Arizona. Looking at the reported time of day for crashes, 86 percent of secondary crashes occurred between 0600 hours (6 a.m.) and 2000 hours (8 p.m.). Secondary crashes repeatedly peaked in the months of October and November during the five years examined, as shown in the figure below.

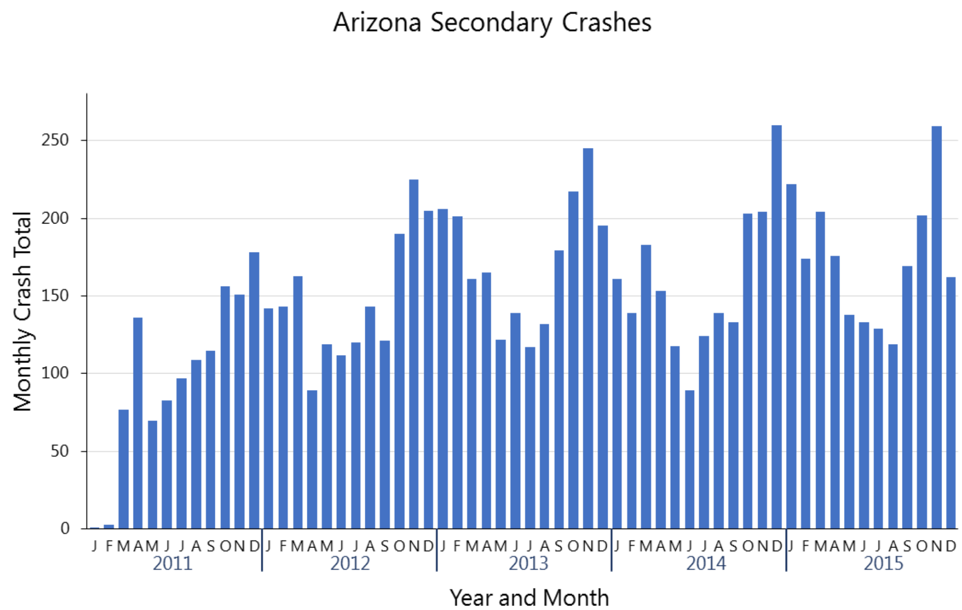


**Figure 2. Arizona Secondary Crash Totals on the State Highway System 2011-2015**

In short, most of Arizona's secondary crashes occurred in populated areas and during times when the largest proportion of traffic was active on the transportation network. While this is significant, it should also be noted that of the 11 DPS officers killed in secondary crashes, seven of those fatalities occurred in rural Arizona on non-congested roadways.

Close examination of the data provided by DPS specific to collection of the TIM performance measures revealed many lessons learned and improvements made over time to improve the quality of the TIM data being collected. The TIM data fields were initially collected on a mandatory crash supplement rather than the crash report itself. This was done to assure the collection of the data even when the electronic version of the crash report was not used. During the first year of electronic crash reporting, officers could still use paper forms when the electronic crash report form was not readily available in the field due to lack of equipment or other needed resources. Even though electronic reporting was not mandatory, the majority of crashes were reported using the electronic method in TraCS.

Prior to electronic reporting, locating crashes by assigning the latitude and longitude occurred when the crash report was manually entered into the ADOT crash records system. To supplement the DPS electronic crash report, ADOT and DPS created an incident location tool that functioned with TraCS to enable the officers to capture the latitude and longitude of incident locations via three electronic options on their devices. (Because these three options created inconsistent reporting initially, up to 14 percent of early secondary crash data used in this study lacked latitude and longitude information.) As DPS continually refined its reporting procedures, a lesson learned was to require the officer to specifically report the latitude and longitude and not to default to the automatic entry based on the location of the device. This was key because many times the device location was no longer the same as the incident location; the officer may have been entering the data sometime after the incident, as in the case of delayed reports or when the crash was removed from the roadway.

As the electronic reporting capability was refined, use of electronic reporting became mandatory for all crash reports and geo-locating incidents by latitude and longitude by selecting the tool became a mandatory field.

