HIGHWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

Chattanooga, Tennessee

HWY15MH009

(38 pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C.

HIGHWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	Interstate 75 (I-75) milepost 11.71, Chattanooga, Hamilton, County, TN.
Vehicle #1:	2007 Peterbilt truck tractor
Operator #1:	Cool Runnings Express, Inc.
Vehicle #2:	2010 Toyota Prius
Vehicle #3	2010 Scion
Vehicle #4	2003 Mazda
Vehicle #5	2005 GMC
Vehicle #6	2001 Ford pick-up
Vehicle #7	2007 Chevrolet Uplander
Vehicle #8	2014 Cadillac
Vehicle #9	Toyota Tundra
Date:	June 25, 2015
Time:	Approximately 7:10 p.m. EDT
NTSB #:	**HWY15MH009**

B. HIGHWAY FACTORS GROUP

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C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary Report* in the docket for this investigation.

D. DETAILS OF THE HIGHWAY FACTORS INVESTIGATION

The highway group obtained information related to the design, maintenance, and operation of the highway environment to establish a foundation for evaluating whether the condition, design, or operation of the highway facility contributed to or caused the accident. Prefatory data was obtained giving a general description of the highway location; highway information including geometric design, traffic metrics, and accident history were obtained from the Tennessee Department of Transportation (TDOT). Traffic control plans for the Temporary Traffic Control (TTC) zone that existed at the time of the accident were examined and evaluated. Also statewide work zone accident statistics were gathered and nationwide statistics and programs to reduce work zone accidents were obtained.

1. Prefatory Data

The accident occurred within the City of Chattanooga on I-75 on the northbound lanes about milepost (MP) 11.71 or 473 feet south of milepost 11.8 near station no. 553+51. The GPS Coordinates for the accident location were Latitude 35.086740 –Longitude 85.066480. In this area, I-75 is being resurfaced along a 5.820-mile-long project that encompasses lane mile 12.78 in Hamilton County to lane mile 2.98 in Bradley County. The project extends for 2.84 miles in Hamilton County and 2.98 miles in Bradley County.[1]Construction contract specifications can be found in **(Highway Attachment 1)** From milepost 0 at the Georgia state line to near the accident area, I-75 is a 6-lane to 8 lane highway with entrance and exit lanes. The north and southbound lanes are separated by a 52.5-inch high, test-level 5[2], single slope, Concrete Median Barrier (CMB). Near the accident area, there are three northbound lanes and an entrance ramp. The left lane was closed at milepost 12 and repaving began at milepost 12.8. At this location the third or right-hand lane drops off along with the entrance ramp from US 11. So in the construction area the northbound side had dual lanes with the left lane closed so only one lane was available to accommodate the traffic.

The three lanes northbound were approximately 12-foot-wide lanes delineated by approximately 10-foot-long painted white pavement stripes located at 30-foot intervals. The three main lines were delineated from the 6.5-foot-wide right-hand shoulder by a solid white pavement stripe. The median shoulder or the shoulder separating the three

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[1] For construction details see Tennessee DOT Contract CNN306 and Federal Project NH-I-75-1(138),06001-8178-443305-8178-44

[2] This barrier is accepted for use by FHWA as tested in accordance with level -5 test procedures found in NCHRP 350, which require the barrier to undergo a 50 mph crash test at a 15-degree angle with an 80,000-pound truck tractor semi-trailer.

South to North lanes was approximately 10 feet wide. This shoulder was delineated from the main travel lanes by a solid yellow pavement stripe. The right and left-hand shoulders had milled intermittent or non-continuous rumble strips that were 6 feet long and 3 feet wide spaced at 25-foot intervals. The Chattanooga Police Survey showed that the left and right lanes were 11-feet-wide and the center lane was 12 feet wide. The gore area that separates the three northbound lanes from the U.S. Highway 11 entrance ramp was 24 feet wide. The entrance ramp was 15.5 feet wide. The following paragraph describes the highway alignment:

A crest vertical curve[3] or hill crest is located at station No. 502+70 near milepost 10.8., or approximately 1 mile from the impact area. A clear view exists from the hill crest to the impact area. A minus 5.1 percent, 3267.78-foot-long downgrade is located after the hill crest followed by a 1.44 percent up grade and a 1 degree left-hand curve which begins at Station No. 552+80.65 or about 100 feet before the impact area in the center lane. The 1-degree or 5,729.58-foot radius curve is 4,497 feet long. See **Highway Attachment 2** Plan and Profile sheets for more information.

2.0 Accident History

The NTSB requested the TDOT provide a 5-year accident history for the six-mile long area from Milepost 9- to Milepost 15 on I-75 for accidents in general and for statewide records on work zone crashes. The records showed that for this location 5 fatal, 13 incapacitating injury crashes, 102 non-incapacitating injury crashes, and 421 property damage accidents occurred along this six mile long area from 2010 to 2014. Thus far in 2015, 2 fatal crashes, 2 incapacitating injury crashes, 8 non-incapacitating injury crashes and 44 property damage accidents occurred in this area. These crashes involved 15 Single Unit Trucks (SUT's) and 88 Truck Tractor-Semitrailer accidents. Both fatal crashes in 2015 occurred within this work zone. The first fatal crash involved a pedestrian that climbed over the median barrier wall and was hit by a passing truck. The second fatal crash was the subject of this investigation.

Statewide in Tennessee, 68 fatalities occurred in work zones in the five-year-period from 2010 to 2014.[4] Between 2008-2012 there were 16 fatal work zone crashes involving heavy trucks in Tennessee.

See Table 1

[3] A vertical curve is parabolic curve or hill used to provide a smooth transition from one roadway grade to another.
[4] Statistics were provided by the Tennessee Integrated Traffic Analysis Network (TITAN)

TN WORK ZONE FATALITIES DATA (TITAN)					
2010	2011	2012	2013	2014	5-year Total
8	15	12	15	18	68

3.0 Traffic Metrics

3.1 Volume – The TDOT indicated that the Average Daily Traffic (ADT) on I-75 was over 70,000 Vehicles Per Day (VPD) before the U.S Highway 11 interchange and it dropped to 60,300 VPD after the interchange on the approach to the impact area. Truck traffic comprised 24 percent of the overall ADT. 85th percentile speed surveys were not available for this area.[5] The speed limit was posted at 65 mph for passenger vehicles and 55 mph for trucks prior to the work zone. The work zone speed limit was posted at 60 mph. There was a warning sign warning of a regulatory change in speed limit (W3-5a) posted at MP 11.5, but the actual change to a work zone speed limit did not occur until MP 12.

4.0 Federal Work Zone Oversight

The FHWA exercises oversight of federal-aid project work zones through requirements found in 23 CFR Part 630 Subpart J, "Traffic Safety in Highway and Street Work Zones." Subpart J was retitled "Work Zone Safety and Mobility" in October 2007 in response to federal rulemaking in 2004. (See 69 FR54562, published September 9, 2004, for more information.)

The key components of the update rule included the following:

1. Development and implementation of an overall, agency-level work zone safety and mobility policy to institutionalize work zone processes and procedures.
2. Development of agency-level processes and procedures to support policy implementation, including procedures for work zone impact assessments, analyzing work zone data, training, and process reviews.
3. Development of procedures to assess and manage work zone impacts of individual projects.

5.0 Tennessee Work Zone Oversight

[5] The 85th percentile speed is the speed at which 85 percent of the traffic is traveling at or below.

The TDOT used federal-aid funding for this construction contract. The TDOT *Standard Specification 711, and its* contract specifications comply with the federal *Manual for Uniform Traffic Control Devices for Streets and Highways* (MUTCD) and the provisions of 23 CFR Part 630 Subpart J. Additionally, the TDOT Work Zone Safety and Mobility Manual aligns with the Final rule in the Code of Federal Regulations. These documents provide for the advanced planning, work zone impact analyses, training, and inspection of work zones. See **Highway Attachment 3**, TDOT Special Provision SP712PTQ for detailed guidelines regarding Traffic Queue Protection, the TDOT Work Zone Safety and Mobility manual, and the Transportation Management Plan for this project. This provision requires manual queue protection by the use of queue protection trucks with portable changeable message signs at the back of all traffic queues. In other words, the manned queue protection truck operator continuously monitors the traffic back-up and moves the truck if necessary to maintain at least a ½-mile warning in advance of the queue. Additionally Tennessee requires 3 miles advance warning on all interstate lane closures. For more information on TDOT's Response to this accident see **Highway Attachment 4,** TDOT's After Action Report on I-75 Accident.

Additionally, in the early implementation stages of the contract, a pre-construction conference was held on April 2, 2015, to discuss all matters relating to the contract, including the traffic control plan. Participants included the TDOT, contractors, and sub-contractors. The Tennessee Highway Patrol was not present at the meeting. The TDOT Region 2 Director of Operations indicated they had forgotten to invite THP to the conference. He added that in the past it was a routine function to assure that THP was invited to all pre-construction conferences, but with re-assignment and retirement of key points of contact at both agencies they had recently failed to ensure this occurred. Construction inspectors noted the high ADT at the meeting, indicating the traffic control was critical. For more information see **Highway Attachment 5,** CNN 306 Pre-Construction Conference Minutes and Contractor Personnel Lists. A list of other strategies used by Tennessee to reduce the number and severity of work zone crashes can be found in the Tennessee 2014 Strategic Highway safety Plan, pages 62-64. **See Highway Attachment 6,** Tennessee 2014 Strategic Highway Safety Plan for detailed information.

TDOT provides information to motorists through its 511 telephone system, the queue lane closure website, and through the Transportation Management Centers (TMC's). Lane closure information is updated statewide within every ½ hour by TMC personnel and is available on the telephone or website. The truck driver in this accident could have learned about any existing lane closure on his route through Tennessee if he had use the telephone for the 511 system or accessed the TDOT website at WWW.TNSmartway.com . The TMC in district 2 Chattanooga operates 27 different overhead Dynamic Message Signs (DMS) on the highways surrounding Chattanooga.

