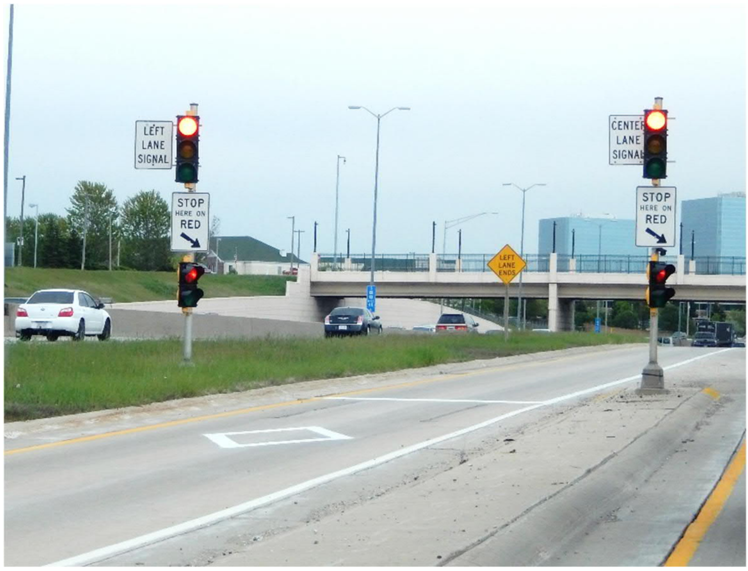
Ramp Metering

Ramp metering is the use of traffic signals, installed on freeway on-ramps, that control the rate vehicles enter a freeway facility. Ramp metering reduces the impact that traffic entering the freeway has on mainline traffic flow by storing vehicles on the ramp rather than releasing them in closely spaced platoons. By managing the rate that traffic can enter the freeway, closely spaced vehicle platoons are spread and individual vehicles can merge more smoothly with mainline traffic. Controlling the overall volume that enters the freeway can also reduce short periods of high freeway volume that results in flow breakdown.

Benefits of effective ramp metering include mobility (e.g., traffic speed increase and travel time reduction), safety (e.g., collision reduction), and environmental (e.g., emissions reduction).



Planning and Design Considerations:

- Ramp peak hour volume – Affects the required storage length and width of the ramp.
- Freeway operating speed – Affects the acceleration distance required downstream of the stop bar.
- Right-of-Way Availability – Affects whether or not the ramp can be lengthened or widened.
- Diversion – May cause drivers to bypass queues that form at the meter in lieu of arterials that parallel a freeway.
- Equity – May result in the perception that ramp meters adversely impact or penalize trips that occur within metered zones versus those that occur outside them.

Range of Concepts:

- Local, pre-timed – Simplest and least expensive form of metering best applied for localized safety problems. Does not require mainline or ramp vehicle detection.
- Corridor, pre-timed – Similar to local, pre-timed systems but implemented along a corridor rather. Can be effective addressing recurring congestion.
- Local, adaptive/responsive - Bases metering rates on real-time freeway conditions near the metered ramp. Requires vehicle detection on the ramp and freeway.
- Corridor, adaptive/responsive - Optimizes traffic flow along a metered stretch of freeway, rather than at a specific point on the freeway. Requires vehicle detection on the ramp and freeway.

Potential Application

- Localized or corridor based freeway traffic issues – Ramp metering is primarily used to address recurring freeway congestion and safety problems. It can be applied at specific locations or along entire corridors to smooth traffic flows and prevent or delay the onset of flow breakdown.
- Network load balancing - Ramp metering may also be used to discourage short trips using the freeway and thus reducing the interference that these trips introduce to freeway operations, particularly as traffic volumes approach levels where traffic flow begins to break down.
- Work zone activity – Ramp meters can help improve safety and/or maintain consistent traffic flows immediately upstream and within work zones.

Dynamic Shoulder Use

The dynamic opening of a shoulder lane to traffic on a temporary basis in response to increasing congestion or incidents. This strategy can provide additional capacity when it is needed such as during peak travel periods or special events. The temporary addition of a shoulder lane allows congested roadways to have higher throughput.

Shoulder use can temporality increase capacity helping to postpone the onset of congestion and its effects on travel reliability and safety. It can also improve travel reliability for specified vehicle classes (e.g., buses increasing person throughput and encouraging mode shift.

Planning and Design Considerations:

- Pavement width and depth – Full width and full depth pavement is required; shoulder widening and/or rebuilding, may be necessary in certain conditions.
- Existing physical constraints and infrastructure – Shoulder use must consider horizontal and vertical clearances. Physical constraints might also impact sight distances.
- Periods of operation – Detailed analysis of traffic flow is required to determine flow thresholds for opening and closing the shoulder.
- Through interchange running – For right shoulder lanes, merges for entrances and exits must conform to safety standards.
- Emergency refuge – Use of the shoulder removes the existing area of refuge and therefore, additional areas of refuge should be identified or constructed.
- Surveillance – allows operators to monitor the shoulder to ensure that there are no parked vehicles or debris in the lane prior to opening. Lighting may be needed to enhance visibility.
- Drainage – Existing drainage systems should be evaluated to determine if changes are needed.

