CENTER FOR TRANSPORTATION INFRASTRUCTURE SYSTEMS
THE UNIVERSITY OF TEXAS AT EL PASO

Project Summary Report 0-4764-S

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PROJECT SUMMARY REPORT

Development and Assessment of Peak-Period Ramp Closure Strategies for Interstate Highways: Summary

In spite of the advent of Intelligent Transportation Systems (ITS) technologies and improved practices for traffic operation, freeway traffic management continues to be one of the most challenging tasks for engineers in maintaining satisfactory mobility of Texas highway networks. Among all the freeway management strategies, controlling freeway inflow/outflow has been a widely used approach. This type of techniques, as defined by the latest Freeway Management and Operation Handbook, includes ramp metering, entrance ramp closure, and exit ramp closure. Ramp metering is perhaps the most widely applied and fully tested technique among the three.

The use of ramp meters has been extensively researched in Texas and has shown both operational and safety benefits. However, not all ramps or travel corridors lend themselves to the application of ramp metering. This research addresses the use of ramp closure as an alternative strategy for traffic management and congestion mitigation. Several TxDOT Districts (Austin, El Paso, and Houston) have already considered the use of ramp closure during peak-periods to relieve recurrent congestion. The area of ramp closure has not received significant study in the past; however, several other states (Connecticut and Hawaii) have recently implemented and evaluated ramp closures. This research investigates the following components of ramp closure strategies with the objectives being to:

- Characterize conditions that warrant the application of ramp closure.

- Develop guidelines for integrated traffic operation strategies using conventional traffic engineering approaches and/or ITS technologies (if available) from traffic management and safety improvement perspectives.

- Develop guidelines for gate design and operations, including operational methods, crash-worthiness, and other associated traffic control devices in the vicinity of the gate.

- Address ramp closure gate operations issues.

- Develop an evaluation plan for continual improvement of ramp closure implementation.

Two case study sites were considered in this research. One is the Interstate Highway 10 (IH-10) in the vicinity of IH-10/US-54 interchange in El Paso Texas. This site has long been observed to have high traffic volumes as well as high weaving intensity because many trucks use the US-54 southbound exit ramp to reach the Mexico-bound commercial Port-of-Entry (POE) Bridge of the Americas (BOTA). Dense ramp accesses and short weaving sections, combined with high traffic volumes, have made the study site one of the most congested and dangerous segments along the IH-10 corridor in El Paso, Texas.

Another freeway segment under consideration is the northbound section of Interstate 35 from the Yager exit to the Wells Branch Parkway exit in Austin, Texas. The northbound Interstate has been a highly congested section with a very low level-of-service (LOS) which has been complicated by drivers using the frontage road for freeway queue jumping during peak periods.

What We Did …

We surveyed the state-of-art and start-of-the-practice in ramp closure operations and found that most ramp-closure operations relate to traffic flow control under severe weather or under contra-flow operation situations. The survey also found that a sufficient field-testing period is necessary to obtain equilibrated traffic dynamics on both freeways and surface arterials.

We developed an engineering analysis framework and procedure for evaluating the feasibility of ramp closure. The framework entails the following analysis procedure: (1) identify the application and candidate location of on-ramp closure, (2) characterize the pattern and intensity of highway traffic congestion, (3) check to see if the ramp meets basic qualification, and (4) evaluate

the ramp closure effectiveness in terms of (a) highway level-of-service, (b) regional surface traffic impact, (c) level of closure information provision, and (d) safety impact. Operational strategies to assist implementing the ramp closure include: (a) closure time and duration, (b) closure information provision strategies, and (c) ITS strategies.

Analyses were performed according to the proposed research framework to study both ramp metering and ramp closure scenarios using both the Highway Capacity Manual (HCM) and a microscopic simulation approach (CORSIM). In the El Paso case, the ramp studied is a 250 ft one-lane ramp with no acceleration lane and is within 200 ft of the Paisano/Gateway W. intersection. Study results show that the intended ramp is not a suitable candidate for ramp metering because of its (1) proximity to arterial intersection, (2) limited number of ramp lanes (3) lack of ramp storage, and (4) lack of acceleration lane. There is no acceleration or auxiliary lane at the Paisano ramp. Vehicles have difficulty in speeding up from metered stop and merging into the main lanes once passing the ramp metering signal.

Surveys of existing traffic conditions and simulation analysis show that the site is currently experiencing LOS F, which represents rather undesirable level of service for peak-hour traffic.

Analyzing the ramp closure benefit/impact entails a number of scenarios that distribute the Paisano on-ramp flow to other ramps. This is a necessary step to assessing possible traffic conditions upstream or downstream of the study site that result from the closure. Extensive simulation experiments show that after closure, the target freeway segment receives significant and consistent LOS improvement, while other upstream segments of the freeway maintain the same or better LOS because of the improvement at the downstream target freeway segment. For detailed LOS information, please refer to Exhibit 2.

