Late Merge Work Zone Traffic Control Strategy

The *Late Merge* is designed to encourage drivers to use either the open or closed lane until they reach the merge point at the lane closure taper rather than merging as soon as possible into the open lane. One example of the *Late Merge*is the system developed by the Pennsylvania Department of Transportation (PennDOT). This system was implemented as a means to reduce the road rage engendered between drivers who merge into the open lane early and those who remain in the closed lane and merge into the open lane near the front of the queue at the last minute. Approximately 1.5 miles in advance of the lane closure, USE BOTH LANES TO MERGE POINT signs are placed on both sides of the roadway. These signs are followed by conventional ROAD WORK AHEAD and advance lane closed signs. Finally, MERGE HERE TAKE YOUR TURN signs are placed on both sides of the roadway near the beginning of the taper.

The primary intent of the *Late Merge* developed by the PennDOT is to reduce the road rage between early and late mergers by informing drivers that it is permissible for traffic to travel in both lanes to the merge point. Although it is not standard practice, the *Late Merge* is used regularly at work zones on freeways by one PennDOT district office. No problems have been reported with its use, and it seems to be well received by drivers. A study of its operational effects found that it increased the capacity of the merging operations by as much as 15 percent.

Since the *Late Merge* seems to address many of the problems experienced with the *conventional merge* during congestion, the UNL also conducted field studies *(footnote 1)* to compare the safety and operational effects of the PennDOT *Late Merge* and the *conventional merge*. The results of these studies revealed that the conflict rates are substantially lower with the *Late Merge*. At higher densities, about 75 percent fewer forced merges and 30 percent fewer lane straddles were observed for the *Late Merge*; and, at densities below 25 vpm, no conflicts were observed for the *Late Merge*, whereas conflicts were observed for the *conventional merge*. The studies also found the capacity of the *Late Merge* to be nearly 20 percent higher than that of the *conventional merge*.

Conceptually the *Late Merge* addresses many of the problems that are associated with traffic operations in advance of lane closures at work zones on rural freeways, especially during periods of congestion. In particular, the lengths of the queues that form as a result of congestion are reduced by about 50 percent, because the queued vehicles are stored in two lanes instead of only one. The shorter queue lengths reduce the likelihood of them extending back beyond the work zone's advance warning signs and surprising approaching drivers, which in turn reduces the potential of rear-end accidents. In addition, driver experience less anxiety about knowing which lane is closed, because either lane can be used to reach the merge point. The availability of both lanes also reduces the frustration levels of drivers. Drivers in the open lane are less likely to be irritated by others passing by them in the closed lane, because this maneuver is permissible with the *Late Merge*. Drivers are able to select the lane with the shortest queue and not be concerned about others blocking their path to the merge point.

However, despite the obvious advantages of the *Late Merge* during peak traffic flow conditions, there is a concern about the safety of its operation during off-peak periods when traffic demand is below the capacity of the open lane and traffic speed is high. Under these conditions, it may be more difficult for drivers to decide who has the right-of-way. This indecision could increase the potential for collisions at the merge point. This was not found to be a problem at the *Late Merge* study site in the UNL study *(footnote 1)*. At this location, drivers merged according to the *Early Merge* concept during off-peak periods, because the USE BOTH LANES TO MERGE POINT signs were followed by a series of advance lane closed signs which enabled them to merge into

the open lane before reaching the merge point. Although these signs may have improved the safety of the merging operation during the off-peak periods, they also seemed to reduce the effectiveness of the *Late Merge*during peak periods, because some drivers did not stay in the closed lane until the merge point. Instead, they slowed to merge into the open before the merge point. This behavior often resulted in some forced merges, which reduced both the safety and capacity of the merging operation.

Dilemma

The results of the UNL study *(footnote 1)* indicate that both the *Early Merge*and *Late Merge* provide safer merging operations than the *conventional merge*. Both systems were observed to have lower merging conflict rates than the *conventional merge*. But, there is a concern about the potential for driver confusion at the merge point of the *Late Merge*, especially under high-speed, low-volume conditions, which could adversely affect safety. On the other hand, the *Late Merge*was found to have a higher capacity than the *conventional merge*and the *Early Merge (footnote 1)*. The *Late Merge*'s higher capacity and larger queue storage area reduce the probability of congestion extending back beyond the advance warning signs; thus, reducing the potential of rear-end collisions on the approach to the work zone. The higher capacity also reduces the duration of congestion, which in turn reduces the exposure to rear-end collisions. In addition, because of its higher capacity, the *Late Merge*reduces congestion delay; whereas, the *Early Merge*has been found to increase travel times, especially under high traffic volumes *(footnotes 3,4)*.

Based on these findings, the best system of merge control during peak periods is the *Late Merge*. However, because of the safety concerns regarding its operation under high-speed, low-volume conditions, the *Late Merge*may not be the best system during off-peak periods. Therefore, in order to maintain optimum merging operations at all times, it would be necessary to convert from the *conventional merge* during periods of uncongested flow to the *Late Merge*during periods of congested flow. In other words, a *Dynamic Late Merge*would be needed.

References

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