Freeway Bottlenecks: Innovative Mitigation Strategies & Improved Modeling Approaches

NJDOT Research Showcase (West Windsor, NJ)  
October 25th, 2017

David K. Hale, Ph.D., PMP
Presentation Objective

- Discuss three ongoing, related FHWA projects
  - Improved modeling of freeway bottlenecks
  - Innovative/emerging bottleneck mitigation strategies
    - Not requiring CAV technology
- Provide status update on all three projects
- Provide professional opinion on the likely outcomes
  - For all mitigation strategies and modeling approaches
Summary of Projects

- Narrowing of Freeway Lanes and Shoulders
  - 50% complete
- Alternative Designs for Merge/Diverge Areas
  - 20% complete
- Improved Simulation of Freeway Bottlenecks
  - Scheduled to start in November 2017
Project #1 Objectives

- Narrowing of Freeway Lanes and Shoulders
  - Collect data at real world sites
  - Update the HCM procedure
  - Update microsimulation tools
  - Multi-objective (operations & safety) recommendations

Before

After

Neudorff, Jenior, Dowling, Nevers, FHWA-HOP-16-060, 2016
Project #2 Objectives

- Alternative Designs for Merge/Diverge Areas
  - Review merge/diverge issues at typical on/off-ramps
  - Review similar issues at managed (HOV/HOT) lanes
  - Come up with new (non-CAV) mitigation strategies
  - Conduct simulations to evaluate effectiveness
Project #3 Objectives

- Improved Simulation of Freeway Bottlenecks
  - Driver behavior believed to be different at bottlenecks
  - Collect data at real-world bottlenecks
  - Develop new car-following and lane-changing models
  - Old models will still be used in uncongested areas
Project #1 Status Update

- Narrowing of Freeway Lanes and Shoulders
  - New models for the HCM
  - New models for safety prediction
  - Simulation models behind schedule
    - Drone videos, FAA approvals, machine processing

Before

After

Neudorff, Jenir, Dowling, Nevers, FHWA-HOP-16-060, 2016
Project #1 Status Update

Free-flow speed (mi/h) vs. Lane width (ft)

- HCM
- 50 mi/h
- 60 mi/h
- 65 mi/h
- 70 mi/h
- 75 mi/h
**Project #1 Status Update**

\[ FFS = BFFS - f_{LW} - f_{RLC} - 3.22 \times TRD^{0.84} \]

\[ FFS = 4.99 + 1.0982 \text{Number of lanes} + 0.0833 \text{Shoulder Width} + 0.9906 \text{SL1} + 0.6964 \text{SL2} - 0.3744 \text{Lane Width} + 0.0 \text{Type_basic} - 1.6963 \text{Type_diverge} - 1.1524 \text{Type_merge} + 0.01917 \text{Lane Width*SL2} \]  

(4)
Project #1 Status Update

- Drone Surveys (Quality Counts)
- Hi-Def. Videos
- Trajectory Data
- Machine Processing (DataFromSky)
- Model Development (PTV, TSS)
- Car-Following Models

Accelerate:

\[ V_a(n, t + T) = V(n, t) + 2.5 a(n) \left( 1 - \frac{V(n, t)}{V^*(n)} \right) \sqrt{0.025 + \frac{V(n, t)}{V^*(n)}} \]
Project #2 Status Update

- Alternative Designs for Merge/Diverge Areas
  - Multiple merge points on accel/decel lanes
  - Speed optimization (e.g., dynamic calming devices)
  - Dynamic signal control (a.k.a., mainline metering)
  - Coordinated ramp metering (e.g., HERO)
  - Open-access managed lanes on the right
  - Managed lane access point optimization
Most Likely Outcomes
(Professional Opinion)
Project #1 Likely Outcomes

- Narrowing of Freeway Lanes and Shoulders
  - Safety won’t be a deal-breaker (see next slide)
  - Minor changes to HCM & simulation models
  - Narrow lanes will be a cost-effective mitigation strategy
  - Dynamic lane narrowing technology may emerge

Before

After

Neudorff, Jenior, Dowling, Nevers, FHWA-HOP-16-060, 2016
## Project #1 Likely Outcomes

- F to E: accept slight crash increase to get moving again
- E to D: narrow lane risk cancelled out by reduced density

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<tbody>
<tr>
<td>Crash Probability</td>
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Project #1 Likely Outcomes

- Dynamic lane narrowing technologies may emerge
  - Revert to 12-foot lanes during off-peak periods

Source: SmartRoads, LLC
Project #2 Likely Outcomes

- Alternative Designs for Merge/Diverge Areas
  - Multiple auxiliary lane merge points: *limited application*
  - Dynamic traffic calming: *political challenges*
  - Dynamic signal control: *political challenges*
  - Coordinated ramp metering: *will find a niche*
  - Open-access ML on the right: *little benefit*
  - ML access point optimization: *insufficient data*
Project #3 Objectives

- Improved Simulation of Freeway Bottlenecks
  - Some tools will adopt multiple car-following models
  - Overall impact hard to predict
  - TSS-Aimsun already did this:

  Car-Following model extension for congested highways
  We’ve improved car-following in congested conditions by using a modified Gipps model to achieve more accurate simulated speeds.

https://www.aimsun.com/aimsun/new-features/
Final Predictions

- Methods that will gain traction
  - Static lane narrowing to add a freeway lane
  - Coordinated ramp metering
  - Alternate car-following models for bottlenecks

- Methods facing political headwinds
  - Dynamic lane narrowing technologies
  - Dynamic traffic calming devices on freeways
  - Dynamic signal control on freeways
Thank you

David K. Hale, Ph.D., PMP
Senior Transportation Project Manager
McLean, VA

DAVID.K.HALE@leidos.com