5.1 Tennessee Highway Patrol (THP) Traffic Control Oversight

The troopers assigned to traffic control in work zones are required to obtain a 4-hour class in Traffic Incident Management before being assigned to provide supplemental traffic control in work zones. In this work zone a trooper was assigned to perform a presence function by positioning his squad car in the median at milepost 12.2 where the lane was closed. This had the strategic effect of controlling traffic speed as the vehicles approached the work area where the pavement was being repaved. Troopers are not permitted to occupy lanes but must provide warning from shoulder or median areas. The contract provisions require the contractor to request for Troopers 48 hours in advance of the scheduled work. Troopers were required in this work zone by contract provision. A Memorandum of Understanding (MOU) between TDOT and THP provides for payment with state funds from TDOT for law enforcement officers used in work zones. The American Association of Traffic Safety Services Association (ATSSA) in cooperation with the Federal highway administration published a guideline in September 2015, "Safe Practices for Law Enforcement Personnel Operating in Highway Work Zones". For more information see this document in **Highway Attachment 7.**

6.0 Lane Closure in Operation at the Time of the Accident

The TDOT Region 2 Director of Operations indicated that the left-hand lane of I-75 was closed at MP 12 and the repaving operation began about MP 13. The traffic queued back to approximately MP 11.7 or 3/10ths of a mile at the time of the accident. Troopers working the zone indicated that the queue was slightly longer on the day of the accident but it was not uncommon for traffic to slow up in this area for approximately 2/10ths of a mile. Drivers interviewed by the survival group indicated that traffic was moving slowly at 5-10 mph in the two right lanes and had come to a stop in the left-hand lane (lane that was closed). The locations and descriptions of traffic control devices were determined through personal observations and measurements along with interviews of Superior Sign Control personnel. For interview summaries see **Highway Attachment 8,** Interview Summaries

The work zone had the following warning signs and devices:

1. Warning began with a message on the permanent overhead Dynamic Message Sign (DMS) at MP 2, indicating the left lane was blocked and to be prepared to stop. This message was activated at 7:04 p.m.
2. At MP 9.4 a fixed sign was erected on both sides of the road warning of road work 3 miles ahead.
3. At MP 10 a queue protection truck was located on the right-hand shoulder. The truck was equipped with a portable changeable message sign and crash attenuator. The message displayed was, "Left Lane Closed, Be Prepared to Stop."[6]
4. At MP 10.4 a fixed sign was located on both sides of the road warning of "Road Work 2 Miles." Also at this location an overhead DMS sign displayed the following message, "Left Lane Blocked" "Be Prepared to Stop"
5. At MP 11.4 fixed signs were location on both sides of the road warning of "Road Work 1 Mile."
6. At MP 11.5 the speed limit is reduced from 65 mph to 60 mph.
7. At MP 11.57 a temporary warning sign on both sides of the road warned 'Left Lane Closed ½ mile."

[6] See Highway Photos 3 & 4 in the Public Docket which shows the queue truck with Portable Changeable Message Signboard (PCMS)

8. At MP 11.71 the Impact occurred.
9. At MP 11.79 a temporary sign in the gore and on the left shoulder warned, Left Lane closed 1500 feet.
10. At MP 12 an arrowboard was positioned on the shoulder the 780 foot long taper began.
11. There were fixed signs warning of road work at, 1500, 1000, and 500 feet.
12. These were followed by Road Work Next 8 miles.

For a detailed view of the signs see Figure 1.

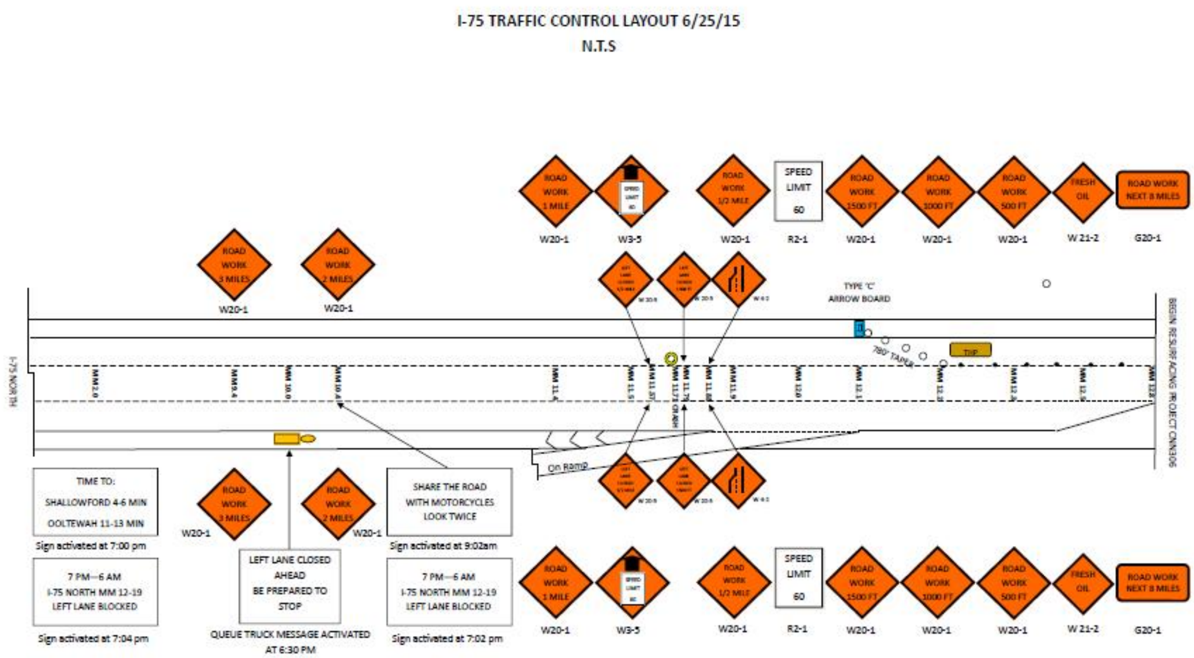

Figure 1

A larger view of Figure 1 is available in Attachment 3, Work Zone Sign Detail Sheets[7]

7.0 Temporary Traffic Control Devices

Section 6C.04, Advance Warning Area, in the MUTCD, provides guidance on sign placement for advance warning before a Temporary Traffic Control Zone. The guidance indicates that typical distances for placement of advance warning signs on freeways and

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[7] See Highway Photos 1-2 and5-17 in the Public docket for views of the work zone signage, highway alignment, and accident scene

expressways should be longer than conventional highways because drivers are conditioned to uninterrupted flow. “Therefore, the advance warning sign placement should extend on these facilities as far as ½ mile or more.” In this work zone accident, the TDOT required advance warning to be extended 3 miles in advance of the beginning of the taper. Additionally, a queue protection truck was located 2 miles in advance of the lane closure, and overhead DMS signs were activated 1.6 and 10 miles in advance of the lane closure.

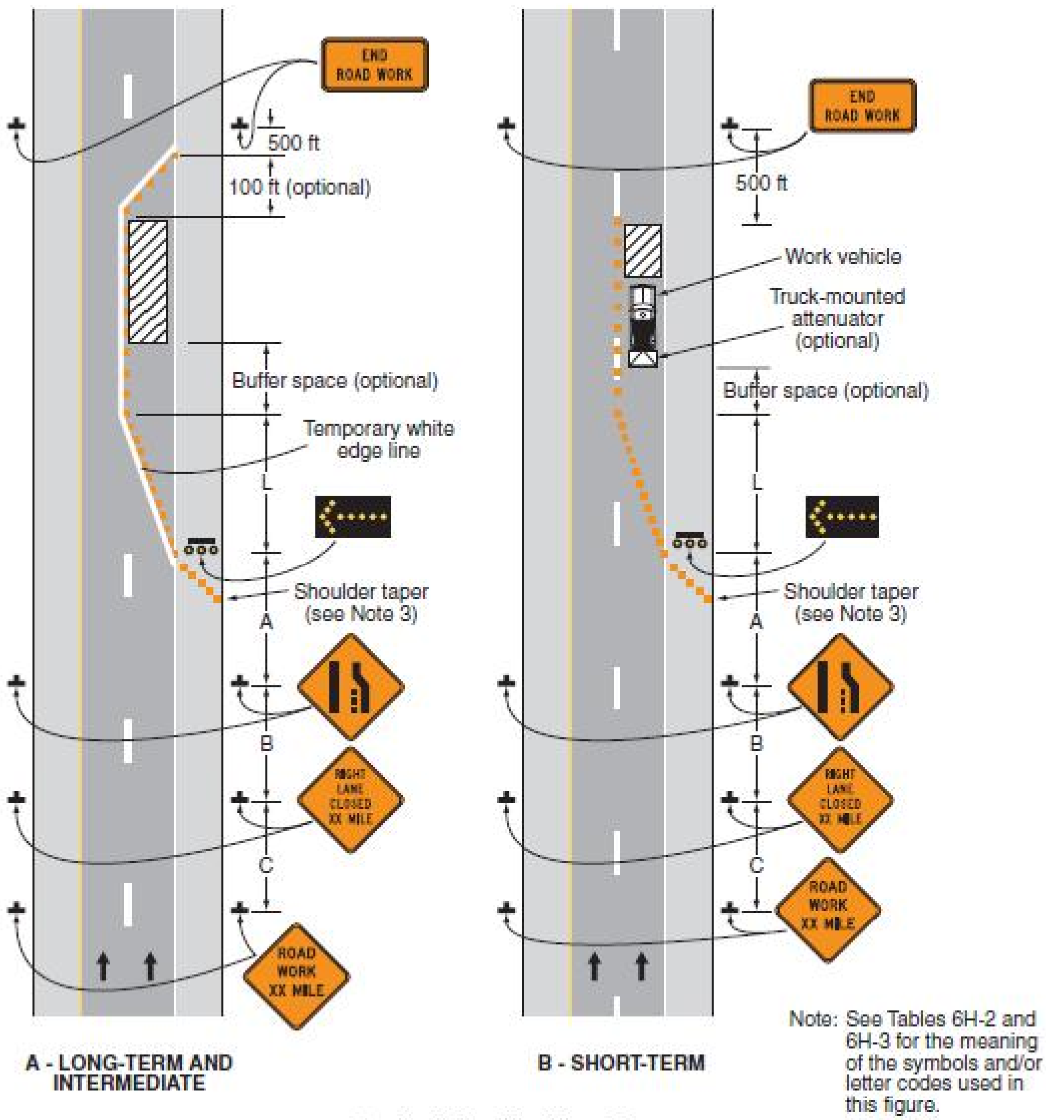
The transition area of a temporary traffic control zone is that section of highway where road users are redirected out of their normal path. Transition areas normally involve the use of tapers. Tapers are created by using a series of channelization devices or pavement markings to move traffic out of the normal path. The appropriate taper length should be determined using the criteria shown in MUTCD table 6C-3 and 6C-4.

Table 6C-4 provides formulas for determining taper length. In a speed zone of 45 mph or greater, the length of the taper is expressed by L=WS where L is the taper length expressed in feet, W is the width of the offset expressed in feet, and S is the posted speed limit or the anticipated operation speed expressed in mph. This expression indicates that the minimum taper length should have been 720 feet for channeling traffic out of a 12-foot-wide lane in the 60-mph work zone. However, in this accident, the taper length exceeded this minimum requirement. The taper length was 780 feet to close the left-hand lane. The FHWA and the American Traffic Safety Services Association (ATSSA) recommend using longer tapers to help smooth traffic flow at merge locations.[8]

Section 6G.14 of the 2009 MUTCD, “Work Within the Traveled Way of a Freeway or Expressway,” addresses lane closures and multiple lane closures on high-speed freeways and expressways. The standard requires that an arrow board shall be used when a freeway lane is closed. Also when more than one lane is closed, a separate arrow board shall be used for each closed lane. Examples of proper placement of traffic control devices are given in Typical Application (TA 33).

[8] “Treating Potential Back-of-Queue Safety Hazards,” American Traffic Safety Services Association, FHWA Grant No. DTFH61-06-G00004.

