

# Research Record

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## Dynamic Solution to the “Forced Late Lane Merge” Phenomenon

### MDOT Evaluates Improved Safety and Time Savings in Lane Merging Construction Work Zones

As highway construction throughout the state increases, so does the danger to both road workers and motorists in road construction zones. What was once a familiar setting becomes an area that is compressed and hazardous. Increased frustration and impatience leads to aggressive behavior by drivers, causing traffic crashes, deaths, injuries and property damage. Most crashes occur in areas where one or more lanes are closed. In Michigan, over 15,000 crashes occurred in lane closure areas from 1999-2003; twenty-four of these crashes were fatal.

The most common problem in lane closure work zones is the “forced late lane merge phenomena.” This happens when drivers are forced to enter the continuing lane at the last moment. Some drivers are inadvertently trapped in the lane that is about to end, while others are there intentionally trying to race ahead of other traffic. Not only is the late merge dangerous, it also disrupts the flow of traffic causing what is called the “shock wave phenomena” (SWP). SWP is when one driver applies the brakes and subsequent drivers behind him or her are forced to apply brakes suddenly, which causes interruptions in traffic and delays in travel time.

#### Overview

Over the years MDOT has used a variety of innovative work zone traffic control technologies as a way to improve traffic flow and increase safety. Using modified ideas from the Indiana Department of Transportation and the Pennsylvania Department of Transportation, MDOT developed the Dynamic Lane Merge

System (DLMS). The main benefit of this system is that it establishes a “no passing zone” in road construction zones, thus making aggressive driver behavior punishable by law enforcement.

Initially there were two systems, manual and dynamic. The manual system used manual or static “Do Not Pass/When Flashing” signs. The manual signs were switched to the flashing



**Figure 1.** The DO NOT PASS WHEN FLASHING Sign is an Important Part of the DLMS.

mode to create a no passing zone depending on anticipated times of congestion and were left on for an extended period of time. The manual system was found to be unsuccessful because the flashers were always on and were not consistent with traffic volumes. Wayne State University (WSU) researcher, Dr. Tapan Datta reported that “drivers follow traffic control if they feel it is needed. If you keep the flashers on all the time, even when it is not needed, drivers disobey the control.”

The dynamic system used the dynamic “Do Not Pass/When Flashing” signs. Dynamic signs are signs that can send and receive signals that are evaluated by an on-board computer that triggers the signs to start flashing when established traffic congestion levels are reached. Information collected from the traffic sensors is relayed from one sign to the next upstream sign, lengthening the no passing zone as needed and encouraging drivers to merge sooner.

To determine the effectiveness of the DLMS, MDOT began a pilot test in the 2000 construction

season. The DLMS was implemented at five work zone locations on the state highway system. As this system was new to Michigan, WSU researchers were asked to study the initial pilot test sites.

Phase I of the DLMS was designed to reduce traffic from two lanes down to one lane (see Figure 2). The system totaled a 7700 ft. construction zone, using advisory, dynamic and work zone signs in the following layout;

- 1400 ft. of advisory signs; “Road Work Ahead” sign, “Traffic Fines Double In Work Zones” sign and “Form One Lane/Right” sign.
- 4200 ft. of three dynamic “Do Not Pass/When Flashing” signs created a dynamic no passing zone, a “Left Lane Closed Ahead” sign and a “Do Not Pass When Flashing” sign that is always in the flashing mode.
- 2100 ft. prior to the taper area was signed with work zone warning signs; “Reduced Speed Ahead”, “Merge Left” and a “Speed Limit” sign.