We also propose a comprehensive traffic control plan. This plan includes recommending the nearby Paisano/Gateway W. intersection to run at a special "All Red" phase for 5-10 seconds, so that no vehicle heads to the Paisano ramp while the gate is in transition to closure. Four traffic flashers are recommended to be installed at major inbound approaches. Changeable message signs are recommended for temporary installation at major inbound approaches. The public is notified of the event through various media channels.

We further propose a system performance monitoring and assessment plan, consisting of both short-term and long-term performance evaluation and improvement strategies. The short-term evaluation is recommended to continue for at least one month. The long-term evaluation is

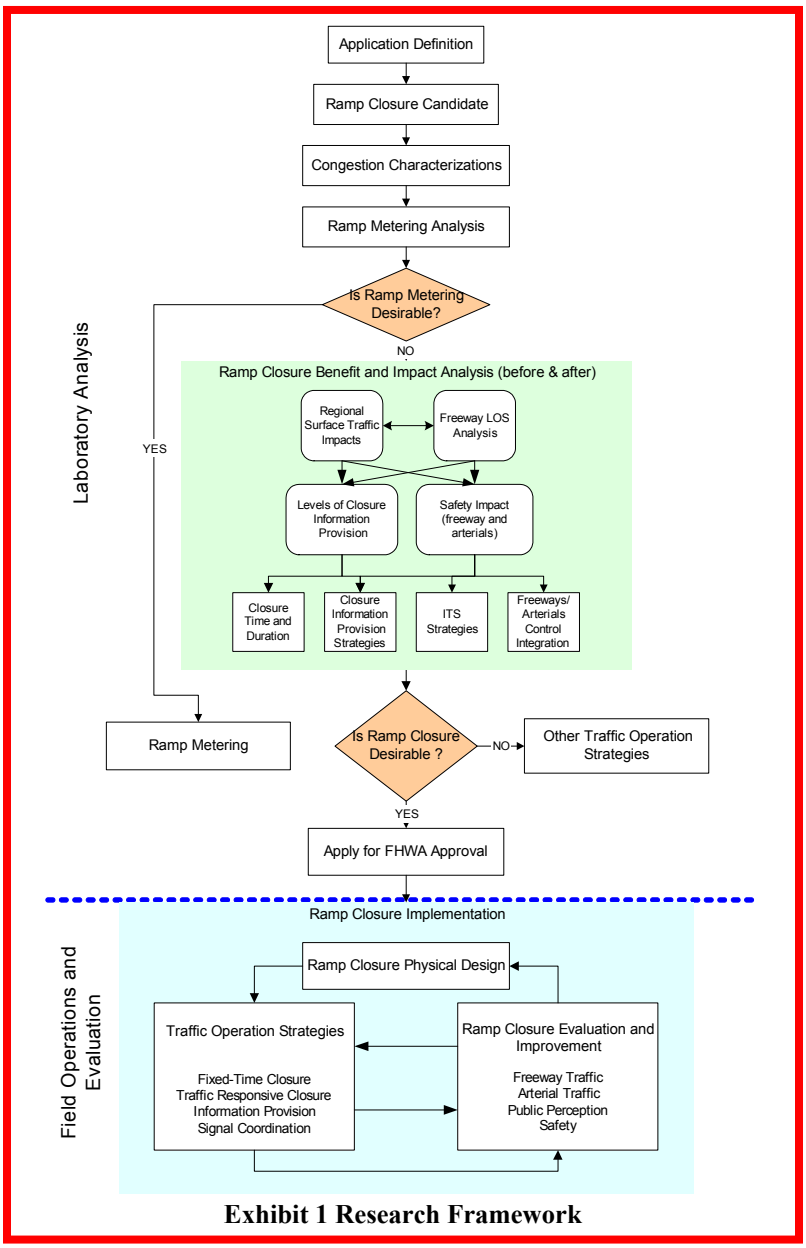


Exhibit 1 Research Framework

recommended to continue for at least 6-12 months.

What We Found ...

Peak-hour ramp closure has been found to be a low-cost and effective strategy for both freeway main-lane flow control and managing queue jumping applications. Compared with permanent closure, this strategy retains the original connectivity and capacities of ramp access during the non-peak period.

Ramp metering has been shown not to be effective or feasible when the traffic flow downstream of the metered ramp exceeds capacity. Metering the ramp does not improve the traffic flow conditions. It also imposes excessive queue on the ramp. In the study case, due to the short length of the ramp, the queue spills back to the upstream intersection for a significant period. Closing the ramp, equivalent to zero metering rate, is more effective in preventing intersection spillbacks and minimizing the violations.