When the TIM performance measures were initially added to the electronic crash form the use of time stamps verses calculating durations was elected for consistency with other times reported on the crash form such as the time of the crash and time of officer arrival. Times were recorded using the 4 digit military time format. Very early in the internal analysis of data, it was realized that the date must also be captured to accurately calculate duration when the crash investigation and/or scene cleanup passed midnight. Until this error was addressed on the form, internal analysis by DPS looked closely at durations exceeding 16 hours to correct the issue. Ultimately during further refinements of the electronic form, the format of these time stamps was changed to capture the date in the background. Accurately linking date and time which improves calculations of duration and thus enables more dynamic analysis within future risk assessment models.

Another issue observed early during internal analysis was related to when the crash did not block any lanes beyond the time it took responders to move it off the roadway or, in cases where the crash was immediately removed, clearing the incident. In these cases, the roadway clearance time and incident clearance time would be zero, requiring the officers to put the time of time of crash into the respective fields. This was not initially intuitive and initial training suggested that, if the time duration was zero, or not applicable, then field would be left blank. This was later addressed in the crash report instructions, advising officers that if the crash did not result in a closure of the roadway, then to enter the time of the crash. While it may involve only a slight difference, DPS chose to use the time of the crash versus time of first awareness because the roadway and associated traffic would be impacted beginning at the time of the crash.

To demonstrate the concept for the future risk model, the research team chose to modify the automated security risk assessment methodology (RAM) tool developed at Sandia National Laboratories. The Sandia model calculates relative risk by attempting to define the likelihood of a terrorist attack; the consequences of a successful attack; and the effectiveness of various security strategies (Jaeger, Roehrig, and Torres 2008).

While initially designed to assess and manage an obviously different type of risk, the Sandia model was designed to be adaptable and is publicly available. Linking performance measures to relative risk theory helps focus the existing and potential Arizona data on TIM practices. When applied to TIM, the likelihood of a terrorist attack was replaced in the model's equation by the likelihood of a secondary crash, the consequences of a successful attack by the cost of the crash, and facility security strategies were replaced by TIM strategies. Future modifications to this risk model might include additional variables described later to enhance the probability or likelihood of a secondary crash, making this assessment more dynamic and useful to warn responders in the area.

The three components used to determine risk are the probability of a secondary crash, the effectiveness of TIM strategies, and a measure of the crash's severity or impact. The relative risk function, as adapted for secondary crashes and TIM strategies, takes the following form:

$$R = f(P2C, PTIME, C)$$

$$R = P2C * (1-PTIME) * C$$

where

R = relative risk

P2C = probability of a secondary crash

PTIME = probability of TIM strategy effectiveness

C = consequence of extended duration

## RISK MODEL ESTIMATION

An objective of the modified Sandia risk assessment model was to obtain a relative risk score using a combination of inputs from statistical models and coefficients obtained from experienced traffic engineers, previous studies, and research, as outlined here.

### *Variables and Estimates for Risk Assessment Model*

In the recommended risk model, the risk term, R, was intentionally relative, meaning that it was not defined in absolute terms but reflected changes relative to a baseline existing condition. For comparison purposes across different times and locations throughout Arizona, it needed to be multiplied by a level of exposure. Exposure to this risk may itself be a function of traffic volume, primary crash rates, or other factors. Although certain locations may have a very high risk associated with secondary crashes, if volumes are very low, the magnitude of a safety and economic cost may be low, thus targeting those locations with mitigation resources will have less impact and be less efficient.

Both P2C and PTIME are probabilities that by definition range from 0 to 1. As P2C increases, risk increases; as PTIME increases, risk decreases. The consequence term, C, represents a factor that may be applied to average crash costs for given circumstances.