Figure 6H-33. Stationary Lane Closure on a Divided Highway (TA-33)



Typical Application 33

Figure 2

The only devices not found in this work zone that are sometimes used in other states were temporary transverse rumble strips across the lanes to give motorists a tactile warning to alert them.

Section 6G.19 of the MUTCD provides for special consideration of temporary traffic control during nighttime hours. The following guidance is provided:

> "Considering the safety issues inherent to night work, consideration should be given to enhancing traffic controls (see Section 6G.04) to provide added visibility and driver guidance, and increased protection for workers."

Section 6G04, "Modifications to Fulfill Special Needs," provides guidance on devices that may be added to supplement the devices provided in typical applications. "When conditions are more complex, typical applications should be modified by giving particular attention to the provisions set forth in Chapter 6B[9] and by incorporating appropriate devices and practices from the following list:

A. Additional Devices

1. Signs.
2. Arrow boards.
3. More channelizing devices at closer spacing.
4. Temporary raised pavement markers.
5. High-level warning devices.
6. PCM signs.
7. Temporary traffic control signals.
8. Temporary traffic barriers.
9. Crash cushions.
10. Screens.
11. Rumble strips.
12. More delineation.

B. Upgrading of devices

1. A full complement of standard pavement markings.
2. Brighter and/or wider pavement markings.
3. Larger and/or brighter signs.
4. Channelizing devices with greater conspicuity.
5. Temporary traffic control barriers instead of channelizing devices.

[9] Section 6B.01provides detailed information about the seven fundamental principles of temporary traffic control, pages 549-550, 2009 edition MUTCD.

C. Improved geometrics at detours or crossovers

D. Increased distances

1. Longer advance warning area.
2. Longer tapers.

E. Lighting

1. Temporary roadway lighting.
2. steady-burn lights used with channelizing devices.
3. Flashing lights for isolated hazards.
4. Illuminated signs.
5. Flood lights.

F. Pedestrian routes and temporary facilities

G. Bicycle diversions and temporary facilities

Additional guidance found in section 6G.19 indicates that consideration should be given to stationing uniformed law enforcement officers and lighted patrol cars at night work locations where there is a concern that high speeds or impaired drivers might result in undue risks for workers or other drivers.

The TDOT had a marked unit from the THP assigned to this work zone.

The only existing standard for nighttime temporary traffic control is a requirement for temporary lighting at all flagger stations during nighttime.

7.1 Example of Transverse Rumble Strip Use

The Maryland State Highway Administration (MSHA) has a special provision for the use of transverse rumble strips in those locations where conditions suggest that tactile warning would be beneficial and additional warning is needed to alert motorists to unusual conditions. For more information see **Highway Attachment 9**, MSHA Guidelines for the Application of Rumble Strips.

In 2013 Texas began requiring transverse rumble strips for lane closures on conventional highways with 70 mph or less speed zones. Additionally, they are experimenting with rumble strip use on interstate lane closures in a 2 billion dollar project on I-35 in Central Texas. For more information see https://www.workzonesafety.org/research/record/47841. Researchers indicated the smart work zone with automated queue protection and rumble strips reduced crashes up to 45 percent. For more information see **Attachment 10** Texas Transverse Rumble Strip Policy Memo. The Work Zone Best Practices Guidebook (BPG) which is available at www.workzonesafety.org was accessed to see if a Best Practice was available for the use of transverse rumble strips in TTC or work zones. A Best Practice was not available as of October

1, 2015.[10] However, FHWA grants indicated that Best Practice G4-10 for rumble strip applications was being prepared. For more information see **Highway Attachment 11,** Third Edition Work Zone Best Practices Guidebook.

Guidance on rumble strip use in found in the MUTCD section 6F.87. "Transverse rumble strips consist of intermittent, narrow, transverse areas of rough textured or slightly raised or depressed road surface that extend across the travel lanes to alert drivers to unusual vehicular traffic conditions." Through noise and vibration they attract the driver's attention to such features as unexpected changes in alignment and to conditions requiring a stop." The standard for rumble strips describes the required colors of the strips. There is no specific guidance or requirement relating to rumble strip use for lane closures on freeways.

In 1989 FHWA published a work zone traffic management synthesis on rumble strip use in work zones.[11] The authors concluded, "There have been only a few studies of the use of rumble strips in work zones. The results have varied, and there are diverse opinions as to the effectiveness of rumble strips in work zones." However, as indicated earlier rumble strip use in smart work zones in Texas have reduced accidents by 45 percent.

8.0 Research Related to the Scope of TTC or Work Zone Accidents

The FHWA amended 23 CFR Part 630 Subpart J in 2004 with a requirement for the states to institute the changes by 2007. Therefore, this report will provide the accident statistics for the 6-year period 2007-2012 to assess the general scope of the problem, highlight the problem of truck accidents in work zones by showing a list of fatal truck crashes in work zones, and provide a list of fatal accidents in work zones for the 50 states.

First, however, the report will list the data for work zone fatalities that occurred in the 6-year-period (2001-2006) before the amendments were to be instituted. [12]

- 2001- 1,026 work zone fatalities.
- 2002 – 1,186 work zone fatalities.
- 2003 – 1,095 work zone fatalities.
- 2004 – 1,063 work zone fatalities.
- 2005 – 1,058 work zone fatalities.
- 2006 – 1,004 work zone fatalities.

The following list provides the number of fatalities from motor vehicle crashes (including all types of vehicles) in work zones for the years 2007-2012:

[10] The online version can be searched using key words for the 172 best practices listed in 11 different categories – http:www.ops.fhwa.dot.gov/wz/practices/best/bestpractices.htm
[11] FHWA-TS-89-037, July 1989, Federal Highway Administration Washington, D.C.
[12] All data sourced from www.workzonesafety.org/crash_data/workzone-fatalities, accessed on December 16, 2014.

- 2007 – 831 work zone fatalities.
- 2008 – 716 work zone fatalities.
- 2009 – 680 work zone fatalities.
- 2010 – 586 work zone fatalities.
- 2011 – 590 work zone fatalities.
- 2012 – 609 work zone fatalities.

The next list shows the number of large trucks involved in fatal and injury work zone crashes for the period 2003-2007.[13]

- 2003 – 196 fatal work zone crashes, 2003 – 3,000 injury work zone crashes.
- 2004 – 225 fatal work zone crashes, 2004 – 4,000 injury work zone crashes.
- 2005 – 235 fatal work zone crashes, 2005 – 4,000 injury work zone crashes.
- 2006 – 216 fatal work zone crashes, 2006 – 2,000 injury work zone crashes.
- 2007 – 174 fatal work zone crashes, 2007 – 2,000 injury work zone crashes.

Additional research showed that on average there were 213 fatalities per year for the period 1996-2000 that involved heavy trucks in work zones. Twenty-four percent of the work zone fatalities that occurred in 2000 involved large trucks in the crash (264 out of 1,093). In 1999, 868 fatalities resulted from motor vehicle crashes in work zones. Twenty-six percent of these fatalities resulted from crashes involving large trucks. In November 2014, the Federal Motor Carrier Safety Administration (FMCSA) published more recent data regarding heavy trucks in fatal work zone crashes.[14] The analysis of Fatality Analysis Report System (FARS) data indicated that 23.6 percent of fatal work zone crashes for the 5-year period 2008-2012 involved at least one heavy truck. This number increased to 28 percent for the year 2013. Other highlights of the study showed that large truck fatal crashes in work zones are more likely to involve three or more vehicles. In 2012, 32.6 percent of large truck fatal crashes in work zones involved three or more vehicles, while 16.0 percent of fatal large truck crashes in general involved three or more vehicles. Another highlighted fact in the report showed that the majority of large truck fatal crashes in work zones involved large trucks in transport, and most were rear-ended. In 2012, approximately 19 percent of fatal crashes in work zones involved at least one truck that was parked on the shoulder or working in the work zone. The majority (81 percent) of work zone fatal crashes that involved a large truck were in transport or traveling through the work zone. In 2012, 56.2 percent of large trucks in work zone fatal crashes were rear-ended. Table 2 below provides a summary of this information.

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[13] *Large Truck and Bus Crash Facts 2007*, Federal Motor Carrier Safety Administration.
[14] Analysis Brief, "Work Zone Fatal Crashes Involving Large Trucks, 2012," Federal Motor Carrier Safety Administration, Washington, DC. November 2014.

NTSB Table 2

Table 2. Summary of Results from 2012 Analysis of Work Zone Fatal Crashes Involving Large Trucks		
Crash Type	All Fatal Crashes	Work Zone Fatal Crashes
Involved at Least One Large Truck	11.2%	23.6%
Involved a Large Truck and Two or More Vehicles	16.9%	32.6%
Involved a Large Truck That Was Parked/Working	4.1%	18.9%

Note: Parked/Working large truck data comes from the Parkwork datafile in FARS.
Source: USDOT, NHTSA, FARS, available at: http://www.nhtsa.gov/FARS.

Table 3. below summarizes the highlighted descriptions above:

NTSB Table 3.

Table 1. Fatal Crashes by Work Zone, 2008–12										
	2008		2009		2010		2011		2012	
Crash Location	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Fatal Crashes Involving Large Trucks										
Not a Work Zone	3,584	95.5	2,852	95.6	3,153	96.4	3,214	95.5	3,335	96.3
Work Zone	170	4.5	131	4.4	117	3.6	145	4.3	129	3.7
Unknown	0	0.0	0	0.0	1	0.0	6	0.2	0	0.0
Total	**3,754**	**100.0**	**2,983**	**100.0**	**3,271**	**100.0**	**3,365**	**100.0**	**3,464**	**100.0**
All Fatal Motor Vehicle Crashes										
Not a Work Zone	33,510	98.1	30,273	98.1	29,756	98.2	29,300	98.1	30,253	98.2
Work Zone	662	1.9	589	1.9	521	1.7	533	1.8	547	1.8
Unknown	0	0.0	0	0.0	19	0.1	34	0.1	0	0.0
Total	**34,172**	**100.0**	**30,862**	**100.0**	**30,296**	**100.0**	**29,867**	**100.0**	**30,800**	**100.0**

Source: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA), Fatality Analysis Reporting System (FARS), available at: http://www.nhtsa.gov/FARS.

The following table 4 shows the states with the highest number of fatal work zone crashes involving a large truck.

NTSB Table 4.

Table 6. Top 10 States by Number of Work Zone Fatal Crashes Involving Large Trucks, 2008–12					
State	**2008**	**2009**	**2010**	**2011**	**2012**
Texas	27	17	14	23	28
Illinois	13	10	12	7	9
California	7	9	5	11	16
Florida	13	8	8	7	7
Georgia	11	4	10	6	6
Indiana	6	5	2	11	4
Arkansas	4	5	3	5	4
Tennessee	3	3	0	5	5
Wisconsin	2	4	2	1	5
Nebraska	1	2	1	3	4
Total	**170**	**131**	**117**	**145**	**129**

Source: USDOT, NHTSA, FARS, available at: http://www.nhtsa.gov/FARS.

