RAMP FLOW CONTROL

Description

Ramp flow control (also known as ramp metering) uses specialized traffic signals that release vehicles onto a freeway in a smooth and even manner. The goal is to minimize the interference of entering vehicles on freeway traffic and prevent stop-and-go traffic that ripples upstream and slows the entire freeway. Flow signals facilitate smoother traffic merging and keep the freeway moving efficiently for a longer period of time by releasing only one or two vehicles at a time. Less stop-and-go traffic means fewer crashes that can cause additional congestion. In return, vehicles wait on the ramp, which may also reduce demand by causing diversion. This strategy may not eliminate traffic congestion but can delay its onset and shorten its duration.

Target Market

Freeways with recurring flow breakdowns

Recurring freeway breakdowns occur daily in most congested metropolitan areas. Researchers have observed that average speeds may decrease but will generally remain close to free-flow speed as flow increases. The freeway will begin to approach a breaking point and reach an unstable condition as the flow approaches the available capacity. This breakdown of the freeway causes the congestion and queues to reach farther back in the traffic stream. The discharging vehicles from the bottleneck can then increase their speeds, but the freeway will stabilize at characteristics well below the freeway capacity. Flow control can limit the number of vehicles entering a freeway and help prevent a flow breakdown.

Stop-and-go traffic conditions

Flow signals can be considered for freeway entrance ramps upstream of freeway sections where stop-and-go traffic occurs on a routine basis. They are also suitable for freeway entrance ramps servicing high numbers of platooned vehicles.

Cost:	●●●○○
Time:	**Short**
Impact:	**Corridor**
Who:	**State**
Hurdles:	**Acceptance**

How Will This Help?

- Ramp control can <u>improve safety</u> by decreasing the crash rate in the controlled areas.
- Implementing ramp control can <u>increase volume and speed</u> on the freeway segment in the area, reducing travel time for all users.
- Ramp control plans and devices can be implemented at <u>relatively low cost</u> (if an existing communication network is already in place) when compared to other congestion mitigation techniques.

For more information, please refer to: <u>http://mobility.tamu.edu/mip/strategies.php</u>.

Implementation Examples

Minneapolis/St. Paul, MN: The Minnesota DOT operates 433 flow signals in Minneapolis and St. Paul. A bill passed by the state legislature in 2000 forced the DOT to evaluate the benefits by temporarily shutting down the flow signals. The evaluation revealed that flow signals produced a 21 percent reduction in crashes, an eight percent increase in freeway speeds, a 22 percent reduction in travel time, and a 16 percent increase in vehicle throughput.[1]

California: California has the highest number of flow signals in the U.S.; there are 988 locations in Los Angeles and Ventura counties alone. California DOT (Caltrans) staff believes that the benefits are similar to those reported in Minnesota.[2]

Baton Rouge, LA: In Baton Rouge, Louisiana, 14 flow signals were installed in 2010 along IH 12. Initial results show a 12 percent reduction in merge point crashes and a 17 percent improvement in travel time. Drivers at two of the ramps have complained about an increase in their commute time, but the Louisiana Department of Transportation and Development believes a road-widening project is the cause of these delays. Flow signals are planned for installation at two additional on-ramps.[3]

Houston, TX: Houston had 86 flow signals in 2009. These signals operated in a relatively 'fast' mode; vehicles were released onto the freeway at close intervals. The relatively short entrance ramps in Texas do not allow a traditional flow control system that requires longer wait times. Even with the rapid metering system, however, the Texas signals improve ramp merge operation and delay the onset of congestion.[4]

Application Principles and Techniques

There are numerous forms of flow signal implementation principles that can generally be characterized as operations or design; in most cases the operational requirements dictate the design attributes.

Types of Operations

Local or coordinated — A ramp under local control uses local traffic conditions regardless of how many adjacent ramps are in the system. System-wide conditions dictate flow control levels at a group of ramps in coordinated operation. Houston uses local operation with a maximum metering rate. The Los Angeles District of Caltrans uses a combination of local and coordinated modes, and Minnesota DOT uses the coordinated mode, where a freeway is divided into zones consisting of several on-ramps.