### *Probability of Traffic Incident Management Effectiveness (PTIME)*

To demonstrate the concept of a risk model, PTIME was quantified through the ranking of an inventory of TIM strategies being deployed in a given area. In summary, over 80 TIM tactics or strategies were assigned values by a panel of TIM professionals and then ranked. Over time these may change as new tactics and strategies are introduced and may enable the refinement of PTIME. Only the TIM strategies currently in use by law enforcement in Arizona were included in a calculated average probability of effectiveness equal to 0.4667 (~47 percent). Although some variation in tactics by region, route, or other factors may exist, these data are currently unavailable. The concept analysis proceeded with the statewide measure, but with an eye toward further refinement. The continued practice of geo-locating incident locations, which could be combined with reporting travel direction and road name or route number descriptors, would allow analysts to tie crash risk to specific roadways and sections of roadways in the risk model.

### *Probability of a Secondary Crash (P2C)*

A future more robust and dynamic model for P2C may include a wide variety of independent variables such as location, volume, geometry, lanes, clearance times, speed limit, trucks, etc. For current purposes, further data collection and development of more complex models are reserved for refinement later.

A statewide value of P2C was estimated as the proportion of secondary crashes relative to total crashes over the analysis time frame (2011-2015). The crash data furnished by DPS contained 134,159 crashes. Of these, 125,139 were primary crashes and 9,020 were secondary crashes. The proportion of secondary crashes to total crashes was about 7.2 percent. However, this was with existing TIM practices already in place that influence secondary crash occurrences.

Therefore, estimating secondary crash probability — under current circumstances and present TIM practices — was based on the historic prevalence of secondary crashes during instances of primary crashes, adjusted by the estimate of PTIME. With a statewide PTIME estimate of 0.4667, P2C was calculated as:

$$P2C_{statewide} = (9{,}020 / 125{,}139) / (1 – 0.4667) = 0.1351 \text{ (~13.5\%)}.$$

### *Consequence (C)*

The consequence term, C, represented a crash cost factor that may be time and location specific, and was relative to a statewide average such as the average crash cost or the equivalent property damage only (EPDO) crash cost. Severity level was a crucial factor in determining the consequence because there is a significant difference between a property damage only crash and a fatal crash in terms of the relative risk for a particular area. This factor can be applied to the average crash (economic) cost in specific circumstances, as it is a function of location, time, severity, cost, and potentially other variables.

The statewide average (secondary) crash cost is determined from historical average crash severity distributions and current average crash costs per severity level. Note this is done per crash, not per injury or fatality. Average crash cost is the sum of the product of costs for fatal, injury, and non-injury crashes and the historical proportion or estimated probability (P, ranging from zero to one) for each severity. The secondary crash severity percents are listed below.

$$Cost_{average} = Cost_{fatal}*P_{fatal} + Cost_{injury}*P_{injury} + Cost_{non\text{-}inj}*P_{non\text{-}inj}$$

The crash costs provided by ADOT for this project align with the “KABCO” scale, where K is a fatal crash, A is a crash with an incapacitating injury, B is a crash with a non-incapacitating injury, C is a crash with a possible injury, and O is a property damage only (PDO) crash. The KABCO injury scale was developed by the National Safety Council (NSC) and is frequently used by law enforcement for classifying injuries. For its Highway Safety Improvement Program (HSIP), ADOT developed crash cost estimates for different injury severities based on the 2008 guidance from the U.S. Department of Transportation, which established the economic value of a statistical life as $5.8 million. (See Table 1.) The other values per injury severity are proportionate to that dollar amount. (It is noted in Table 1 that in January 2018 FHWA published updated guidance that increased the dollar amounts, but these values are too new to have affected the earlier calculations made in this study.)

**Table 1. Crash Costs Associated with KABCO Scale**

| Type of Crash by Severity | Associated Cost Estimate* (2008) | Updated Associated Cost Estimate** (2018) |
|---|---:|---:|
| Fatal crash (K) | $5,800,000 | $11,295,400 |
| Incapacitating injury crash (A) | $400,000 | $655,000 |
| Non-incapacitating injury crash (B) | $80,000 | $198,500 |
| Possible injury crash (C) | $42,000 | $125,600 |
| Property damage only (O) | $4,000 | $11,900 |

*Used by ADOT HSIP **Source: FHWA 2018

For this project, only the DPS crash data provided were considered, since they represented the best primary crash versus secondary crash delineation. The data set used for this concept model combined all injury crashes into one category and did not separate them by severity according to the three injury categories in the KABCO scale. The secondary crash data used for this study contained three levels of severity identified as: fatal crash, injury crash, and non-injury/PDO/other. (Fatal crashes had at least one fatality. Injury crashes indicated at least one injury with no specific severity but no fatalities.)