Over the 5-year period 2008-2012, Texas has had the highest average number of fatal work zone crashes involving a large truck, averaging 21.8 per year. Texas is followed by Illinois, with an average of 10.2 per year, and California, with an average of 9.6 per year. In comparison, Tennessee had sixteen fatal work zone accidents over the 5-year period 2008-2012 involving large trucks or 3.2 per year

In 2012, the most critical precrash event was traveling in the same direction with a higher speed, accounting for 27.2 percent of fatal work zone crashes involving a large truck.

The table below summarizes critical precrash event for large trucks in fatal work zone crashes for the period 2010-2012.

NTSB Table 5.

Table 9. Top Five Critical Pre-Crash Events for Large Trucks Involved in Work Zone Fatal Crashes, 2010-2012			
Critical Pre-Crash Event	**2010**	**2011**	**2012**
Traveling in same direction with higher speed	39	46	44
From opposite direction over left lane line	9	18	19
Other vehicle stopped	16	25	18
Pedestrian involved	6	11	10
Traveling in same direction with lower or steady speed	5	5	10
Total	**150**	**175**	**162**

Note: The FARS variable this table is based on was first introduced in 2010. Individual rows do not add up to total as total includes work zone fatal crashes with other critical pre-crash events.
Source: USDOT, NHTSA, FARS, available at: http://www.nhtsa.gov/FARS.

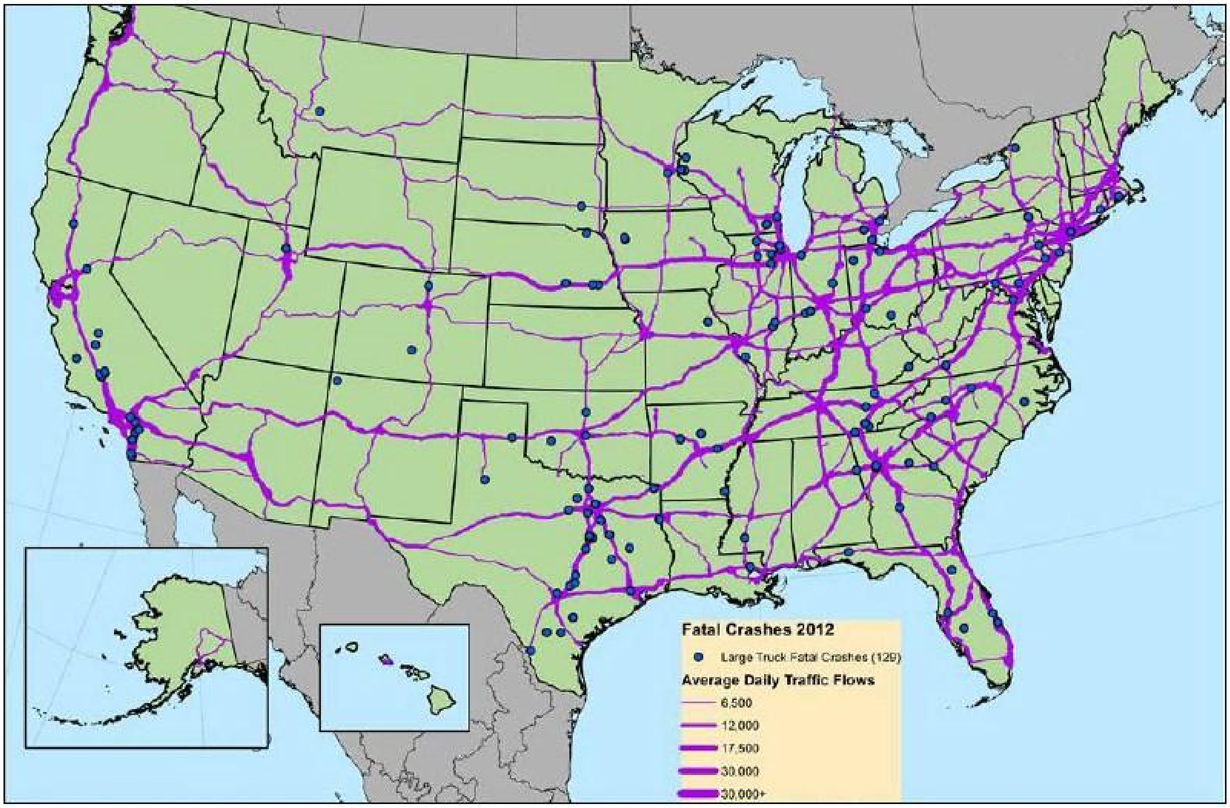
The next table describes the manner of collision, or orientation, for in-transport motor vehicles in fatal work zone crashes involving at least one large truck. Since 2008, the greatest proportion (on average 41.8 percent) of fatal crashes in work zones has been front to rear collisions. In 2012, 56.2 percent of large trucks involved in fatal work zone crashes were impacted at 6 o'clock (i.e. rear-ended) and 39 percent were impacted at 12 o'clock (i.e., front impact).

NTSB Table 6.

Table 10. Manner of Collision for Work Zone Fatal Crashes Involving Large Trucks, 2008–12					
Manner of Collision	**2008**	**2009**	**2010**	**2011**	**2012**
Not a Collision with Motor Vehicle In-transport	41	34	29	46	34
Front-to-rear	70	52	49	59	59
Front-to-front	15	8	11	11	12
Angle	32	21	19	19	17
Sideswipe—Same Direction	8	9	6	7	5
Sideswipe—Opposite Direction	3	4	2	1	1
Rear-to-side	0	1	1	0	1
Other	1	0	0	1	0
Unknown	0	2	0	1	0
Total	**170**	**131**	**117**	**145**	**129**

Source: USDOT, NHTSA, FARS, available at: http://www.nhtsa.gov/FARS.

The map below shows the United States with interstate roadways and their corresponding average daily truck traffic flows, with a colored circle representing each of the 129 fatal work zone crashes in 2012 that involved a large truck.



Note: Average Daily Truck Traffic Flows are based on Freight Analysis Framework (FAF) 3.4.
Sources: **Fatal Crashes** – USDOT, NHTSA, FARS, available at: http://www.nhtsa.gov/FARS. **Traffic Flows** - USDOT FHA, FAF Version 3, available at: http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/.

Figure 3

The next table shows the number of fatal work zone crashes in each state for 2012.

NTSB Table 7.

Fatalities in Motor Vehicle Traffic Crashes by State and Work Zone (2012)

State	Not in Work Zone Number	In Work Zone Number	Total Number
Alabama	856	9	865
Alaska	59	0	59
Arizona	819	6	825
Arkansas	541	11	552
California	2,790	67	2,857
Colorado	464	8	472
Connecticut	235	1	236
Delaware	112	2	114
District of Columbia	15	0	15
Florida	2,373	51	2,424
Georgia	1,172	20	1,192
Hawaii	124	2	126
Idaho	183	1	184
Illinois	937	19	956
Indiana	765	14	779
Iowa	358	7	365
Kansas	397	8	405
Kentucky	738	8	746
Louisiana	710	12	722
Maine	163	1	164
Maryland	499	6	505
Massachusetts	343	6	349
Michigan	924	14	938
Minnesota	391	4	395
Mississippi	579	3	582
Missouri	819	7	826
Montana	204	1	205
Nebraska	205	7	212
Nevada	243	15	258
New Hampshire	108	0	108
New Jersey	579	10	589
New Mexico	361	4	365
New York	1,152	16	1,168
North Carolina	1,281	11	1,292
North Dakota	169	1	170
Ohio	1,006	17	1,123
Oklahoma	688	20	708
Oregon	331	5	336
Pennsylvania	1,289	21	1,310
Rhode Island	64	0	64
South Carolina	860	3	863
South Dakota	131	2	133
Tennessee	1,002	12	1,014
Texas	3,273	125	3,398
Utah	199	18	217
Vermont	76	1	77

NTSB Table 7 continued.

Fatalities in Motor Vehicle Traffic Crashes by State and Work Zone (2012) | WorkZoneS... Page 2 of 2

Virginia	764	13	777
Washington	443	1	444
West Virginia	333	6	339
Wisconsin	602	13	615
Wyoming	123	0	123
Total	32,952	609	33,561
Puerto Rico	345	2	347

Source: Fatality Analysis Reporting System (FARS) 2012 ARF, NHTSA

Last verified: 11/25/2013

Research at the Texas Transportation Institute (TTI)[15] shows that truck involvement in fatal work zone crashes is over-represented. FARS data show that trucks are involved in 11-12 percent of all fatal crashes, but they were involved in 23.6 percent of fatal work zone crashes for the 8-year period 2005-2012. This percentage is consistent with previous estimates in 1999 and 2000, showing that large truck over-involvement in fatal work zone crashes has remained a consistent problem, spanning several years. According to the FMCSA fatal crashes in work zones that involved a heavy truck increased to 28 percent for 2013. Other evaluation work has been the subject of National Cooperative Highway Research Projects (NCHRP).[16] In NCHRP 627, researchers concluded the following:

1. Overall, working at night does not result in significantly greater crash risk for an individual motorist traveling through the work zone than does working during the day.
2. Crashes that occur in nighttime work zones are not necessarily more severe than those that occur in similar daytime work zones.
3. For work activities that require temporary lane closures, the total safety impacts to the motoring public are less if the work is done at night.

Strategies that appear to offer the greatest potential for crash cost reduction include the following:

1. Practices to reduce the number and duration of work zones required;
2. Use of full-directional roadway closures via median crossovers or detours onto adjacent frontage roads;
3. Use of time-related construction contract provisions to reduce construction duration;

[15] *FHWA Webinar Truck Crash Trends in Work Zones*, October 2014, Ullman, Gerald L, Ph.D., P.E., Texas Transportation Institute.

[16] NCHRP Program Report 500, *Guidance for the Implementation of the AASHTO Strategic Highway Safety Plan*, Volume 17, "Guidance for Reducing Work Zone Collisions," Transportation Research Board, 2006, Washington, DC, and NCHRP 627, *Traffic Safety Evaluation of Nighttime and Daytime Work Zones*, 2008 Transportation Research Board, Washington, DC.

4. Moving appropriate work activities (i.e., those require temporary lane closures) to nighttime hours;
5. Use of demand management programs to reduce volumes through work zones; and
6. Use of enhanced traffic law enforcement.

Other strategies may offer moderate reductions in crash costs due to work zones, depending on conditions. Strategies that have been grouped into this category include the following:

1. Designing adequate future work zone capacity into highways;
2. Use of full roadway closures that require traffic detours onto adjacent surface streets;
3. Use of Intelligent Transportation Systems (ITS) strategies to reduce congestion and improve safety;
4. Improvement of work zone traffic control device visibility;
5. Efforts to reduce flaggers exposure to traffic; and
6. Efforts to reduce workspace intrusions and their consequences- primarily at long-term, high-volume work zones.

One mediation effort that began early in the decade was the development and application of ITS in work zones. ITS in work zones is referred to as Smart Work Zones (SWZ) in the research literature.