Time-of-day, traffic responsive, or adaptive — Activation or deactivation of operation occurs at pre-determined times of the day in the time-of-day (TOD) mode. Traffic conditions determine times of operation and metering rates in traffic-responsive and traffic-adaptive modes. Traffic-responsive operation uses information about the immediate past to make decisions. The adaptive mode makes decisions based on predicted conditions. TxDOT uses TOD and traffic-responsive modes in Houston. Caltrans operations in Los Angeles, the Seattle area, and Minnesota use adaptive modes.

Strict or flexible — Strict operation makes control decisions without regard to their consequences on ramp traffic. Flexible operation uses queue detectors on the ramp to adjust flow rates based on traffic conditions at the ramp. The extreme form of this type of control temporarily turns-off the signal to allow vehicles to enter the freeway (queue flush operation) when it reaches the maximum length (typically to avoid stacking traffic into a street intersection). Prior to 2000, Minnesota used strict metering, which resulted in long delays at many ramps. Current operation incorporates a queue override to maintain ramp delays below four minutes. Caltrans also uses flexible operation, which increases the maximum metering rates in the presence of a ramp queue. In Houston, the presence of a very long queue on the ramp triggers the flush mode by turning off the signal until the queue is dissipated.

Single- or dual-lane — A single-lane ramp services all vehicles from a single lane. A dual-lane ramp provides two lanes of storage and alternates the release of vehicles from these lanes. Single-lane operation is the most common. Denver uses dual-lane operation at several ramps. An HOV bypass lane can be added to either type of ramp to provide priority to these vehicles. Caltrans' Los Angeles District is in the process of changing their HOV bypass lanes from free-flow (no stopping at the signal) to metered operation.

One car or multiple cars per green — Standard flow signal operation releases one vehicle at a time. Multiple-car-per-green (or bulk metering) operation allows two or more vehicles to be released at a time. Houston and Caltrans' Los Angeles District use bulk metering at ramps with demands higher than the capacity of a single-lane flow signal.

Operational Considerations

Single- and dual-lane strategies provide realistic capacities of 800 and 1,600 vehicles per hour, respectively. With bulk metering, the capacity of a single-lane meter can be increased to 1,050 vehicles per hour. When used in conjunction with queue flush operation, single-lane, bulk, and dual-lane metering strategies provide good quality control for demand levels of up to 1,000, 1,200, and 1,650 vehicles per hour. To the extent possible, metering rates should be set to prevent ramp queues from reaching and blocking the upstream intersection.

