Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

0-6945: Ramp Metering Impact Study with Potential Regional Deployment within the Dallas-Fort Worth Ozone Nonattainment Area

Background

There is an increasing interest by public officials in the use of ramp metering for congestion mitigation at various freeway locations in the Dallas-Fort Worth (DFW) metroplex. DFW is currently in nonattainment for ground-level ozone, and transportation improvements in the area are subject to the transportation conformity process. The Texas Department of Transportation (TxDOT) in collaboration with the North Central Texas Council of Governments initiated this project to assess if the use of ramp metering can improve operations of congested freeways while improving air quality.

What the Researchers Did

To achieve project objectives, researchers performed the following activities:

1. Conducted a state-of-the-practice review and evaluated the applicability of existing data.
2. Using existing speed data, evaluated the severity and duration of congestion in several freeway corridors and identified two corridors for detailed evaluation.
3. Used dynamic traffic assignment (DTA) to study the impacts of strict metering on freeway corridors and adjacent facilities up to a 5-mile zone around each test corridor.
4. Used microsimulation models to evaluate impacts of strict metering and metering with queue flush on each corridor and nearby adjacent roads.
5. Used DFW-specific emissions rates from the MOVES model and applied these rates to simulation outputs to assess the air quality impacts of ramp metering.
6. Developed and used an interactive visual dashboard to evaluate results.
7. Estimated potential costs and benefits of ramp metering.

Figure 1 shows the limits of the two corridors selected for mesoscopic modeling (blue lines) and microscopic modeling (red lines). In these corridors, freeway speeds drop to below 50 mph during periods of recurring congestion. The US 75 test corridor has continuous frontage roads and limited influence of uncontrolled freeway-to-freeway (F2F) ramps. The I-20 test corridor has several multilevel interchanges with uncontrolled F2F ramps, no frontage roads in some sections, and several parallel corridors.

What They Found

Existing ramp geometry, funding, public opposition, inter- and intra-agency opposition, and heavy ramp demand are key barriers to ramp metering. States with mature ramp metering systems have a synergetic set of planning processes, design policies tied to established design criteria, clear operational guidelines, and a high level of cooperation among partner agencies. Ramp metering is primarily used to improve freeway travel time and travel-time reliability but rarely air quality. TxDOT has developed design criteria and operational guidelines but currently has no formal policies.

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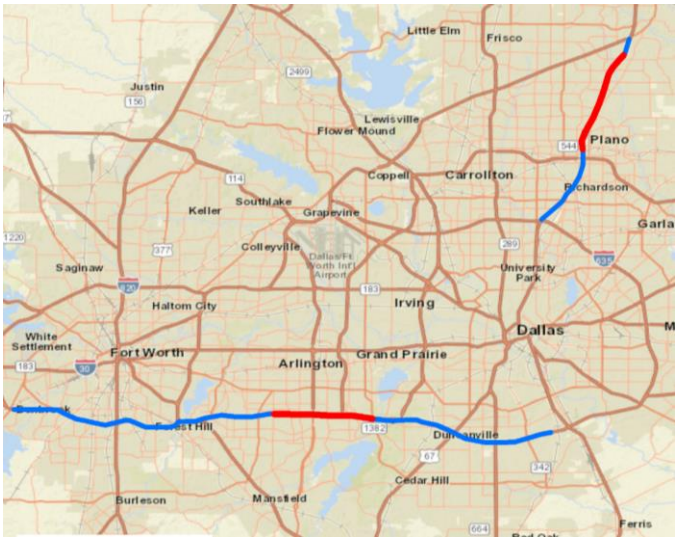

Figure 1. Corridors Modeled.

TxDOT districts may use speed data from their radar sensors and loop detectors to identify potential corridors for ramp metering; however, freely available vehicle probe-based speed and travel time data provide a more accurate picture of the traffic behavior in target corridors.

DTA-based simulations showed immediate benefit of ramp metering on traffic flow and oxides of nitrogen (NOx) emissions for the US 75 test corridor. The benefits to freeways diminished but persisted after user equilibrium (UE) was reached. For I-20, simulation showed minor traffic flow improvements initially and after UE, but both NOx emissions and diesel consumption increased slightly after UE, partly because resulting improvements to traffic flow on I-20 attracted more trucks. In both corridors, the model predicted a negative impact of strict metering on adjacent facilities, but this impact diminished with increased distance. For both test corridors, potential daily monetary benefits, which are dominated by reduction in delay, by far exceed any emissions-related costs.

Results of microscopic simulation show that strict metering causes unacceptable queuing at ramps with demand over meter capacity. Metering with queue flush operation does not have this issue but produces lower levels of improvements to freeway traffic. For the US 75 test corridor, metering reduced emissions for freeway links but resulted in negligible overall increases in NOx and other vehicular emissions. For I-20, both metering scenarios resulted in increased emissions of all pollutants, except NOx for freeway links. The increase in NOx was negligible for metering with queue flush operations. Comparison between the mesoscopic and microsimulation models highlighted the importance of capturing the diversion/re-routing behavior in the impact analysis.

Results show that ramp metering with queue flush operation has the potential to improve freeway traffic flow along the US 75 test corridor, with minimal operational impacts on adjacent facilities. Any negative impacts of ramp metering on air quality are also likely to be minimal in this corridor. Economic analysis conducted by researchers shows a benefit-cost ratio of 18:1 for this corridor. Based on these results, researchers recommend implementation of ramp metering along the US 75 test corridor.

What This Means

Ramp metering can be deployed in sections of freeway corridors that have no or minimal interference of traffic to or from F2F ramps, overall ramp demand below meter capacity, good ramp geometry, and continuous frontage roads. In such corridors, ramp metering can help mitigate freeway traffic congestion without negatively impacting air quality.

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