Dynamic Lane Merge Systems
Acknowledgements

- Maryland State Highway Administration
- University of Maryland, College Park
- Michigan Department of Transportation
- Wayne State University
Lane Merging Issues

• Merging traffic → Traffic conflict
  - Flow disruption
  - Speed variance
  - Driver frustration
  - Safety concerns
  - Increased delay

• Approaches to merge control
  - Merge late
  - Merge early
Goal: Improve safety and mobility through intelligent traffic guidance

- Static signing may lack relevance
- Traffic conditions are not constant
- Appropriate traffic control is not constant
- Relevant control for current conditions
  - Clear and positive guidance
  - Fairness
  - Safety
• Project Location
  Southbound I-83 near Cold Bottom Road

• Project Duration
  October 13 to November 17, 2003

• Project Evaluation
  University of Maryland
Late Merge Concept

- Use both lanes to taper area
- “Zipper” at taper – vehicles alternate from each lane
- With static signs
  - May improve flow under congested conditions
  - Conflict and confusion during mild congestion
Overview of A Dynamic Late Merge System

Approx. 7400’
Overview of A Dynamic Late Merge System

Approx. 7400’
Overview of A Dynamic Late Merge System

PCMS 1: TAKE YOUR TURN
PCMS 2: MERGE HERE
PCMS 3: USE BOTH LANES
PCMS 4: USE BOTH LANES

FLASHING ARROW PANEL

BWA 1: ROAD WORK 0.5 MILE
BWA 4: ROAD WORK 0.5 MILE
BWA 2: RIGHT LANE CLOSED 0.5 MILE
BWA 3: ROAD WORK 1 MILE

0.1 mile 0.5 mile 0.1 mile 1.0 mile 1.5 mile
Late Merge System Control

- Four algorithms available for control of late merge implementation
- “All On – All Off” tested on this project

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Activated</td>
</tr>
<tr>
<td>Dynamic On – Dynamic Off</td>
<td>Any &gt; 15% (Congestion index)</td>
</tr>
<tr>
<td>(Sign 1 always on)</td>
<td></td>
</tr>
<tr>
<td>Dynamic On – Dynamic Off</td>
<td></td>
</tr>
<tr>
<td>All On – All Off</td>
<td></td>
</tr>
<tr>
<td>Dynamic On – All Off</td>
<td></td>
</tr>
</tbody>
</table>
Replacement of Deck for Bridge #3052 on Cold Bottom Road over I-83 (Harrisburg Expressway)

Test Deployment of Dynamic Lane Merge (DLM) System on Southbound I-83

Legend

Traffic Conditions
0-24 MPH  Heavy Congestion
25-49 MPH  Congestion
50+ MPH  Normal

Portable Changeable Message Sign (PCM3)
DLM Not Active
DLM Active

Freeway Incidents
Active Incident
Cleared Incident

Highway Indicators
Work Zone
I-83 Highway

http://tis.irdinc.com/i83construction/public
VIDEO CLIP #2
Measures of Effectiveness:

- **Work zone throughputs (vehicles / hour)**
  - The DLM system is expected to show more throughput than under No-control system.

- **Lane volume distributions (volume difference)**
  - The DLM system is expected to make most vehicles use both lanes uniformly until they approach the merging point.

- **Maximum queue lengths (miles)**
  - The uniformed lane distributions are expected to lead to a reduction on maximum queue length.
Evaluation of Late Merge System

Two Methods:

• Manual counted data analysis
  - Work zone throughputs and lane volume distributions

• Simulation data analysis: to overcome the limitations that the traffic volumes under No-control and DLM control are not identical, and that the view scope of camcorders may not always capture the maximum queue length.
  - Work zone throughputs and maximum queue length
Work zone throughputs

- Manual counts: most work zone throughputs are greater than without dynamic late merge.
- Simulation: work zone throughputs are at least 10% greater than without dynamic late merge.
<table>
<thead>
<tr>
<th>Date</th>
<th>Merging Point</th>
<th>Middle Point</th>
<th>Upstream Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average difference [pcph]</td>
<td>Standard deviation</td>
<td>Average difference [pcph]</td>
</tr>
<tr>
<td>10/10/2003</td>
<td>1297</td>
<td>158</td>
<td>199</td>
</tr>
<tr>
<td>10/22/2003</td>
<td>1207</td>
<td>249</td>
<td>122</td>
</tr>
<tr>
<td>10/23/2003</td>
<td>1114</td>
<td>159</td>
<td>17</td>
</tr>
<tr>
<td>11/07/2003</td>
<td>901</td>
<td>208</td>
<td>1</td>
</tr>
<tr>
<td>11/10/2003</td>
<td>932</td>
<td>174</td>
<td>-4</td>
</tr>
</tbody>
</table>
• The lane volume distributions are more uniform than under no-control (both at the middle and merging points).

• More drivers followed the message sign (i.e., “USE BOTH LANES TO MERGE POINT”) displayed on the PCMSs under the congested traffic condition.

• Many drivers decided to merge at the static merge sign located upstream of the taper area.
**Evaluation of System Performance**

- Based on simulation, substantial reduction in queue length

<table>
<thead>
<tr>
<th>Date</th>
<th>Actual queue (DLM)</th>
<th>Simulated queue (NC)</th>
<th>Reduced %</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/22/2003</td>
<td>1.2 miles</td>
<td>1.3 miles</td>
<td>8.3%</td>
</tr>
<tr>
<td>10/23/2003</td>
<td>1.2 miles</td>
<td>1.4 miles</td>
<td>16.7%</td>
</tr>
<tr>
<td>11/07/2003</td>
<td>1.8 miles</td>
<td>2.0 miles</td>
<td>11.1%</td>
</tr>
<tr>
<td>11/10/2003</td>
<td>0.9 miles</td>
<td>1.2 miles</td>
<td>33.3%</td>
</tr>
</tbody>
</table>
Evaluation of Late Merge System

• Advantages of a Dynamic Late Merge Control
  ✗ Increases throughput
  ✗ Leads to a more uniform volume distribution
  ✗ Reduces the maximum queue length

• Disadvantages of a Dynamic Late Merge Control
  ✗ Stop-and-go maneuvers may increase
  ✗ Multiple merging locations experienced
Early Merge Approach

Dynamic Early Merge Approach

- Merging during congestion is more difficult
- Merge under free flow and low density conditions
- Deter queue jumpers
- Relevant to current conditions
Dynamic Early Merge System Operation
Dynamic Early Merge Trailer

I-69 Near Lansing, Michigan
Michigan Early Merge Evaluation

- Two year study completed by Wayne State University in December 2001
- Implementation of dynamic lane merge system at 6 locations to study deployment issues and effectiveness
- Phase I (2000) – Deployment and configuration
- Phase II (2001) - Effectiveness
Evaluation of Dynamic Early Merge

- Examined best configuration for positive guidance to motorists
- Measured impact of system on traffic
- Provided recommendations for future deployments

Conclusion: “Can be very helpful in reducing aggressive driver behavior, increasing safety and reducing delay at work zones where lane closures are necessary.”
• The average peak period travel time decreased by over 30%

• The average number of stops and duration of stops were decreased

• The number of aggressive driver maneuvers (late merges) during peak hours were reduced by 50-75%

• B/C (Benefit/Cost) ratio is greater than one, if the value of time of $3.80 per person hour is assumed for travel time savings
Conclusion

One goal – improved safety and mobility

• Current and relevant positive guidance to motorists
• Both approaches have potential benefits
• Best approach will depend on specific conditions
Thank You