Phase II of the pilot consisted of modifications made to the system layout in order to address the

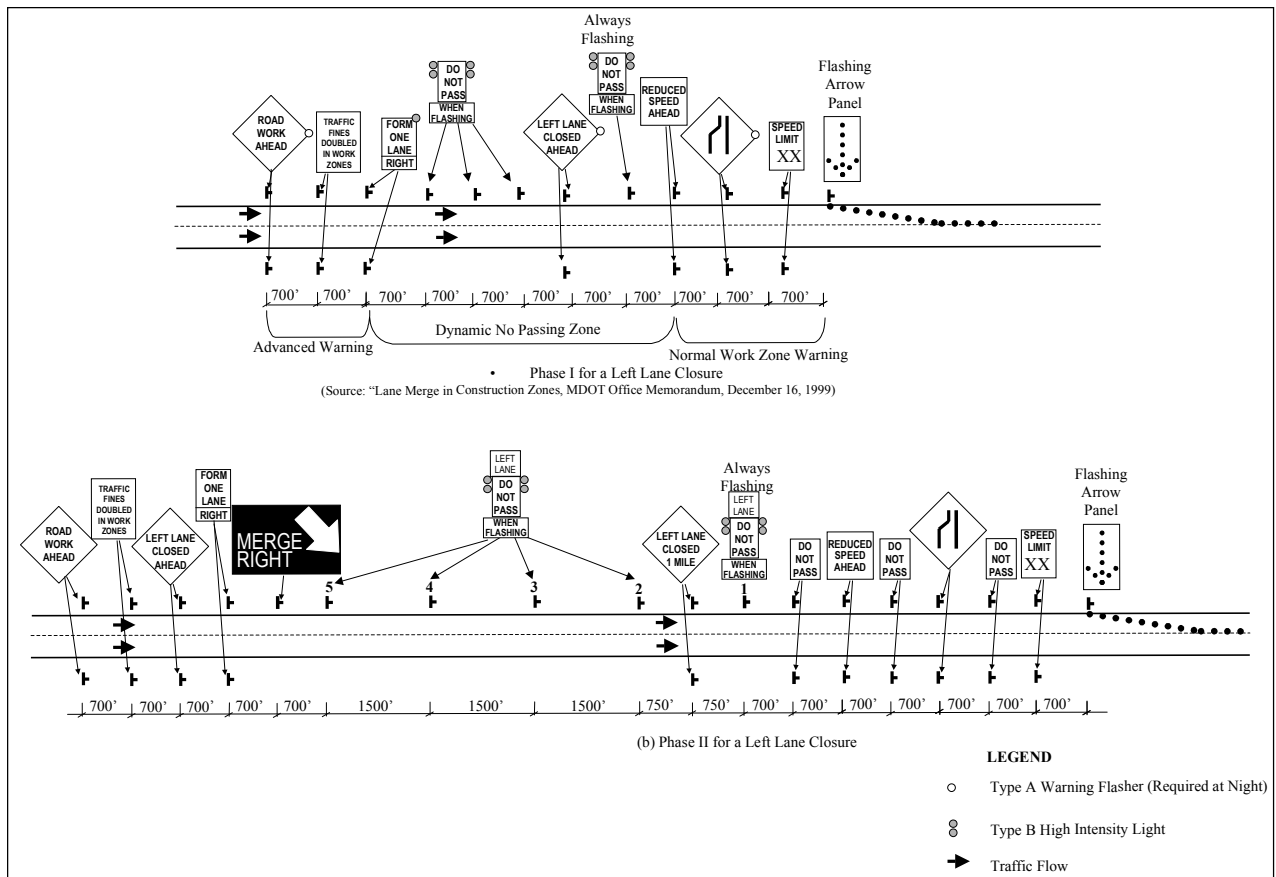


Figure 2. Sign Placement for Phase I and Phase II of the DLMS Study.

problems discovered during the Phase I pilot (see Figure 2). Researchers realized that the length of the zone was not sufficient to allow drivers time to react properly to the signs so they increased the overall signage zone to 17,200 ft. It was determined that additional signs were also needed to clarify expectations of drivers. To correct these problems the following changes were made;

- Static “Do Not Pass” signs were added between the “Left Lane Closed Ahead” sign and the dynamic “Do Not Pass/When Flashing” sign.
- Spacing between the dynamic “Do Not Pass/When Flashing” sign was increased from 700 ft. to 1500 ft.
- A changeable message sign was placed upstream of the dynamic signing with “Merge Right/Left” text and an arrow symbol.
- To enable right lane as well as left lane closures, sign panels with either “Right-Lane” or “Left-Lane” were mounted above the “Do Not Pass/When Flashing” signs.