From the same 2011-2015 crash data used throughout this analysis, the general severity distribution for primary and secondary crashes is summarized in Table 2; the crash data did not differentiate severity between incapacitating, non-incapacitating, and possible injuries. For the initial statewide estimate, the probabilities (the P values in the C equation above) were estimated from the secondary crash data.

**Table 2. Reported Severity of Primary and Secondary Crashes on the Arizona State Highway System (2011-2015)**

| Crash Severity | Number of Primary Crashes (Percent) | Number of Secondary Crashes (Percent) |
|---|---|---|
| Fatal | 767 (0.61%) | 32 (0.35%) |
| Injury | 36,448 (29.13 %) | 2,969 (32.92%) |
| Non-injury | 87,924 (70.26%) | 6,019 (66.73%) |
| Subtotals | 125,139 (100%) | 9,020 (100%) |
| **Total Crashes** | | 134,159 |

The crash costs for injury crash types A, B, and C (from the KABCO scale) must be averaged into one value to apply to the secondary injury crashes. The annual Arizona Motor Vehicle Crash Facts (https://www.azdot.gov/mvd/Statistics/arizona-motor-vehicle-crash-facts) itemizes severity by individual injury, not by crash. There are about 48 percent more injuries than there are injury crashes.

To proceed with the concept, this study used the injury severity breakdown as a proxy for injury crash severity. From 2013, 2014, and 2015 data, this amounts to 8 percent incapacitating injury crashes (A), 35 percent non-incapacitating injury crashes (B), and 57 percent possible injury (C); the letters indicate the corresponding KABCO category.

**Table 3. Percentage of Secondary Crashes by Severity Type with Estimated Cost (2011-2015)**

| Severity | Crashes | Percent | Cost |
|---|---|---|---|
| Fatal (K) | 32 | 0.35 | $5,800,000 |
| Incapacitating Injury (A) | 238 | 2.64 | $400,000 |
| Non-incapacitating Injury (B) | 1,039 | 11.52 | $80,000 |
| Possible Injury (C) | 1,692 | 18.76 | $42,000 |
| Non-injury (O) | 6,019 | 66.73 | $4,000 |
| Total | 9,020 | 100% | |

Therefore, given current circumstances and TIM practices, the statewide average crash cost is calculated as the sum of the product of the crash counts and the costs, by severity, divided by the total crashes. This comes to $50,894 or an EPDO of about 12.7. In addition, for subsequent analysis of the crash data, the average injury crash cost comes to about $83,996.

For this analysis, the statewide average is used as a baseline, so the statewide average consequence term, C, is $50,894 / $50,894 = 1.000 (by definition). The C term may then vary by time, location, or other factors. Two examples:

- Gila County had far fewer secondary crashes compared to some other counties, but the crashes tended to be more severe. The average secondary crash cost in Gila County is $557,307, therefore the corresponding consequence term is $557,307 / $50,894 = 10.932.
- The average secondary crash cost in Maricopa County between 6:00-11:00 AM is $34,834, so the corresponding consequence term is 0.684.

### *Additional Data Exploration*

The following table (Table 4) summarizes all the analysis thus far by county, with the statewide averages shown on the last line.