8.1 Use of ITS in Work Zones

One of the more promising accident reduction applications is the use of ITS in creating smart work zones. A 2011 research project at the TTI[17] explored the value of and defined an approach to integrating ITS into work zones in Texas. Results of various ITS work zone implementations have been shown to positively impact work zones by reducing queues, reducing speeds, reducing crashes, and providing route guidance information to drivers.[18]

Some of the documented successes from smart work zones include the following:

1. Reductions in queue lengths of about 60 percent are possible;
2. Fifty to 85 percent of drivers surveyed changed their routes based on work zone ITS messages;
3. Speed monitoring displays reduced speeds in the range of 4-6 mph and reduced the number of speeding vehicles from 28 to 78 percent.

[17] *Use of Intelligent Transportation Systems in Rural Work Zones*, Texas Transportation Institute, Texas A&M University System, Report No. 0-6427-1, Middleton, Dan, Brydia, Robert, Pesti Geza, Songchitruksa, Praprut, Balke, Kevin, and Ullman, Gerald, August 2011.
[18] USDOT, *Intelligent Transportation Systems for Work Zones*, Washington DC. USDOT FHWA, 2007. FHWA-JPO-07-003.

Smart work zones can also improve driver behavior. For example, dynamic lane merge systems help reduce driver confusion at merge points and reduce aggressive driving and turbulence.[19] Typical work zone ITS applications can include the following:

1. DMS – portable or permanent.
2. Highway advisory radios – portable (site specific) or permanent.
3. Over-height detection systems.
4. Intrusion detection systems.
5. Portable signal systems.
6. Speed detection and display.
7. Speed violation and deterrent systems.
8. Speed violation and enforcement.
9. Variable speed limit systems.
10. Automated flagger assistance.
11. Flashing stop/slow paddles.
12. Project information websites.
13. Dynamic lane merge systems.
14. Queue detections systems.
15. Work zone integration into a Transportation Management Center (TMC).

In this investigation, the TDOT used permanent overhead DMSs, a 511 call system, project websites, and reduced speed limits.

8.2 Specific Smart Work Zone Treatments

The TTI research project reviewed relevant recent literature and paid particular attention to studies evaluating the following:

1. The benefits of using ITS in work zones.
2. Various merge control strategies in advance of work zone lane closures.
3. Variable advisory and posted speeds.

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[19] *Intelligent Infrastructure*, *Roadway Operations and Maintenance, ITS Benefits, Costs, Deployment, and Lessons Learned*, FHWA, USDOT, Washington, DC. 2008 update.

4. Dynamic queue warning systems.

8.2.1 Early Merge Control

Early merge strategies encourage drivers to merge into the open lane farther in advance of the lane closure; they can consist of static or dynamic early merge systems. Static early merge systems consist of additional signage posted at 1-mile intervals several miles in advance of the lane closure. These reduce the potential for merge-related crashes and rear-end crashes by alerting drivers farther in advance of the lane closure. Simulation studies indicated that early merge control strategies significantly reduced the frequency of forced merges but increased travel times through the zone.[20] Vehicles are more likely to be delayed over greater distances by slower vehicles ahead of them in the open lane. This may in turn increase the likelihood of drivers' attempting to use the discontinuous lane to pass slower vehicles, which could increase the potential for lane-change accidents.

Dynamic early merge systems can provide warnings over variable distances based on real-time measurements of traffic conditions. Again, heavier congestion and longer queues can develop when these systems are used during heavy peak flows. An example of an early merge dynamic merge control plan used by Indiana is shown below.

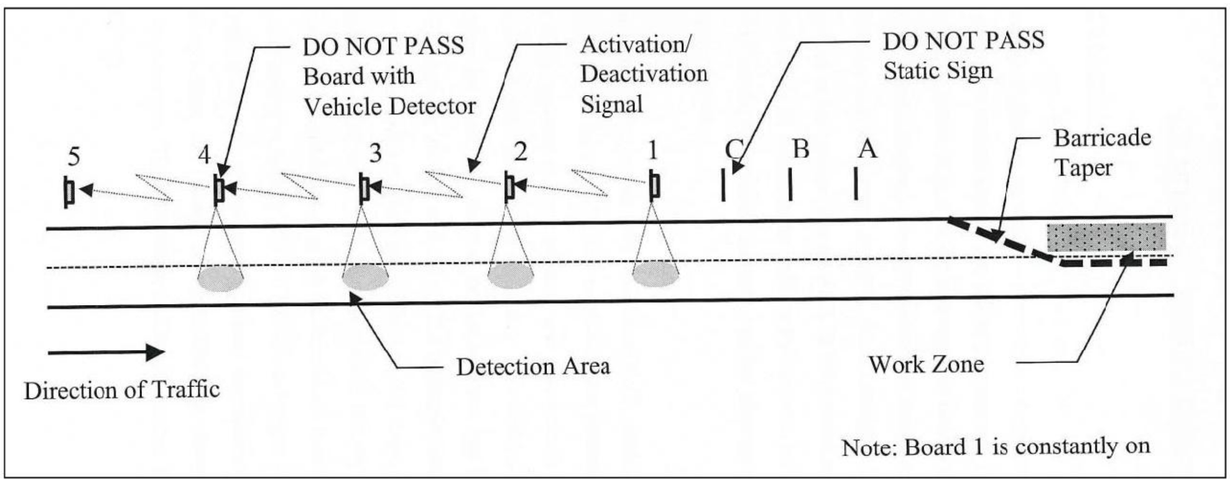

Figure 4

As the traffic backs up, the vehicle detectors warn traffic not to pass at farther distances back from the merge point.

Another strategy is late merge control, which encourages vehicles to occupy both lanes up to a designated point rather than causing early merging. An example used by the Pennsylvania DOT is shown below.

[20] Nemeth, Z.A., and N.M. Rouphail. "Lane Closures at Freeway Work Zones: Simulation Study." Transportation Research Record No: 869, TRB, National Research Council, Washington, DC.

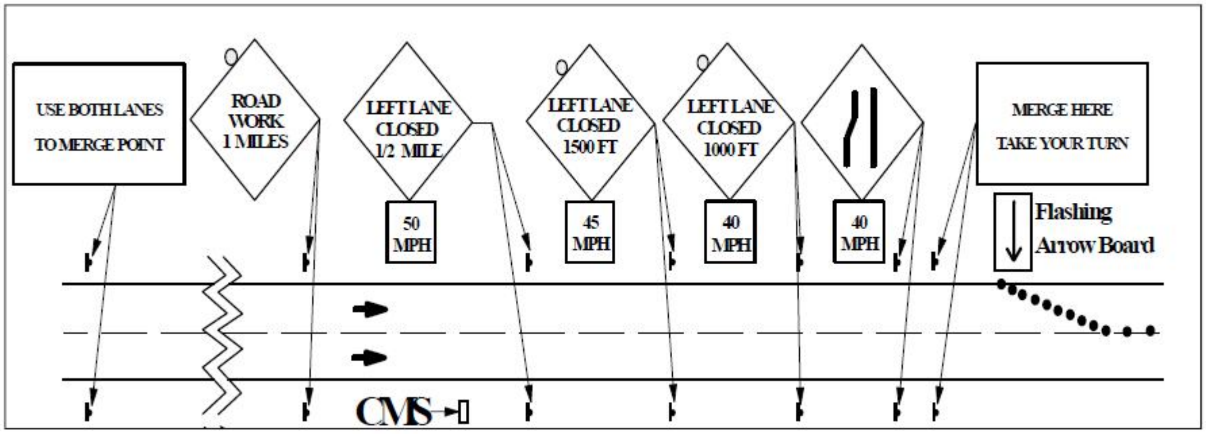

Figure 5

The advantage of this system is that it allows drivers to use the lane with the shortest queue, up to a designated point. Also, dynamic lane merge systems with vehicle detectors have been used in Maryland, as seen in the figure below.

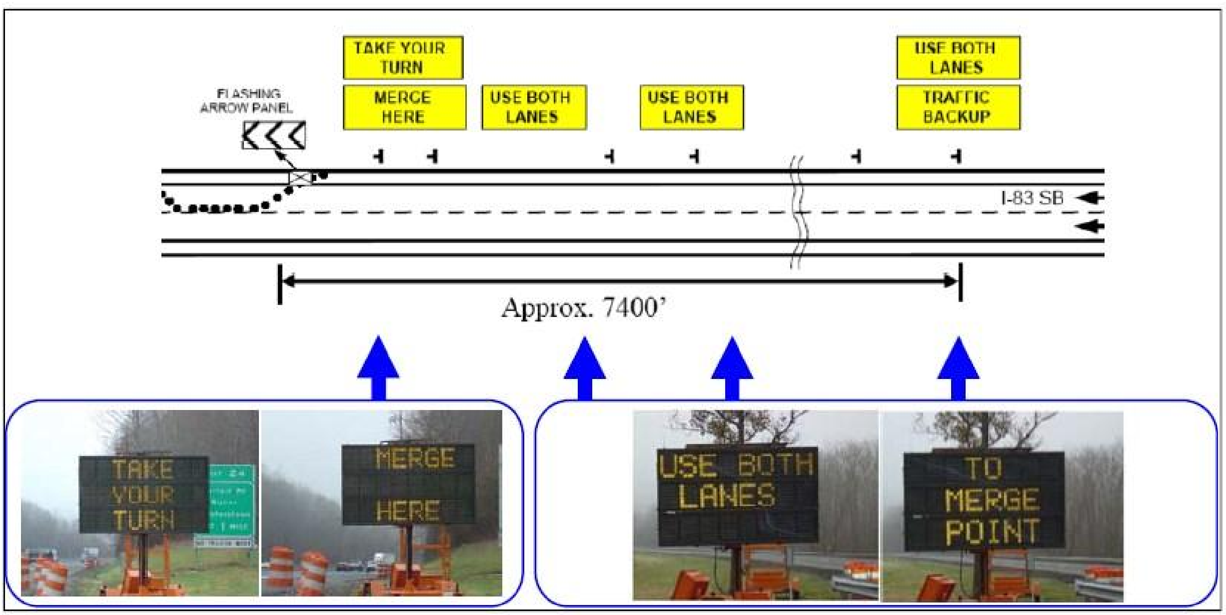

Figure 6

Numerous studies found that rear-end collisions are the most frequent types of crashes on freeway facilities, especially at work zones.[21,22] Several human factors studies concluded that

[21] National Transportation Safety Board, 2001. *Vehicle-and Infrastructure Based Technology for the Prevention of Rear-end Collisions*. Special Investigation Report NTSB/SIR-01/01. Washington, DC. Available: http://www.ntsb.gov/Publictn/2001/SIR/0101.htm.

[22] Battelle Transportation Systems. "Precursor Systems Analyses of Automated Highway Systems," *AHS Roadway and Analysis*. Report No. FHWA-RD-95-043, October 1994.

drivers approaching the end of queues often have poor perception of the time and distance needed to decelerate safely to a stop. A research project conducted in Texas[23] observed between 1 and 16 hard-braking maneuvers per 1,000 approaching vehicles at two work zone sites. A Canadian study determined that drivers were usually aware of approaching slow vehicle queues, but in cases of large speed differentials (over 25 mph), they often had poor perceptions of how quickly they could slow down before getting too close or colliding with slower vehicles ahead. A TTI report[24] provided a comprehensive list of published research in this area.

