



Project Summary Report 1295-5

Project O-1295: Ramp Metering in Houston, Texas

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Flow Signals Aid Traffic in Houston

To reduce traffic congestion, air pollution, and traffic accidents occurring in Texas cities, the Texas Department of Transportation (TxDOT) has reintroduced ramp metering as “flow signals” based on the quality of service provided. This project supported the implementation and testing of basic ramp metering strategies in Houston, Texas, as a part of TxDOT’s ongoing implementation program for improved freeway traffic management.

What We Did . . .

Ramp metering was implemented on five freeways in Houston with nearly 100 ramps now being metered. The first meters were activated along an inbound section of IH-10 (Katy Freeway) on July 31, 1996, with a systematic expansion on additional freeways into 1999.

A large-scale marketing and public information program was planned and pursued as the first ramp metering implementation date

approached in 1996. The term “Flow Signals” was effectively used in public information, TV spots, and newspaper announcements in Houston. Project report 1295-1 provides details of the very successful “Flow Signals” marketing program. The Houston District developed methods to remotely operate and observe different operating strategies in a real world environment in support of this work.

What We Found . . .

Both the general public and TxDOT judged the overall ramp-metering program to be successful. The initial ramp meters were all single-lane designs, releasing one vehicle per green signal and providing a metering capacity of about 800 vehicles per hour (vph). These meters are similar to those deployed in Texas in the late 1960s. One major challenge faced by the ramp metering effort was the high



Figure 1. Dual-Lane Ramp Metering in Houston



entrance ramp demand volumes observed in Houston. Many standard freeway slip-ramp designs had ramp demand volumes in the 1300-1600 vph range during metering periods, with several even exceeding these high volume levels.

Faced with high ramp demands, an investigation of metering strategies used by other states revealed that New York employed a “queued off” strategy when ramps became overloaded. A similar strategy is used in Houston, wherein an upstream ramp queue detector will sense excessive queue formation and then flush any excessive queue to avoid queue spillback into upstream interchanges and excessive ramp delays. Otherwise, the meters are timed to operate such that an arriving motorists ramp access time to the freeway does not exceed 2.0 minutes.

With many ramps in Houston having demand volumes exceeding single-lane metering capacity of 800 vph, higher capacity ramp meter designs were investigated. Dual-lane metering into a single-lane merge was developed and tested at the interchange of US 290 with FM 1960/TX 6 located in northwest Houston, starting in October 1998. This design has a nominal metering capacity of about 1600 vph, subject to site-specific downstream freeway capacity. Dual-lane metering has worked very well at this site where a neck-down diamond ramp (over 1200 feet long) without frontage roads was available. [Figure 1](#)

shows the FM 1960 dual-lane ramp in operation. No public complaints have been received regarding this ramp since it began operation. In fact, many comments were received from concerned motorists during reconstruction from single-lane to dual-lane metering to not permanently turn off the ramp meter. Demand volumes at the FM 1960 ramp are now higher and a dual-lane ramp entry design may be needed to reliably meter such high volumes.

A theoretical model was developed to explain the ramp volume challenges faced in Houston. This model predicts the percent of time the meter operates nominally (its availability to meter routinely), as shown in [Figure 2](#). Three types of ramp metering are examined in [Figure 2](#), including the traditional single-lane meter, platoon (bulk service) metering on single-lane ramps, and dual-lane metering necking down beyond the meter into a single merge lane. The dual-lane meter has a nominal maximum metering rate of about 1600 vph and a ramp flush rate for short time periods of about 1800 vph. Dual-lane metering having dual-entry lanes onto the freeway was not studied in this research. This option would require major geometric design changes downstream of entrance ramps. [Figure 2](#) also shows that:

- (a) single-lane metering can reliably serve ramp demand volumes up to about 800 vph;

- (b) platoon metering (with 2-3 vehicles/per green) may serve up to about 1050-1150 vph before either unreliable ramp operation begins, or ramp vehicles begin violating the signal’s operation; and

- (c) dual-lane metering with single-lane merging can reliably meter ramp volumes as high as 1600 vph if the freeway has adequate downstream capacity.

Minnesota Department of Transportation (DOT) has found that ramp demand volumes exceeding 1600 vph will routinely queue off even dual-lane meters. In such cases, a higher-type freeway ramp entry design should be considered, such as providing a dual-lane, dual-entry connection to the downstream freeway. The freeway metering assessments (Good, Fair, and Fail) shown in [Figure 2](#) are from Minnesota DOT based on its nearly 30 years of operational experience with ramp metering.

Functional controller upgrades, including dual-lane ramp metering, were prepared for TxDOT’s existing 1997 ramp metering controller (RMC) specification. TxDOT recently purchased and deployed several RMC upgrades in Houston, including the FM 1960 dual-lane meter shown in [Figure 1](#). For more details on this dual-lane design, see project report 1295-2.



Researchers Recommend . . .

Ramp metering should be considered as a viable freeway traffic management tool for use in all Texas metropolitan areas. Selection of the type of ramp metering strategy should be based on the expected ramp volumes to be served. Dual-lane metering with single-entry merge and dual-lane metering with dual-entry connection should be used where ramp volumes warrant. Ramp volumes between 1200 - 1600 vph

should be designed for dual-lane, single-entry metering, and projected ramp volumes exceeding 1600 vph should be designed for dual-lane metering with dual-entry ramp connections. Another metering option would be to permit higher ramp delays thereby encouraging more ramp diversion in cases where good alternate routes exist.