Range of Concepts:

- Static –Manages shoulders using time-of-day restrictions and static signing. Lowest complexity and operational abilities.
- Dynamic – Shoulders are actively managed to allow shoulder use as needed based on changing conditions.
- Bus on shoulder – Allows authorized transit vehicles to use the shoulder.
- Shoulder as an HOV lane – Allows vehicles with 2+ or 3+ occupants to use the shoulder.
- Shoulder as a HOT lane – Vehicles can pay a toll to use the shoulder if they don't meet HOV requirements.
- Shoulder open to all vehicles except trucks – Allows all vehicles, except trucks to use the shoulder when opened.
- Shoulder open to all vehicles – Allows all vehicles to use the shoulder when opened.
- Speed restrictions – Allows use of the shoulder but speed restrictions may be implemented to promote safety.
- Inside vs outside shoulder – Shoulder concepts must determine if the inside or outside shoulder will be used.

Potential Application

Dynamic shoulder use can be accomplished in conjunction with dynamic lane use control, which typically expands use of over-the-lane DMS used for dynamic shoulder use across all travel lanes. Potential applications include:

- Reduce temporary (peak-period) congestion – Use of the shoulder adds capacity during peak-periods.
- Promote use of certain vehicle classes - Use of the shoulder is permitted to certain vehicle classes to encourage their use and to promote multi-occupant modes of travel and greater levels of person throughput.
- Counterbalance loss of capacity – Opening of the shoulder may be used to off-set the loss of capacity in one of more other lanes as a result of incidents, construction or another event that may temporarily close a lane.

Variable Advisory Speeds

Variable advisory speed systems recommend safe driving speeds, using over-the-lane or roadside signs, based on prevailing road, traffic, and/or weather conditions. Advisory speeds may be recommended for an entire freeway segment or, in some states, individual lanes. Speeds are typically raised or lowered incrementally to gradually smooth the traffic flow approaching slowed or stopped vehicles. Variable advisory speeds can be coupled with dynamic message signs to provide an explanation for speed reductions, which helps achieve greater levels of driver compliance.

Benefits of effective variable advisory speeds include safety (e.g., slowing vehicles and reducing crashes), mobility (e.g., smoother traffic flow and improved trip reliability) and environmental (e.g., emissions reduction)

Source: Minnesota Department of Transportation

Planning and Design Considerations:

- Visibility – Advisory speed signs should be visible to all drivers, across all lanes.
- Public acceptance and understanding – Drivers must understand why the speed limit is being reduced and why the new speed limit is suggested or required. Dynamic message signs can be used to give drivers a reason for reduced speeds (queue warning).
- Speed display refresh rate – Speeds displayed are generally updated every 20 seconds to 15 minutes. One minute in urban areas and 5 to 15 minutes is generally considered typical practice.
- Driver compliance – Because advisory speed systems do not have legal authority, some states have reported challenges with driver compliance.

Range of Concepts:

- Variable advisory speeds – Variable advisory speeds are recommendations and cannot be legally enforced.
- Variable speed limits – Similar to advisory speeds, variable speed limits are regulatory and can be legally enforced. This concept is usually implemented to achieve greater driver compliance.
- Congestion responsive systems – Used to manage traffic flow in response to incidents or other congestion-causing conditions such as recurring peak-period traffic. This concept steps down speeds gradually in advance of flow break down to minimize hard decelerations.
- Weather responsive systems – Used to manage traffic flow in response to adverse weather or pavement conditions.

Potential Application

Variable advisory speed systems are commonly implemented as part of larger active traffic management programs such as dynamic lane use control and queue warning.

- Crash rate – Applicable for locations where the crash rate is higher than other similar freeway segments.
- Limited stopping sight distance –Applicable for locations where stopping distance for the average driver and vehicle exceeds the available sight distance.
- Congestion – To dynamically and automatically reduce speeds in or before areas of congestion, accidents, or special events to maintain flow and reduce the risk of collisions due to speed differentials.
- Weather - To reduce speeds during periods of inclement weather. Locations that have a history of adverse weather conditions that impact traffic, and have suitable weather or pavement monitoring systems are candidate locations.
- Construction – Variable advisory speeds can be used approaching and within work zones to reduce speeds. Variable speeds may be particularly beneficial within work zones at night when lower traffic volumes allow for faster speeds.

IOWA DOT
GETTING YOU THERE

**INTEGRATED CORRIDOR MANAGEMENT–
DES MOINES METRO AREA**

Queue Warning

Queue warning systems alert drivers of downstream slowed or stopped traffic to prevent sudden slowing and to reduce the number and severity of congestion related crashes. These systems typically consist of sensors located upstream of freeway segments that are frequently congested, impacted by recurring events such as incidents, adverse weather and poor pavement conditions, or construction activity. When slowed or stopped traffic is detected a warning message is displayed on dynamic message signs or on static signs when coupled with flashing lights to indicate that the warning is in effect. This strategy is typically applied at specific locations in advance of known congestion points.