**Table 4. Analysis of 2011-15 Arizona Crashes, Secondary Probability, Consequence, and Risk**

| County | Primary Crash Count | Secondary Crash Count | Probability of Secondary Crash (P2C) | Secondary Crash Count by Severity | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Fatal | Injury | Non-Injury | Consequence (C) | Risk (R) |
| Apache | 1,186 | 20 | 3.16% | 1 | 7 | 12 | 6.323 | 0.1066 |
| Cochise | 1,835 | 32 | 3.27% | 1 | 11 | 20 | 4.178 | 0.0729 |
| Coconino | 5,129 | 182 | 6.65% | 1 | 47 | 134 | 1.110 | 0.0394 |
| Gila | 1,583 | 22 | 2.61% | 2 | 7 | 13 | 10.932 | 0.1519 |
| Graham | 442 | 2 | 0.85% | 0 | 0 | 2 | 0.079 | 0.0004 |
| Greenlee | 247 | 0 | 0.00% | 0 | 0 | 0 | n/a | 0.0000 |
| La Paz | 1,187 | 42 | 6.63% | 0 | 16 | 26 | 0.677 | 0.0240 |
| Maricopa | 91,242 | 7,629 | 15.68% | 21 | 2,529 | 5,079 | 0.913 | 0.0764 |
| Mohave | 2,992 | 94 | 5.89% | 1 | 33 | 60 | 1.842 | 0.0579 |
| Navajo | 1,826 | 26 | 2.67% | 0 | 10 | 16 | 0.683 | 0.0097 |
| Pima | 6,604 | 498 | 14.14% | 2 | 171 | 325 | 1.076 | 0.0811 |
| Pinal | 4,374 | 240 | 10.29% | 1 | 69 | 170 | 1.005 | 0.0551 |
| Santa Cruz | 937 | 27 | 5.40% | 0 | 9 | 18 | 0.603 | 0.0174 |
| Yavapai | 4,504 | 149 | 6.20% | 2 | 48 | 99 | 2.114 | 0.0699 |
| Yuma | 1,051 | 57 | 10.17% | 0 | 12 | 45 | 0.410 | 0.0222 |
| Total | 125,139 | 9,020 | 13.51% | 32 | 2,969 | 6,019 | 1.000 | 0.0721 |

To aid in understanding, interpreting, and utilizing this framework, consider the Maricopa County data. The current P2C is 15.68 percent, with the estimated PTIME of 0.4667 (statewide average). The consequence, C, is 0.913, slightly less than the statewide average (1.000), and current risk, R, is 0.0764 (which can also be referred to as 7.64 percent).

If, for example, through some improvement of TIM practices, the PTIME is increased to 0.55, then the risk, R, is reduced to 6.44 percent. This improvement applied to the approximately 1,700 secondary crashes per year (as a proxy for exposure as discussed at the beginning of this analysis description) in Maricopa County, and multiplied by average crash cost (with the consequence, C), returns an estimated economic benefit of about $940,000 per year. From this benefit, and knowing the incremental cost of the modified TIM practice, economic measures such as cost effectiveness, benefit-cost ratio, return on investment, etc. can all be calculated and used in programming and prioritization.

Greater detail about route and location, as well as identifying certain time periods, can lead to development of a spatial ranking tool to target the greatest potential economic gains from improved TIM practices.

### EARLY TIM STAKEHOLDER INVOLVEMENT

The development of TIM programs at state transportation agencies across the nation have increased dramatically since the Federal Highway Administration (FHWA) conducted advanced TIM workshops in 2011. The nation took a step toward capability maturity in June 2012 with the first Senior Transportation & Public Safety Summit held in Washington, DC. The outcome from the summit resulted in four key pillars that drive TIM programs, and represent an organizational approach to the different areas of focus:

- Legislation and Leadership
- Institutional and Sustainability
- Practitioner Capacity Building
- Public Outreach and Education

FHWA announced the National Emergency Responder Training Course would become part of its Every Day Counts Initiative. FHWA is monitoring progress regularly toward expanding goals to train more than a million emergency responders.

### ARIZONA TIM STAKEHOLDER INVOLVEMENT

The research team of this study used information and opinions from leadership in a 2015 multi-state TIM summit (see Appendix A), survey answers and discussion from practitioners in regional workshops, and existing strengths of the TIM program in general, to make some general recommendations how agencies can work together to advance a TIM program that can reduce secondary crashes.

