U.S.Department of Transportation
Federal Highway Administration

Office of Operations
Research and Development

ALTERNATIVE FREEWAY DESIGNS AT MERGE AND DIVERGE SEGMENTS

INTRODUCTION

Freeway merge and diverge areas are typically associated with unsteadiness and congestion due to an increase in lane changing and slowing down to accommodate vehicles that want to enter or exit the freeway. While waiting on anticipated benefits of connected and automated vehicles (CAVs), cities continue to struggle with worsening freeway congestion. Beyond widening roadways, few short-term, low-cost options exist for increasing freeway capacities. At the Federal Highway Administration's Saxton Transportation Operations Laboratory (STOL) at the Turner-Fairbank Highway Research Center in McLean, VA, a team of researchers are testing various solutions to these capacity problems.

SITE SELECTION

The STOL research team conducted a literature review of current practices and designs for mitigating freeway weave congestion problems across the United States. Through this review, the team selected 16 study sites that exhibited merging problems and did not have improvement plans in place. However, site data was available and there was local support for alleviating these problems.

SOLUTION SIMULATION

The STOL team will use vehicle detector data, online probe data, and traffic data to simulate various merge and diverge bottleneck solutions. Examples of potential solutions are as follows:

Separation of Merge Points on Acceleration and Deceleration Lanes

Separating merging drivers to two acceleration and deceleration lane locations may help to smooth traffic flow. By eliminating the uncertainty of where merge maneuvers will occur for both mainline drivers and ramp drivers, both sets of drivers may potentially be able to prepare for and execute the merging maneuver more efficiently. Similarly, by separating the turbulence associated with diverge maneuvers (at two locations) along the mainline, congestion may potentially be mitigated.

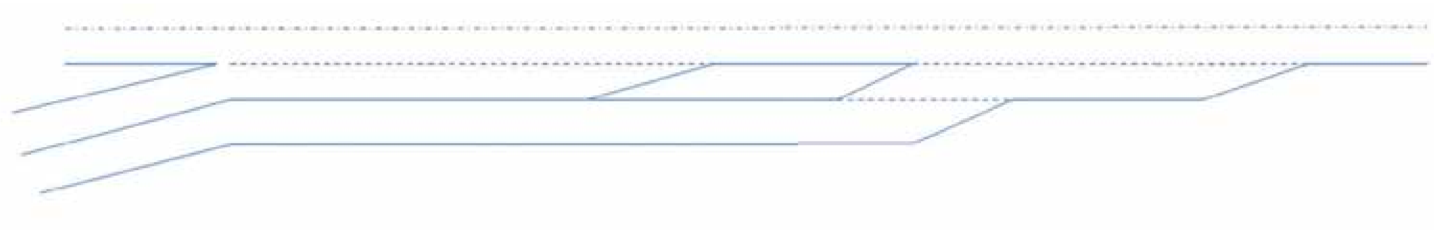

Figure 1. Acceleration lane with two merge points. (Source: FHWA)

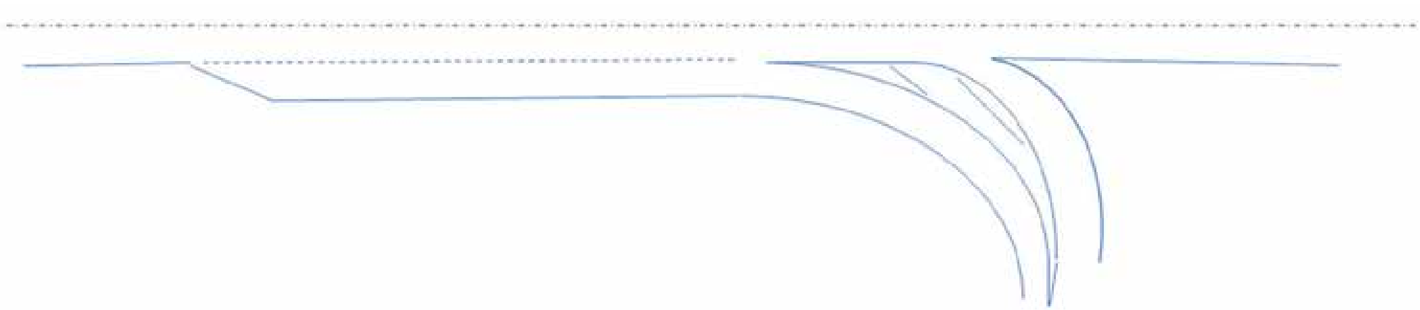

Figure 2. Deceleration lane with separated downstream ramp exits. (Source: FHWA)

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Speed Optimization

Speed harmonization research findings suggest that medium free-flow speeds would be more effective at optimizing freeway traffic flow than low speeds or high speeds. Although the Alternative Freeway Designs Project endeavors to focus on strategies not requiring CAV technology, the team believes that dynamic traffic calming devices (e.g., retractable rumble strips) may soon be capable of convincing drivers to obey recommended speeds at higher rates of compliance.

Dynamic Signal Control

In situations where mainline and ramp vehicle speeds are both very low, traffic signal control applied to both upstream approaches could conceivably optimize the roadway by mitigating merge friction. Although this treatment is not known to be in use anywhere, another form of mainline metering has been observed in the United States where traffic is metered upstream of a bottleneck to reduce demand and improve flow. In this manner, the number of vehicles moving through the bottleneck is regulated.

Coordinated Adaptive Ramp Metering System

In traditional ramp metering, upstream freeway mainline volume is measured to determine ramp flow. Downstream conditions are not typically monitored and therefore do not provide feedback. A downstream problem may not be detected until congestion reaches the detector upstream of the ramp. Coordinated adaptive ramp metering uses feedback logic in a closed loop control system. Traffic conditions are measured at downstream bottlenecks to determine critical occupancy and how much traffic can enter upstream. When applied on a holistic, coordinated, system-wide basis, all ramps continuously communicate with each other to optimally control traffic flow at all onramps within the congested section.

Open Access Managed Lanes on the Right

In the United States, managed lanes are typically located on the driver's far left side, next to the median. Although locating the managed lane on the right side would reduce its capacity, the overall impact on all lanes could conceivably be beneficial. The research team will analyze different managed lane designs on the left side, those with continuous access and those with partial access, and compare them with right side designs.

Managed Lane Access Point Optimization

On the Institute for Transportation Engineers Community Blog, practitioners have claimed that when barriers (such as flex-posts) are used to separate the managed lane, proper determination of entrance and exit points requires extensive knowledge of the overall freeway operation in those segments. The STOL team may perform similar experiments on a set of freeway facilities to determine whether generalized trends and recommendations are possible.

PROJECT STATUS

The research team is now finalizing data on the selected project sites, which are due in January 2018. Simulation of model innovative treatments will begin in July 2018, and a final report of the findings will be available in early 2019.

Figure 3. Right-side managed lane concept. (Source: FHWA)

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