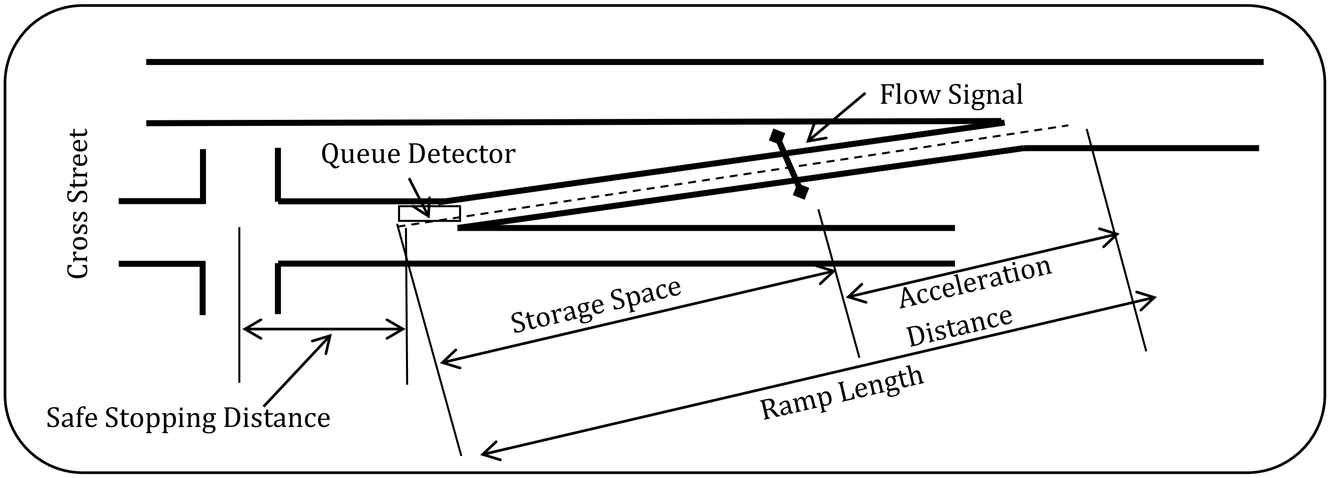
Design Considerations

Installation of a flow signal to achieve the desired objectives requires sufficient room at the entrance ramp. The determination of minimum ramp length to provide safe, efficient, and desirable operation requires careful consideration of several elements listed and illustrated below:[5]

- Sufficient acceleration distance for vehicles stopped at the flow signal to attain safe merge speeds.
- Sufficient space to store arriving vehicles without blocking the upstream intersection.
- Safe stopping distance from the upstream signal to the ramp queue.

Issues

Issues regarding ramp control techniques include potential violations of flow signals and preferential treatment of upstream ramps. Ramp control can also cause a negative public perception of ramp delay, even when the total trip time is reduced. Some of these concerns can be addressed by collaborating with law enforcement agencies and with information and media campaigns.



Who Is Responsible

TxDOT is typically responsible for implementing and maintaining flow signals.

Project Timeframe

Data collection, pre-installation analysis, design, and any geometric modifications may take from a few weeks to several months. Depending on the availability of equipment, installation of hardware could be accomplished in as little as one week.

Cost

Typical installation cost including communications is between $50,000 and $90,000. The typical hardware cost is $10,000 to $15,000.[3,6]

Data Needs

Typical data elements include vehicle volumes for the freeway lanes, freeway speeds, ramp demand, ramp geometry (storage, acceleration distance, etc.), and crash history for one to two years.

Ramp Flow Control Best Practice

- Type of Location: Ramps with safety issues in the merge area, recurring congestion near the ramp, significant weaving, or a downstream bottleneck. Ramp must have sufficient storage and acceleration distances, good sight distance. Ramp demand must be, on average, less than flow signal capacity.
- Agency Practices: Operate only when necessary, minimize excessive delay to ramp traffic, prevent spillback into adjacent facilities, coordinate with partners, and conduct effective information dissemination to public.
- Frequency of Reanalysis: Effectiveness must be continually evaluated.
- Supporting Policies or Actions Needed: Clear identification of objectives; coordination within and outside DOT (i.e., with city and law enforcement agencies); adequate information dissemination to public; policies on the use of hardware (i.e., number of signal heads); signal operations (i.e., not providing yellow interval); and HOV priority.
- Complementary Strategies: Adding new lanes; geometric improvements; managed (HOV-HOT) lanes; traveler information systems, detection and surveillance; integrated corridor management; ramp terminal treatments.

For More Information

Jacobson et al. Ramp Management and Control Handbook. Report FHWA-HOP-06-001, PB Farradyne, Rockville, MD, January 2006.

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3. I-12 Ramp Meters Praised. The Advocate, November 17, 2011. http://theadvocate.com/home/1344772-125/i-12-ramp-meters-praised.html. Accessed: December 14, 2011.

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5. Chaudhary, et al. Ramp-Metering Design and Operations Guidelines for Texas. Report 0-2121-2, TTI, October 2000. http://tti.tamu.edu/documents/2121-2.pdf.

6. Sisiopiku et al. Applications of Freeway Ramp Metering in Alabama. Report 04203, University Transportation Center for Alabama, The University of Alabama, Birmingham, Alabama, 2005.