### Dynamic Early Lane Merge Traffic Control System

After reviewing the results of the Phase I and Phase II studies, WSU researchers developed the Dynamic Early Lane Merge Traffic Control System (DELMTCS).

The DELMTCS was designed to be used in construction zones where three lanes are reduced to two lanes (see Figure 3). After reviewing the per-

formance of the DELMTCS, researchers have determined that with the correct settings and based upon moderate traffic volumes the system could also be used in zones where two lanes are reduced to one lane.

In the DELMTCS system, dynamic signs are mounted on trailers along with computers and sensors that can detect lane occupancy, speed and traffic volume for each lane of the highway. Data was collected at the test and control sites with a video camera and manual observation to determine the appropriate sensor settings. The computers on the dynamic signs perform the traffic volume calculations, then trigger the flashers when the threshold level is met, thus increasing the length of the “No Passing Zone” and prompting drivers to change lanes sooner.

When any of the dynamic signs are flashing, the extended no passing zone is enforceable by police, allowing them to issue warnings or citations.

The researchers recommended that media be used to educate the public of this new system. As the system was in place longer, fewer drivers were observed merging late, thus it was concluded that as motorists became accustomed to the DELMTCS system, the level of law enforcement necessary should decrease.

### Economic Analysis

The objective of the DELMTCS is to improve safety in work zones by reducing congestion and increasing traffic flow. Congestion is measured by