In August of 2016, four regional workshops within Arizona brought together more TIM practitioners, in four separate, but similar workshops. They were facilitated by the consultant research team and included responder groups who met in Flagstaff, Tucson, and Phoenix. At each session, participants used individual and group survey opportunities coupled with discussion to give a picture of current TIM practices. The FHWA's Annual TIM Self-Assessment was completed through group discussion, and it was modified to only include statements that apply to responders and those involved with existing TIM programs for individual assessments. The survey tool was provided to each participant, and 29 were returned.

## DEVELOPMENT OF CRASH MODIFICATION FACTORS

Currently, there are no published CMFs available for the application of TIM tactics related to secondary crashes. A CMF is used to calculate the expected change in number of crashes after a particular countermeasure is implemented. This factor is multiplied by the number of crashes per year for the study area in order to calculate the benefit of the countermeasure implementation. The lower the factor, the more effective the countermeasure is at reducing crashes. For example, a CMF of 0.67 translates to a 33 percent reduction in the number of crashes, while a CMF of 1.20 means that the countermeasure is expected to increase the number of crashes by 20 percent. There are CMFs that are applicable to all types of crashes and others that are limited to specific crash types; the proper CMF must be selected depending on the intended analysis.

This study examined estimating CMFs for TIM tactics in regard to secondary crashes, i.e., to develop factors that could estimate the number of secondary crashes to be expected over a specific time period in a study area after a particular TIM countermeasure was implemented. However, Arizona crash data does not currently document which countermeasures (TIM tactics) were implemented or where, and the Arizona data do not allow for a controlled analysis where each countermeasure can be isolated and assessed according to its individual performance. Because the rigorous statistical analysis needed to create acceptable CMFs requires reliable and adequate data, the existing data did not allow for development of CMFs with this research. Nor is such a development effort, other than for regionally limited CMFs, usually conducted on the state level; CMF development is conducted by the national CMF Clearinghouse, which is a function of the Federal Highway Administration (FHWA) in coordination with the Transportation Research Board (TRB) and the Association of American State Highway Transportation Officials (AASHTO).

Federal Highway Administration (FHWA). 2018. Crash Costs for Highway Safety Analysis. FHWA-SA-17-071. FHWA Office of Safety: Washington, D.C.

Jaeger, Calvin D., Nathaniel S. Roehrig, and Teresa Torres. 2008. Development of an Automated Security Risk Assessment Methodology Tool for Critical Infrastructures. Sandia National Laboratories: Albuquerque, NM.