Urban freeway design of entrance ramps in Texas should consider the type of ramp metering warranted. Procedures should be

developed to provide a cost-effective geometric design for the “warranted” entrance ramps, including ramp cross section, number of lanes, and overall ramp spacing from the upstream interchange/frontage road connection to the downstream freeway merge point to adequately store vehicles queued behind the meter. Research should be conducted to develop the criteria and guidelines needed to achieve these objectives.

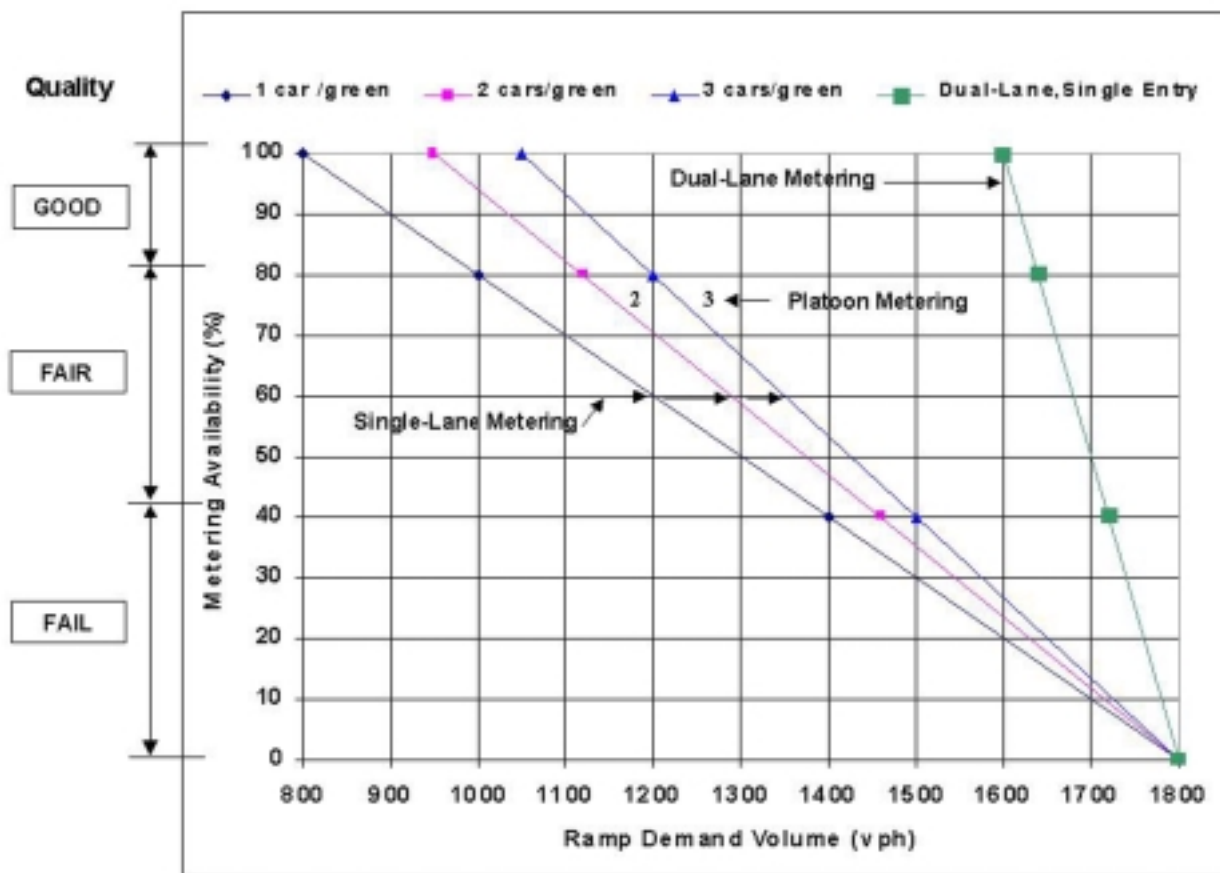


Figure 2. Performance of Metering Strategies with Ramp Demand Volume



For More Details ...

The research described is documented in the following research reports:

Report 1295-1, "Go with the Flow Houston – A Public Outreach Plan"

Report 1295-2, "A Dual-Lane Flow Signal Plan for Texas"

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TxDOT Implementation Status July 2000

TxDOT has already implemented, as part of this research, an enhanced ramp meter controller in Houston. Dual-lane metering can provide nearly twice the ramp metering and queue storage capacity. This is an important feature in Texas where relatively high ramp volumes and short slip ramps are often present. TxDOT has concurrently updated ramp meter specification to permit future purchase of this advanced controller where justified.

TxDOT has been provided with the following products to assist traffic engineers with implementation of dual-lane metering at a specific location:

- *public information campaign* to be used for reference if needed;
- *determination that law enforcement* did not become a significant issue in Houston;
- *improved guidelines* that identify volumes which would warrant use of dual-lane metering; and
- *recommended detector layouts, controller timings, and traffic control devices (signs and markings)* to use with dual-lane metering.

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YOUR INVOLVEMENT IS WELCOME!

This research was performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names are used solely for information and not for product endorsement. The engineer in charge was Carroll J. Messer, P.E. (Texas 31409).