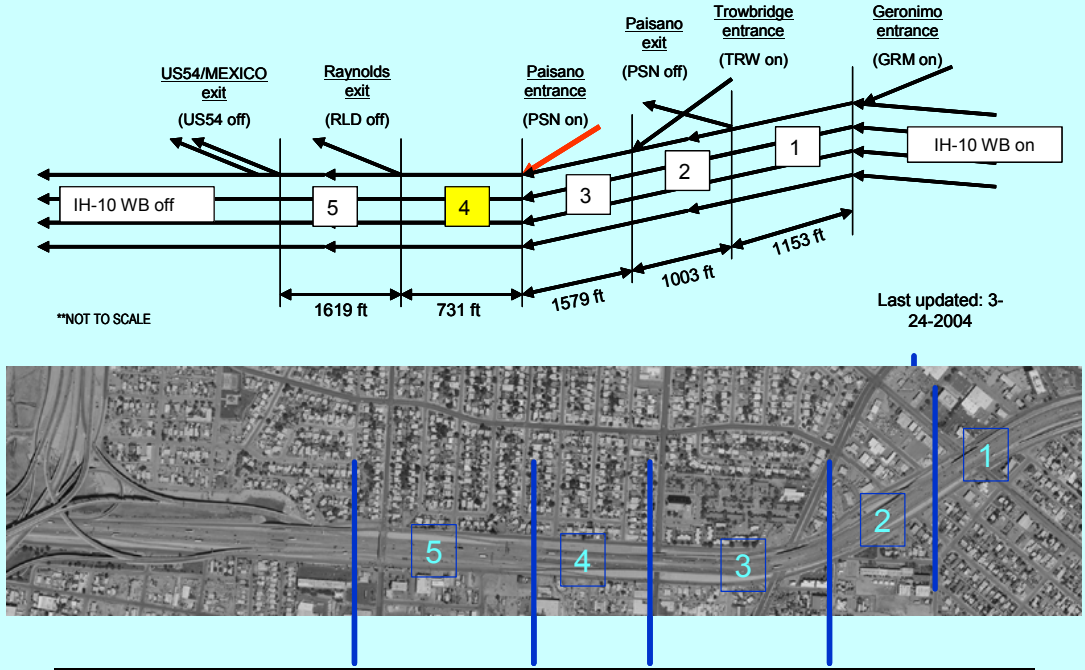
Establishing a suite of traffic control and impact mitigation strategies is the key to a successful implementation of peak-hour ramp closure. These strategies include:

- Synchronizing the adjacent intersection signal to ALL RED in conjunction with the transition of gate closure to prevent collision at onset of the closure.

- Information provision/advance warning is crucial to prevent last-minute diversion and/or confusion at the gate. It also facilitates better traffic diversion farther upstream of the closed ramp. Mobile CMS or DMS are recommended, for use particularly during the short-term evaluation period, to promote public awareness of the peak-hour closure.

- Researchers recommend that continuous performance assessment and improvement is undertaken to ensure consistent and satisfactory operating performance of both the freeways and arterials.

For the Austin case study, variable schedule ramp closure, in which the Yager entrance ramp is closed during peak hours and opened during non-peak hours, is recommended. Hard Closure using automatic swing gates are recommended. The material of the gate is recommended to be aluminum, which is relatively cost effective and has sufficient resistance to low-impact crashes. The components of the closure system must be easily replaceable when damaged due to crashes. The gates used must be FHWA approved or must be crash-tested as per the specifications provided in NCHRP report 350. Since crash testing a gate is a costly and cumbersome process, it is recommended that the gate used be the same as those used in Minnesota or Chicago. These gates are used in closing high-volume, high-speed roads like freeway ramps.



	Segment 5	Segment 4	Segment 3	Segment 2	Segment 1
Before Closure	D	F	C	D	E
After Closure	D	D	E	E	D

Exhibit 2 El Paso Case study site geometry and analysis representation

The Researchers Recommend…

- Ramp closure may be a viable freeway inflow-control strategy when ramp metering is not feasible.
- An automatic gate is recommended for operating the gate closure.
- A sufficient field evaluation period is recommended to obtain an actual performance measure, as drivers need time to adapt to the new control strategy.
- In a situation where the on-ramp is adjacent to an intersection, setting the signal to an ALL RED phase during the gate closure in motion is recommended to prevent motorists from colliding with the gate while the gate is in motion to closure.
- Ramp closure is potentially effective for mitigating queue jumping, which helps reduce freeway inflow fluctuation.
- It is crucial to implement the safest and the most effective traffic control strategies to ensure that the peak-period ramp closure introduces the maximal benefit to the freeway operation and the minimal impact on surface arterials. The safety issue should receive the top priority in overall traffic control planning and implementation.

TxDOT Implementation Status
November 2004

The proposed engineering analysis framework and procedure for evaluating the on-ramp closure for freeway flow-control operation can be widely applied to all districts in the state.

For more information, please contact Wade Odell at the Research and Technology Implementation Office at (512) 465-7403, or e-mail at wodell@dot.state.tx.us .

YOUR INVOLVEMENT IS WELCOME!

For More Details…

The research is documented in technical report

- 0-4764-1, *Development and Assessment of Peak-Period Ramp Closure Strategies for Interstate Highways (October 2004)*

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