# AZTech
# Traffic Incident Management (TIM) Coalition Charter

| Element | Definition | Focus |
|---|---|---|
| **History and Business Case** | Brief history of the situation leading to the chartering of the AZTech TIM Coalition. Business case addresses organizational relevance and urgency [financial, growth/re-alignment, service and culture] | The AZTech Intelligent Transportation System (ITS) Model Deployment began as an experimental project that was federally funded from 1996-2003 in the Phoenix metropolitan area. It is a regional collaboration of both public and private sectors and has been highly successful. The initial phase of AZTech cleared the path for this next phase by removing institutional barriers, building collaborative relationships and garnering resources to ensure its effectiveness. Established in 2010 as a result of the Advanced Traffic Incident Management Workshop organized by the Federal Highway Administration, Maricopa Association of Governments and AZTech held on November 16-17, 2010, in Glendale, Arizona, the AZTech regional TIM Coalition is dedicated to collaborating for safer and more efficient management of incidents that occur on, or significantly impact, the region's roadways to meet the objectives of the ***National Unified Goal (NUG)*** developed by the National Traffic Incident Management Coalition (NTIMC) as follows:<br>▪ Responder Safety<br>▪ Safe, Quick Clearance<br>▪ Prompt, Reliable, Interoperable Communications |
| **Mission** | What business is the AZTech TIM Coalition in? | The mission of the AZTech TIM Coalition is to foster the most efficient and effective incident management response within the Phoenix Metropolitan region by utilizing a multi-disciplinary approach to sharing ideas, lessons learned, best practices and knowledge from all stakeholders. |
| **Vision** | What would we like the AZTech TIM Coalition to become? | AZTech TIM coalition's vision is to be a national model in identifying, responding to, and clearing traffic incidents to provide safe and reliable transportation to the roadway users. |
| **Values** | What common beliefs and ideals does the AZTech value? | ▪ Collaboration<br>▪ Leadership<br>▪ Integration<br>▪ Results |
| **Strategies** | The strategies needed to achieve the AZTech TIM Coalition Mission and Vision | ▪ Establish Education and Outreach Programs<br>▪ Expand and Strengthen Partnerships at the Federal, State, and local levels<br>▪ Optimize State and Local Operations and Management<br>▪ Collect, Analyze, and Develop Data Driven Solutions<br>▪ Debriefing |
| **Purpose of the TIM Coalition (core question & deliverables)** | Reason the TIM Coalition exists | The AZTech TIM Coalition exists to achieve the vision and mission of AZTech as it relates to traffic incident management and the mission and vision of the AZTech TIM Coalition. |
| **AZTech TIM Coalition and Roles** | Organizations Involved, Sets boundaries, constraints and requirements | The AZTech Traffic Incident Management (TIM) Coalition is a multi-disciplinary traffic incident management partnership including state, tribal and local police, fire/EMS agencies, state and local transportation agencies, metropolitan planning organizations and towing companies in the Phoenix Metropolitan Area. The coalition shares ideas, lessons learned, best practices, and knowledge to foster regional traffic incident management. The AZTech TIM Coalition must work within the AZTech structure and will be focused on Traffic Incident Management. |

# AZTech
# Traffic Incident Management (TIM) Coalition Charter

| Element | Definition | Focus |
|---|---|---|
| **Deliverables** | TIM Coalition Deliverables are designed to support TIM Coalition strategies | The TIM Coalition will work to improve the reliability of the transportation system and safety of incident responders and public throughout the Phoenix Metropolitan Area.<br><br>The group will:<br>• Provide training to state and local agencies<br>• Provide training to outside entities on their role in the TIM process<br>• Conduct bi-monthly meetings to facilitate sharing of best practices and information exchange between stakeholders<br>• Complete the annual FHWA Self-Assessment and utilize results to monitor progress of the program<br>• Analyze collected data to monitor performance<br>• Conduct debriefings on major incidents to ensure best practices are being followed |
| **Membership** | Identifies membership requirements, what decisions the team can make, and to whom they are accountable | Membership will be restricted to federal, state, tribal and local law enforcement, fire/EMS, state and local transportation/public works, the towing industry and representation from the metropolitan planning organization and Federal Highway Administration.<br><br>The chair for the AZTech TIM Coalition will be a member of the Arizona Department of Public Safety. When required, the chair will be nominated by current members and approved by the coalition as a whole by a simple majority vote. |
| **Approach** | General approach or methods to be used to achieve purpose. | The AZTech TIM Coalition will work under the guidance of the AZTech Executive Committee. The Coalition will make decisions regarding the direction and focus of the TIM Coalition using a consensus model. The Coalition will meet jointly with the AZTech Advanced Traveler Information Systems (ATIS) Working Group in order to ensure integration of efforts. If there is funding or other resource needs, change in direction or focus, the chair of the AZTech TIM Coalition will raise the issues with both the AZTech Program Manager and the AZTech Executive Committee.<br><br>The chair will develop the bi-monthly meeting agendas with the chair of the ATIS Working Group, attend the AZTech Executive Committee meetings to update the group on the coalition activities, and set up subcommittees as needed for the purpose of addressing a specific issue. |
| **Evaluation** | Identifies the effectiveness of the Coalition and allows the Coalition to identify areas of success as well as areas needing improvement | The AZTech TIM Coalition will utilize the FHWA Self-Assessment as a means for evaluation. The Coalition will utilize results of the Self-Assessment to monitor progress of the program and identify areas of improvement. The Self-Assessment will be completed on an annual basis. Once completed, the Self-Assessment will be brought to the Coalition as a whole for input and comment. The Coalition will acknowledge work done by the members as well as identify areas needing improvement in the near and long term. |