Providing effective advance warning to drivers approaching slow or stopped traffic queues requires an understanding of queue dynamics. The appropriate number and spacing of detectors and warning message signs depend on a number of factors, including queue characteristics, (e.g., maximum queue length and shockwave speed or how quickly the queue builds backwards toward approaching traffic) and roadway geometry. Queue characteristics can be measured in the field or estimated using simulation models for operating speed, traffic volume, and lane configurations. When traffic demand or volume exceeds capacity, shock waves may propagate upstream of the warning. An Iowa study[25] of rural interstate work zones with lane closures determined shockwave speeds as high as 30-40 mph.

8.2.2 Active Speed Warning and Queue Detection Systems

Active Speed Warning Signs (ASWS) were evaluated at a construction zone on I-80 near Lincoln, Nebraska.[26] The system consisted of three speed monitoring displays equipped with radar units. They were displayed at ¼-mile increments in advance of the work zone lane closure. The radar units measured the speed of downstream traffic, and the speed messages displayed were intended to warn drivers of stopped or slow-moving traffic ahead. Figure 8 below shows the speed display and its effect on average speed.

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[23] Ullman, G.L., M.D. Fontaine, S.D. Schrock, and P.B. Wiles. *A Review of Traffic Management and Enforcement Problems and Improvement Options at High-Volume, High-Speed Work Zones in Texas*, Research Report 0-2137-1. TTI, College Station, Texas. February 2001.
[24] Wiles, P.B., S.A. Conner, C.H. Walters, and E.J. Pultorak. *Advance Warning of Stopped Traffic on Freeways: Current Practices and Field Studies of Queue Propagation Speeds*, Research Report 0-4413-1. TTI, College Station, Texas. June 2003.
[25] Maze, T., S.D. Schrock, and A. Kamyab. "Capacity of Freeway Work Zone lane Closures, Proceedings, Mid-Continent Transportation Symposium 2000," Center for Transportation Research and Education, Iowa State University, Ames, 2000.
[26] Pesti, G. *Alternative Way of Using Speed Trailers: Evaluation of the D-25 Speed Advisory Sign System.*

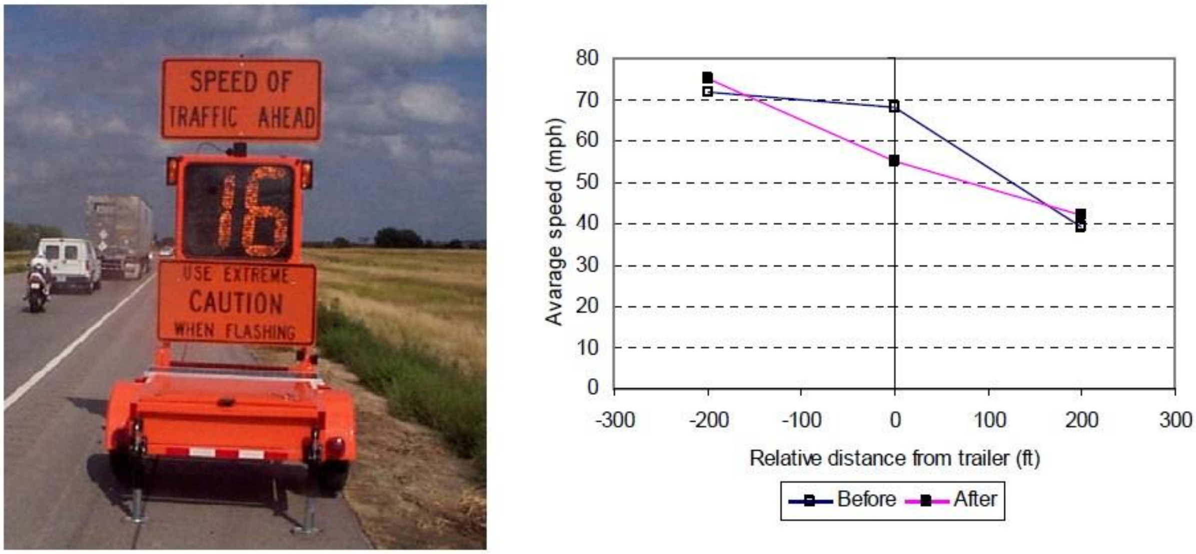

Figure 7

The results of the analysis showed that the speed messages were effective in reducing the speed of vehicles approaching queued traffic. The change in mean deceleration due to the speed advisory system was statistically significant at the 95-percent confidence level.

The University of Michigan developed and evaluated a Work Zone Safety System for adaptive queue warning.[27] It was a distributed queue-warning system that automatically adapts to the traffic flow situation within and upstream of the work zone. Figure 9 below illustrates the concept of the adaptive queue-warning system.

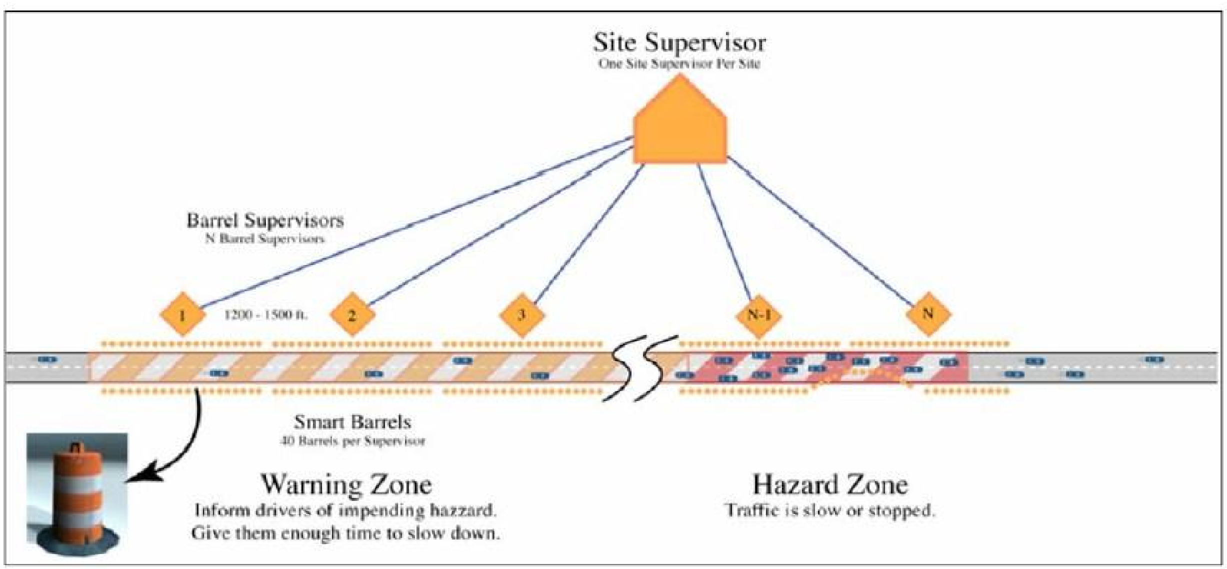

Figure 8

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[27] Sullivan, J.M., C. Winkler, and M.R. Hagan. *Work-Zone Safety Intelligent Transportation Systems: Smart Barrel for an Adaptive Queue-Warning System*. FHWA Report Number: UMTRI-2005-3, Washington, DC, 2005.

A core component of the system is the so-called "smart barrel" (I-cone). The smart barrel is a typical orange traffic-control barrel equipped with an inexpensive speed sensor; a simple, adjustable signaling system; and the necessary equipment for communication to a central controller. The Michigan study prototyped and tested a simple signaling scheme using a series of pole-mounted warning lights in a driving simulator, as illustrated in figure 10.

Driving simulator results indicated that drivers find adaptive systems more helpful than static road signs. Analysts observed systematic positive change in driving performance, which indicates enhanced safety. The technology shows promise in addressing problems of work zone rear-end crashes.

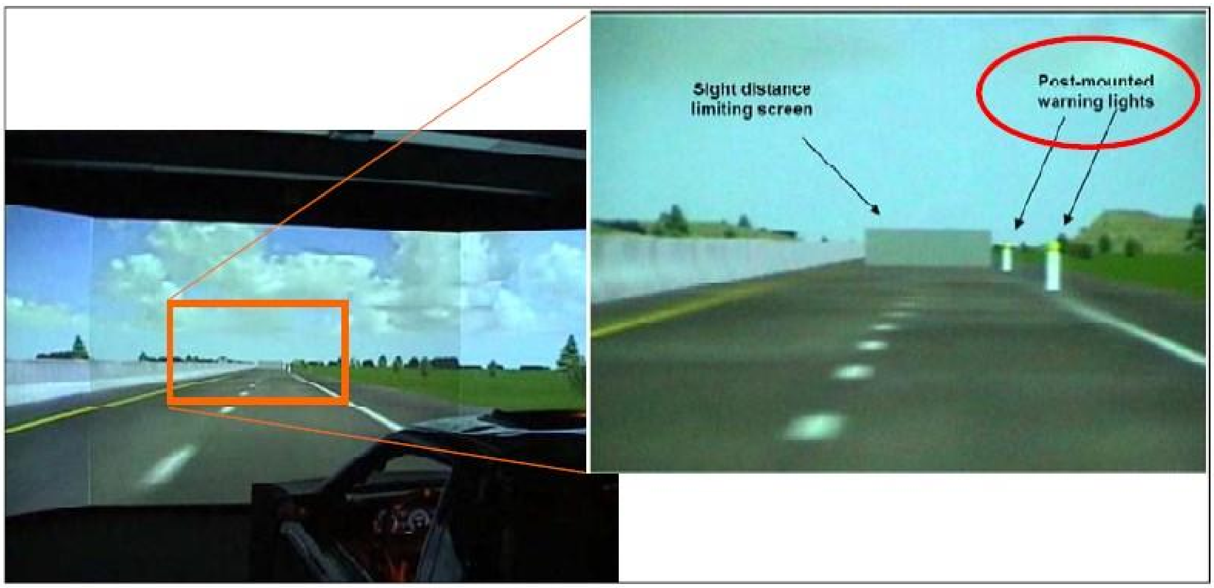

Figure 9

Another speed advisory system found in the Minnesota DOT's Intelligent Work Zone tool box is shown in figure 10.