Benefits of queue warning include safety (e.g., reduced congestion related crashes and reduced speed differential), mobility (e.g., improved travel times, and delays on-set of congestion), and environmental (e.g., reduced noise from braking and acceleration).

Planning and Design Considerations:

- Sensor spacing – Typically, in urban areas sensors are spaced every half mile. In rural areas spacing may be increased to every mile. With more sensors notifications of changes can be provided more quickly.
- Sign and sensor location - Locations should be far enough upstream of impacted freeway segments to allow drivers enough time to change behavior. Signs should be located in advance of typical congested segments so drivers can slow down when warned of congestions.

Range of Concepts:

- Static signs with beacons – Static signs may be used at locations where expected queues lengths do not vary significantly. Beacons will flash to alert drivers of downstream queues. This concept is least expensive and least flexible of communicating where queues are occurring.
- Hybrid static/dynamic signs – If the end of queue location varies, a hybrid static/dynamic sign may yield a compromise between cost and flexibility. The dynamic element of hybrid signs can be used to dynamically indicate how far downstream the end of queue is located.
- Dynamic signs – This concept is the most expensive but offers the greatest flexibility in terms of messaging. If combined with dynamic lane use, dynamic signs installed over each lane may be used to alerts drivers of queues.

Potential Application

The purpose of implementing queue warning systems is to reduce the number and severity of congestion related crashes where problems frequently occur. Potential locations include:

- Work zones – Portable queue warning applications may be suitable to alert drivers of construction-related queues.
- Locations with poor sight distance – Queue warning may beneficial at location where sight distance is poor such as locations with vertical grades, horizontal curves, or poor lighting.
- Locations frequently impacted by adverse weather – Locations where weather events and/or poor pavement conditions result in vehicles suddenly slowing or stopping.
- Other locations with predictable queues – Queue warning may benefit locations that are frequently congested and where queues occur in predicable locations such as a lane drop, major interchange, or high-volume exit ramps.

IOWA DOT

GETTING YOU THERE

INTEGRATED CORRIDOR MANAGEMENT– DES MOINES METRO AREA

Dynamic Lane Use Control

Dynamic lane use control dynamically closes or opens individual traffic lanes as warranted and provides advance warning of closure(s) through the use of lane use control signs, in order to safely merge traffic into adjoining lanes. In an ATM approach, as the network is continuously monitored, real-time incident and congestion data is used to control the lane use ahead of the lane closure(s) and dynamically manage the location to reduce congestion related crashes. Dynamic lane use control is typically used in conjunction with other ATM strategies such as dynamic shoulder use, variable advisory speeds and queue warning.

The benefit of dynamic lane use control is primarily improved safety (reduced congestion related crashes). Secondary benefits include mobility (e.g., traffic speed increase and travel time reduction), and environmental (e.g., emissions reduction).

Planning and Design Considerations:

- Sign hardware – Lane use is often conveyed to drivers using over-the-lane DMS; however, depending on other active traffic management strategies planned, lane use controls can be conveyed to motorists using a single, larger DMS that can display lane use symbols with other types of travel information or side mount DMS which may be less visible to drivers compared to over-the-road/lane signage.
- Spacing – This refers to the spacing of signs/gantries along the freeway. Typical spacing half-mile, but the range varies from .25 mile to 1 mile.
- Default message – Signs used for lane use control can be blanked out when inactive or always-on displaying a message (e.g., constant green arrow).
- Symbols – The MUTCD contains information on lane use control signals. However, the MUTCD is silent on the use of selected symbols and potential use of certain symbols may need to be further analyzed.

Range of Concepts:

- With dynamic speeds – This concept integrates lane use controls with variable advisory speeds (or variable regulatory speed limits).
- With dynamic shoulder use – This concept integrates dynamic shoulder use to manage lane use for general purpose and shoulder lanes.
- With queue warning – This concept provides a message for downstream queues. This may be conveyed with a brief caution message either in text or with a symbol.
- With supplementary information – This concept integrates side mount DMS to provide information or context as to why drivers are being asked to merge into adjacent lanes (or why speeds have been reduced if integrated with dynamic speeds).
- Combination – Dynamic lane use control combined with two or more of the concepts above. Hardware required for dynamic lane use control is complementary of several ATM concepts and can support multiple objectives based on identified needs.

Potential Application

- Increased freeway volumes – dynamic lane use control, used in conjunction with dynamic shoulder use, can be used to temporality increase capacity to keep traffic moving around incidents or construction activity.
- Reduced secondary incidents – dynamic lane use control can instruct drivers to merge out of lanes blocked by incidents or provide advance warning of downstream queues in advance of reaching the incident scene.
- Incident management – Dynamic lane use control can be used to speed response and improve responder safety.