| Element | Definition | Focus |
|---|---|---|
| **Issue Resolution** | Process used to resolve issues that may arise. | Issues will arise with any group over the course of time. The issue resolution process is in place to allow members to address these issues in a systematic approach that is agreed upon prior to the issue arising. The AZTech TIM Coalition will utilize the Issue Resolution process described below.<br><br>Any member of the AZTech TIM Coalition may request to have an item added to the agenda for discussion. Once on the agenda, the issue may be brought forward to the Coalition as a whole. Both sides of the issue will be given the opportunity to provide their input into the issue. Once heard, the Coalition will have the opportunity to make a motion and vote to settle the issue at that time, or if more information is required, a motion may be made to table the issue until further information is collected. Once voted on, the issue will be decided and documented in the meeting minutes for future reference. |
| **Communication Plans** | Communication among members of the TIM Coalition is vital to its success. | The communication process for the Coalition is vital to its success. Members are encouraged to participate in the bi-monthly meetings in person or via teleconference. This will allow all members to receive the information in a timely manner. Following each meeting, the meeting minutes will be developed and distributed to all members for review. These meeting minutes will be discussed at the next scheduled meeting to address any issues or concerns. |

Approved by the AZTech Executive Committee: October 22, 2015

### *Collaboration and Outreach*

"The Florida Traffic Incident Management Strategic Plan" emphasizes collaboration and outreach to all types of organizations, including the private sector.

Florida Department of Transportation. 2006. Florida Traffic Incident Management Program Strategic Plan. Tallahassee: Florida Department of Transportation.

### *Programmatic Investment*

The West Virginia Department of Highways invested in beta testing of TIM training before implementation, hired consultant professional staff to direct the TIM program and state specific training, and invested $1 million to resource public agencies participating in the TIM program.

Federal Highway Administration Traffic Incident and Events Management Knowledge Management System. 2015. "Lesson Learned: West Virginia Finds, Targets Additional TIM Funding. West Virginia Department of Highways." Accessed September 21, 2018. http://kms.timnetwork.org/article/AA-00403/0/Lesson-Learned%3A-West-Virginia-Finds-Targets-Additional-TIM-Funding

### *Outreach on Legislation*

"Successfully Managing Traffic Incidents Is No Accident" was a report on successful management of traffic incidents, with a special focus on the need for public outreach on laws governing movement of traffic in and near TIM work areas.

Vásconez, Kimberly C. 2013. "Successfully Managing Traffic Incidents Is No Accident." Public Roads. July/August 2013 Vol. 77. No. 1. FHWA-HRT-13-005. Washington, D.C.: Federal Highway Administration.

### *Inclusivity in Organization*

The "TAC Report on Traffic Incident Management" studied TIM programming and had a special focus on the involvement of Metropolitan Planning Organizations as agents of change. It suggested foundational involvement of other local agencies in addition to state agencies to make programming effective.

Yorks, Chuck, Robert Taylor, and Dennis Lebo. 2014. Traffic Incident Management Final Report. Pennsylvania State Transportation Advisory Committee..

### *Training and Safety*

"Best Practices in Traffic Incident Management" was an early identifier of the need for baseline training for all responders, based on a scan of European practices.

Carson, Jodi L. 2010. Best Practices in Traffic Incident Management. FHWA-HOP-10-050. Washington, D.C.: Federal Highway Administration.

### *Specific Guidelines*

"Traffic Incident Management Quick Clearance Guidance and Implications examined the guidelines for a Virginia DOT quick clearance pilot effort dubbed "Operation Instant Tow," which reduced incident clearance times through simultaneous dispatch of police and towing/recovery.

Dougald, Lance E., Noah J. Goodall, and Ramkumar Venkatanarayana. 2016. Traffic Incident Management Quick Clearance Guidance and Implications. FHWA/VTRC 16-R9 Charlottesville: Virginia Department of Transportation.