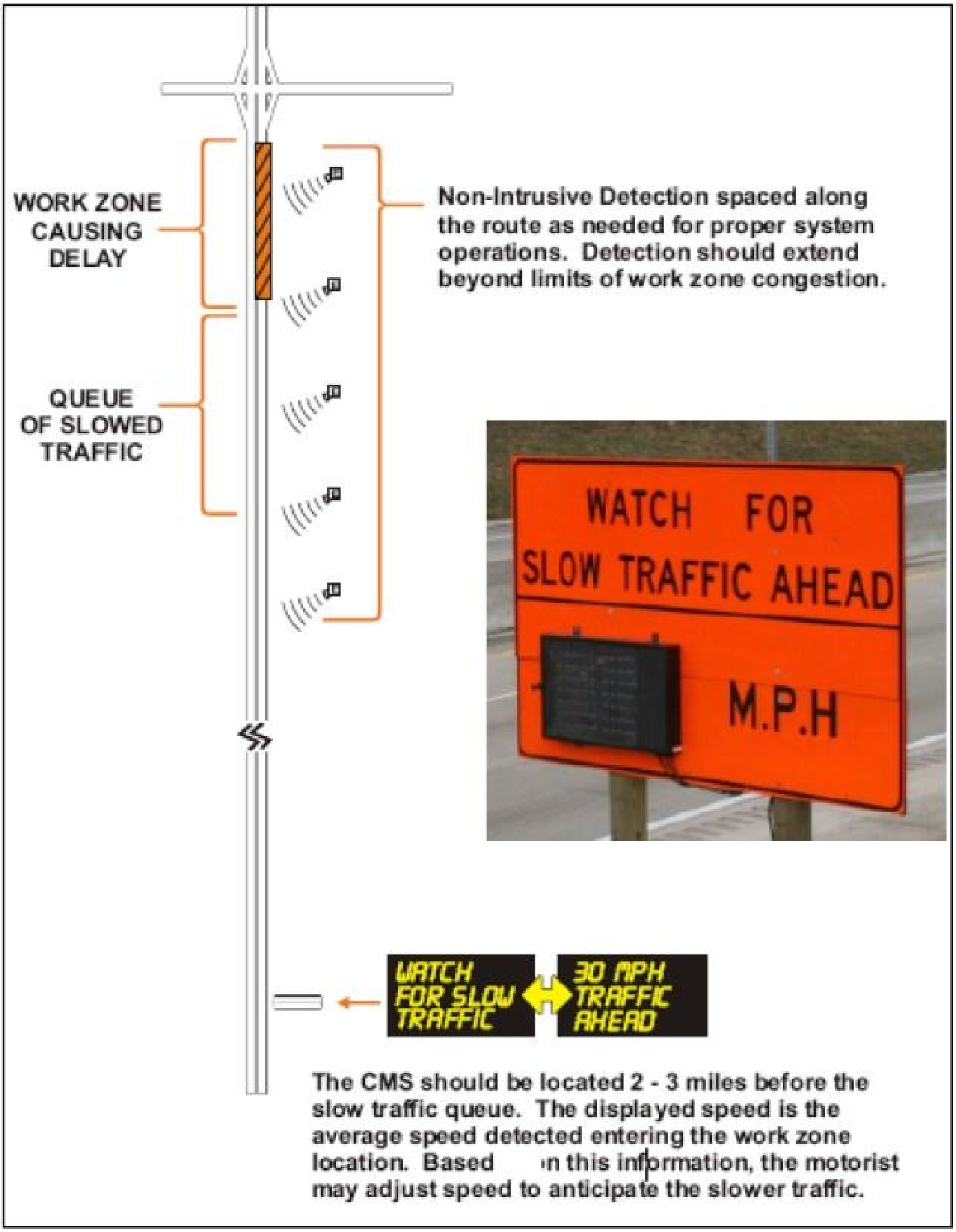
WORK ZONE CAUSING DELAY
QUEUE OF SLOWED TRAFFIC
Non-Intrusive Detection spaced along the route as needed for proper system operations. Detection should extend beyond limits of work zone congestion.
WATCH FOR SLOW TRAFFIC AHEAD
M.P.H
WATCH FOR SLOW TRAFFIC
30 MPH TRAFFIC AHEAD
The CMS should be located 2 - 3 miles before the slow traffic queue. The displayed speed is the average speed detected entering the work zone location. Based on this information, the motorist may adjust speed to anticipate the slower traffic.

Figure 10

Minnesota uses a similar dynamic sign set-up to warn of stopped traffic ahead. See figure 12.

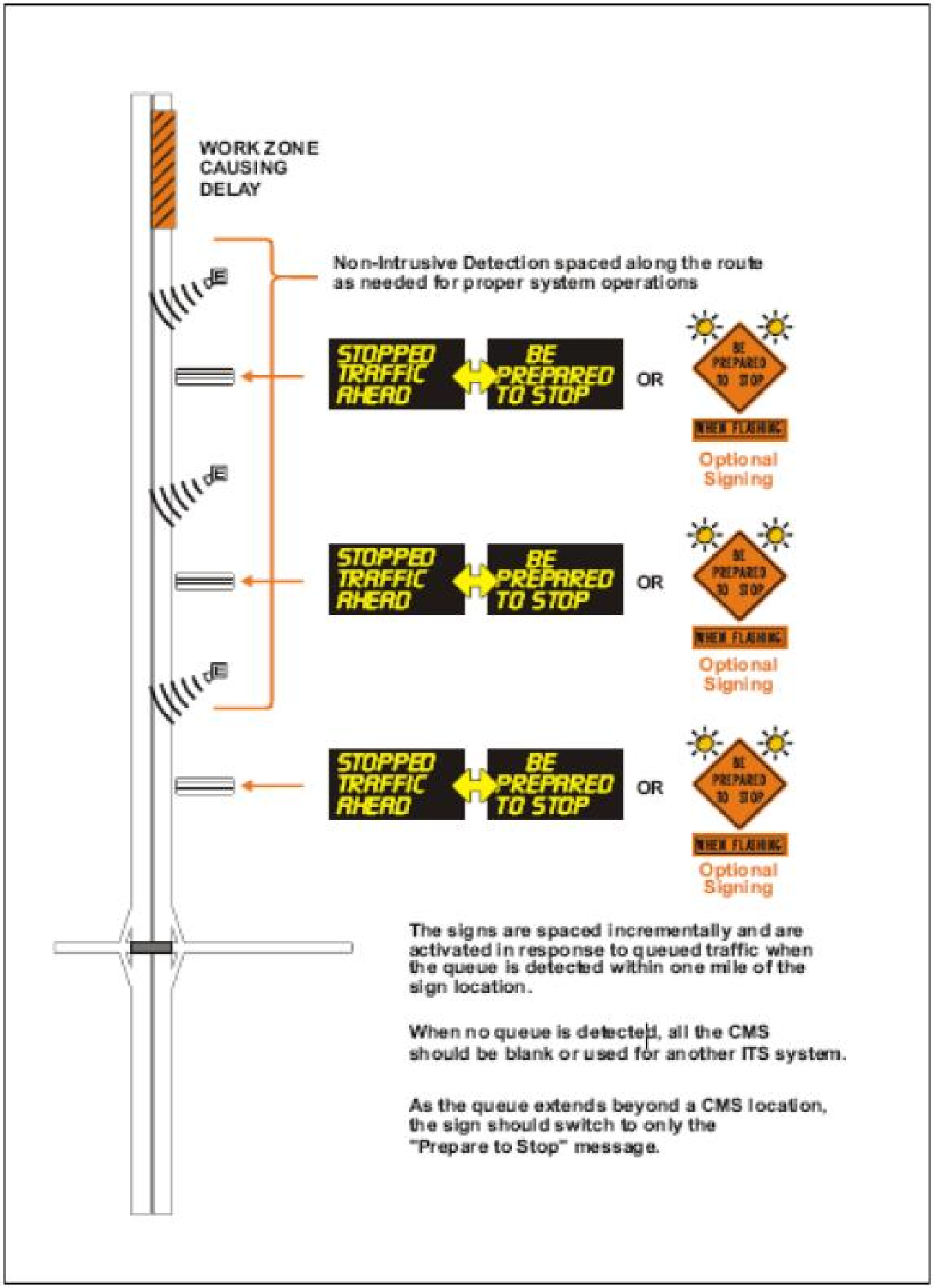

Figure 11

Researchers examined another ITS project implemented by the Texas Department of Transportation (TXDOT) in October 2006 on I-35 near Hillsboro, Texas. The purpose of the system was to monitor traffic conditions and improve mobility and safety along I-35W, I-35E, and I-35 to the south of the split. Figure 13 shows the Hillsboro area and indicates the work zone.

Figure 12

I-35 splits north of Waco into I-35E to Dallas and I-35W to Fort Worth. All three roadways are freeways with four lanes, two in each direction, and are otherwise similar. The work zone project was 10 miles in length, began construction in July 2006, and was scheduled for completion in mid-2008. The system provided real-time delay information to motorists based on predetermined speed and occupancy thresholds and recommended alternate routes via DMSs. Three wireless closed circuit cameras provided imagery for monitoring traffic by TXDOT.

The work involved reconstructing the main interchange and rehabilitating the pavement and structures along the route. Lane closures were involved, reducing the capacity of the roadway. TXDOT expected long queues and delays, especially along southbound I-35W upstream of the split. Much of the traffic was commuter traffic.

The system consisted of the following components:

1. Six solar-powered portable microwave detection trailers (sidefire orientation).
2. Six solar-powered Portable Changeable Message Signs (PCMS).
3. Three portable video trailers (with cameras).
4. A system server, web host, and associated software and equipment.

5. A website for use by the general public and TXDOT.

Two sensors monitored traffic on each approach to the work zone and sent messages to two PCM signs, based on predetermined speed and occupancy thresholds. TXDOT had the ability to do the following:

- Dynamically adjust queue thresholds,
- Preempt messages, and
- Alert appropriated personnel if problems occurred.

Objectives of the ITS system included the following:

- Provide delay information and route guidance to motorists,
- Reduce demand and congestion by diverting traffic as needed, and
- Provide trip planning information to commuters and management information to TXDOT.

Objectives of the evaluation included the following:

- Determine traveler response to work zone information,
- Determine the effect of traveler response to traffic conditions, and
- Determine whether the system detected congestion in real time and posted appropriate messages

The study team used diversion rates at freeway exit ramps as the primary measure of effectiveness to evaluate system effectiveness. During times of heavy congestion, motorists were more likely to follow diversion guidance posted on the message boards. The system demonstrated that it could detect congestion and display appropriate messages. Specifically, it posted travel times for free-flow conditions, SLOW TRAFFIC AHEAD and similar messages when speeds dropped, and diversion messages when occupancy met the desired threshold. TXDOT also developed a queue warning system for use on I-35. To evaluate the expected performance of the proposed queue warning system, the research team selected a freeway work zone with a nighttime lane closure from 7 p.m. to 8 a.m. The work zone was located on the southern boundary of an approximately 10-mile-long segment in the southbound direction of I-35 between Hillsboro and West, Texas. The work required closing the left-hand lane of the two-lane southbound freeway. The traffic was modeled using the traffic simulation software VISSIM. The simulation replicated the speed sensors of the queue warning system by placing virtual detectors every ½ mile upstream of the work zone entrance point up to Hillsboro. Every virtual detector could be activated or deactivated during simulation, making it possible to study the impacts of different detector spacings.

The simulation used an average daily traffic of 69,000 vehicles per day with a truck percentage of 37 percent. Figure 13 shows the hourly distribution of traffic volumes, and the estimated capacity was 1,285 vehicles per hour per lane.