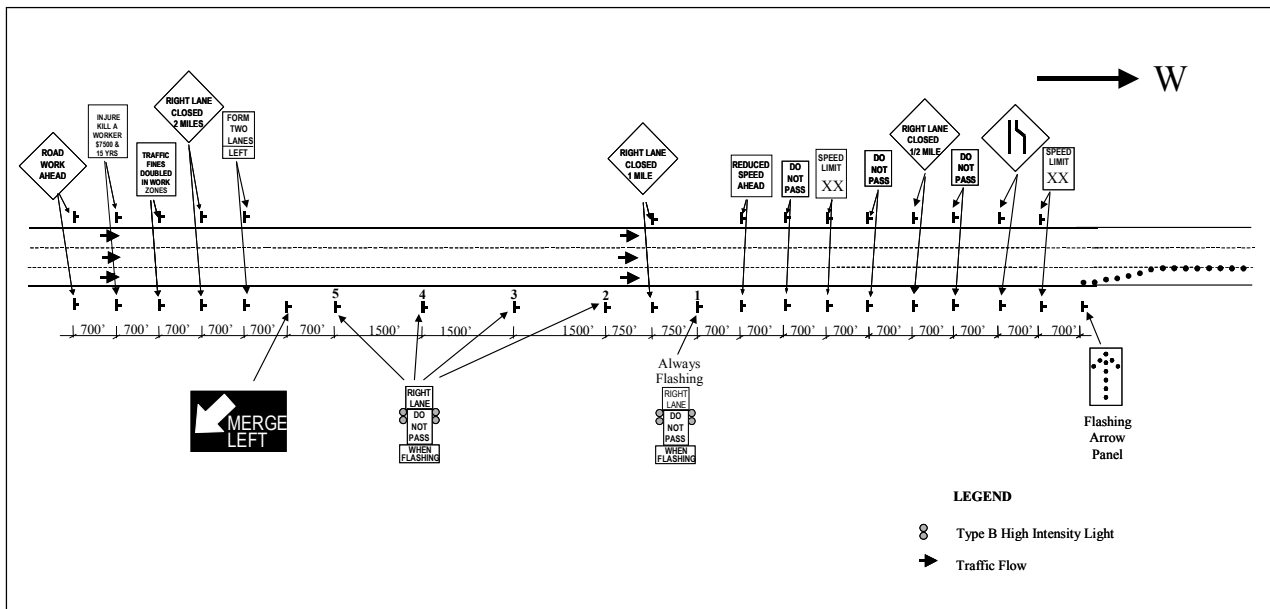


Figure 3. Dynamic Early Lane Merge Traffic Control System for Three to Two Lane Closure Areas in Work Zones

delays, increased travel time, and unnecessary stops along the travel route. Through past research in traffic flow optimization, congestion has been linked directly to fuel consumption and emissions such as carbon monoxide, nitrogen oxides and, volatile oxygen compounds. To determine the effectiveness of the DELMTCS in regards to fuel usage and emissions, travel time and delay studies were performed in the I-94 project in Macomb, MI. The studies were performed in the zones with test cars using the "Floating Car Method" for both the before and the after period. It was determined that at \$1.50 per gallon, the fuel savings for the 2002–2003 construction season was \$35,361 for one such installation.

The environmental benefits of using the DELMTCS were in the reduction of vehicle emissions. For the 2002 construction season the emissions were reduced by 31.3% and, for the 2003 season emissions were reduced by 11.34%.

A cost benefit analysis was performed regarding the DELMTCS. The total cost for the installation and operation of the system for the I-94 installation in the 2002–2003 construction seasons was \$111,134. For a person's value of time the system's break even point is reached at \$3.33 per hour (see Table 1).

Value of Time per Hour	Time Savings	Fuel Savings	Cost	Total Benefit
\$ 3.00	\$ 68,322 +	\$ 35,361 -	\$ 111,134 =	\$ (-7451)
5.00	113,870 +	\$ 35,361 -	\$ 111,134 =	38,096
9.00	204,966 +	\$ 35,361 -	\$ 111,134 =	129,192
11.00	250,514 +	\$ 35,361 -	\$ 111,134 =	174,740
15.00	341,610 +	\$ 35,361 -	\$ 111,134 =	265,836

**Table 1.** Dollar Value of the DELMTCS at Various Hourly Wage Levels.

### Conclusion

The DELMTCS has shown to be an effective tool for reducing the "forced late lane merge phenomena," which is the greatest danger in highway construction zones.

According to Brian Zimmerman, Work Zone Technical Administrator at MDOT, "The system has proven to be successful. MDOT plans to use it for projects in 2006 and beyond."

The DELMTCS success has been attributed to several components. The expansion of the pre-taper area from 7700 ft. up to the current design of 17,200 ft.

gives drivers more time to read the signs. The increased signage, including the full matrix portable changeable message board, has given drivers more information and better instructions to prepare and merge into the lane sooner. The dynamic "Do Not Pass/When Flashing" signs have assisted the early merging in that they are more visible. When traffic reaches the trigger value, the dynamic signs activate their flashers, creating an enforceable no passing zone. As congestion increases, more of the signs are activated upstream from the taper area. The sooner people merged, the less "forced late lane merging" occurred, thereby reducing congestion and increasing the flow of traffic.

Other benefits attributed to the DELMTCS are financial, travel time and environmental. The cost of the system in comparison to the benefits of time saved by a motorist is met at \$3.33 per hour. The DELMTCS also aided fuel savings for the 2002 construction season at 16,768 gallons and for the 2003 season 6806 gallons. The emission reduction for 2002 was 31.3% and for 2003, 11.34%.

### References

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Traffic crash statistics: [http://www.michigantrafficcrashfacts.org/doc/1999/1999MTCF\\_vol1.pdf](http://www.michigantrafficcrashfacts.org/doc/1999/1999MTCF_vol1.pdf)

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