Hour	19-20	20-21	21-22	22-23	23-24	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
Volume (vph)	1690	1449	1241	1034	828	620	517	448	448	517	758	1104	1414

Figure 13

Figure 14 shows a plot of the queue lengths over the entire period of the simulated nighttime work zone lane closure. The unit of measure is feet, and the distance is measured from the lane closure upstream. The maximum queue length was 2.4 miles, and most of the queueing was between 7 p.m. and midnight.

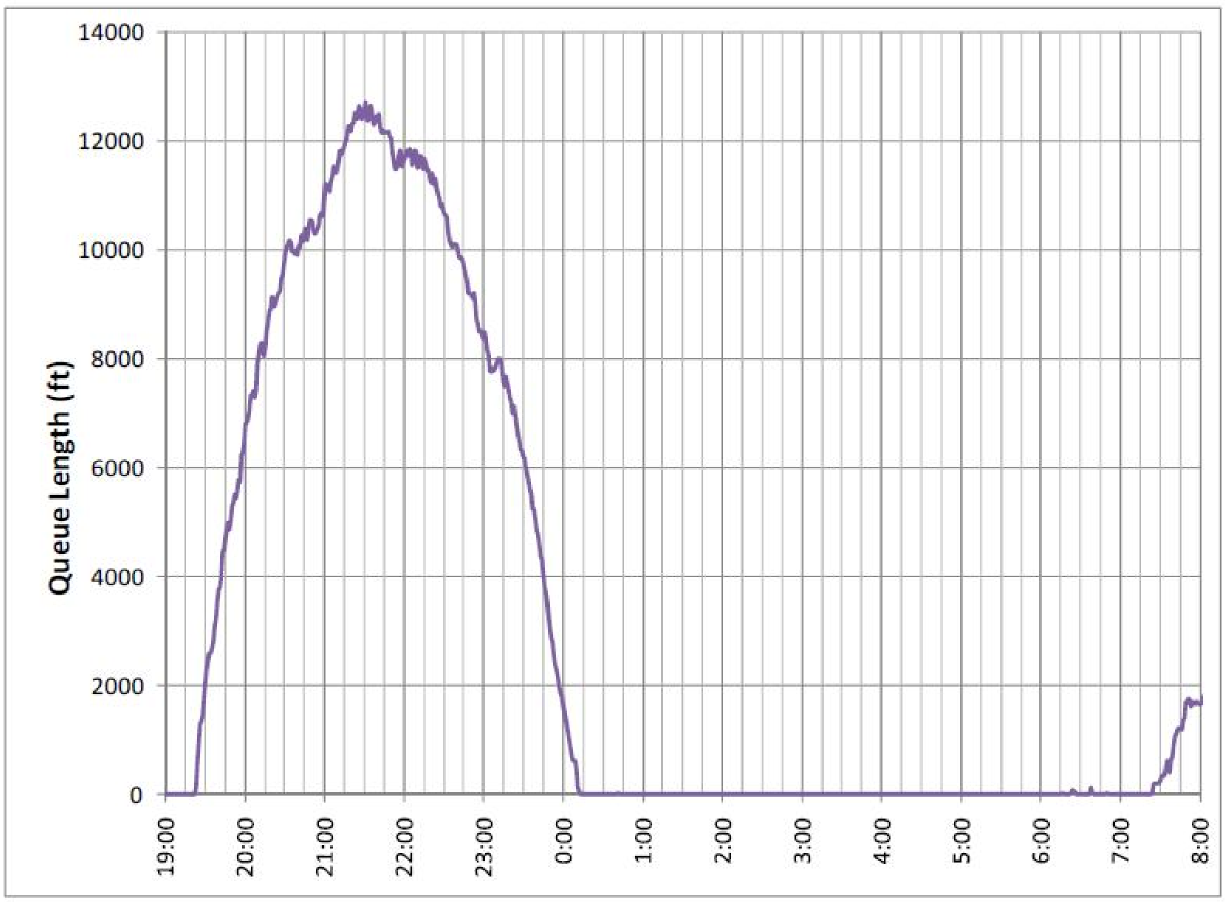

Figure 14

Based on the findings of the simulation, the research team recommended the queue warning system design parameters summarized in figure 15.

Design Parameter	Recommended Value
Speed threshold for STOPPED TRAFFIC	35 mph
Speed threshold for SLOW TRAFFIC	55 mph
Detector spacing	½ mile
Speed aggregation interval	5 minutes
PCMS message update interval	1 or 5 minutes
PCMS distance upstream of lane closure	1–2 miles upstream of the longest expected queue

Figure 15

Once the operational characteristics of the work zone queue are understood through simulation, the number and spacing of detectors can be established. Figure 16 shows an example of the system with detector spacings.

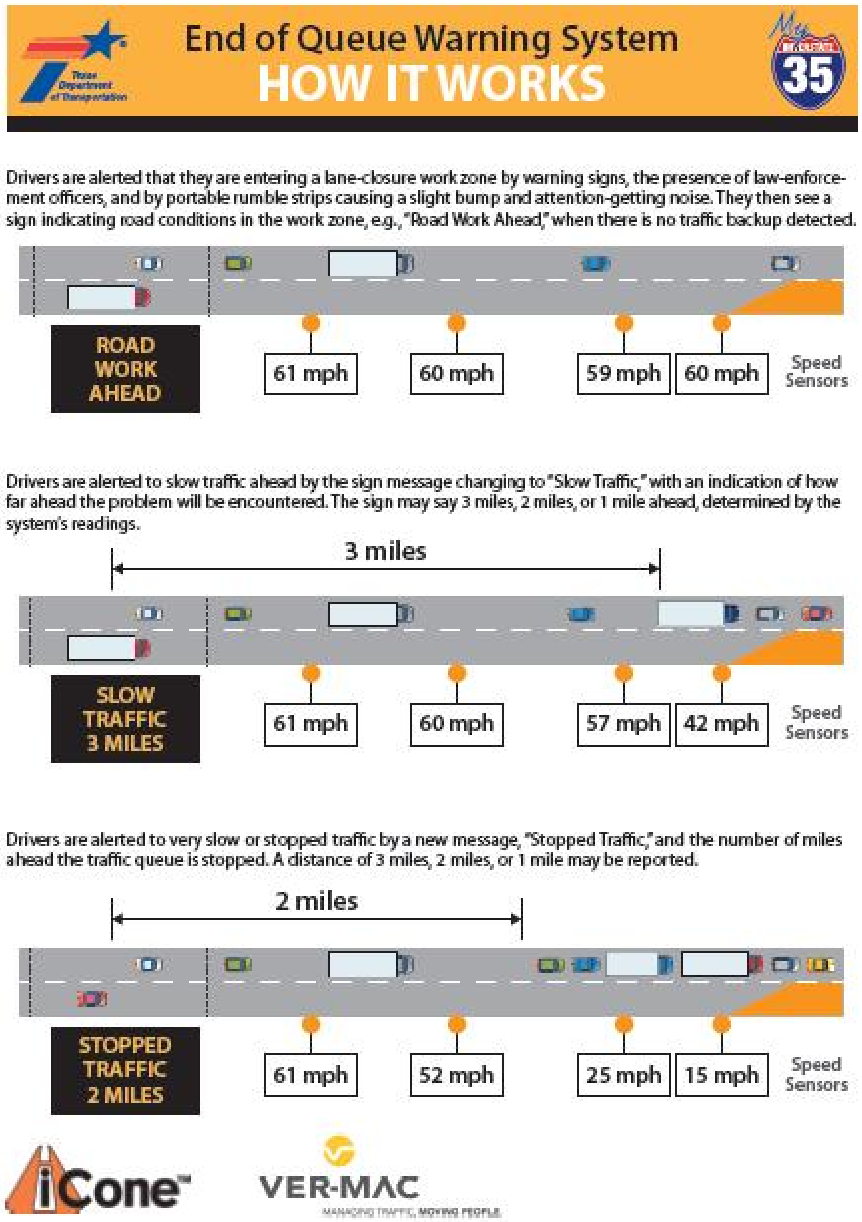

Figure 16

In summary, smart work zones have been shown to be effective in reducing congestion, travel times, and accidents, but proper investigation of field performance or simulation must be undertaken to ensure that ITS is effective, just as in-field observations of more common static temporary traffic control devices are performed to ensure they are meeting needed objectives. In 2015 the FHWA is conducting three webinars on Smart Work Zone design and implementation, Additionally, the Federal Highway Administration, Federal Motor carrier Safety Administration, the National Highway Traffic Safety Administration, and the Commercial Vehicle Safety Alliance (CVSA) conducted a national symposium on fatal truck crashes in work zones at the quarterly CVSA meeting in Jacksonville, Florida in April 2015, to gather information on needed changes to improve the fatal truck crash problem in work zones. In this accident, the manual queue protection requirement in the special provisions served to provide warning at all times in advance of any slow moving or stopped traffic. The traffic queue was 3/10ths of a mile from the arrow board which was closing the lane at MP 12 and the queue protection truck was located at MP 10 warning drivers that the left lane was closed and to be prepared to stop.

9.0 TDOT Incident Management Following the Accident

The TDOT Transportation Management Center (TMC) was notified of the accident at 7:14 p.m. At 7:18 p.m. the DMS sign at MP2 was changed to reflect that all traffic was block on I-75 and being diverted to a detour at exit 11. By 7:45 p.m. all available help and queue trucks were marshalled at the TMC and dispatched to crucial interchanges in the Chattanooga area. Queue trucks from Bradley and McMinn County were also used at the US 64/I-75 interchange at exit 20. At 9:13 p.m. Atlanta, Georgia P.D. was notified that I-75 was closed in the Chattanooga area and to be cautious about traffic queues extending into the Atlanta area, which was approximately 100 miles away. At 11:10 p.m. a secondary non-injury crash occurred on I-75 near MP 9.8. The THP and Chattanooga P.D. on-scene investigation along with body and vehicle removal was complete, and the incident was cleared with I-75 re-opening at 7:02 a.m. on June 26, 2015. For more details see **Highway Attachment 12,** TMC Incident Timeline.

E. DOCKET MATERIAL

The following attachments and photographs are included in the docket for this investigation:

LIST OF ATTACHMENTS

HIGHWAY Attachment 1 - CNN 306 Construction Contract

HIGHWAY Attachment 2 - Plan and Profile sheets for I-75 near Accident Site

HIGHWAY Attachment 3 - TDOT Work Zone Safety and Mobility Manual and Special Provision SP712PTQ – Queue Truck Protection and Transportation Management Plan (TMP)

HIGHWAY Attachment 4 - TDOT's After Action Report on Accident

HIGHWAY Attachment 5 - CNN 306 Pre-Construction Conference Minutes

HIGHWAY Attachment 6 - Tennessee 2016 Strategic Highway Safety Plan

HIGHWAY Attachment 7 - Safe Practices for Law Enforcement Personnel Operating in Work Zones

HIGHWAY Attachment 8 - Interview Summaries

LIST OF PHOTOGRAPHS

HIGHWAY Photo 17	View of “Left Lane closed 1500 Feet” sign @ MP 11.79, or approximately 424 feet after the initial impact

END OF REPORT

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Senior Highway Factors Investigator