MAXIMIZING THE FLOW

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The Kansas and Missouri Departments of Transportation

Ramp Metering
2011 evaluation report
Executive Summary

Using a variety of tools, including ramp metering, the Kansas Department of Transportation (KDOT) and Missouri Department of Transportation (MoDOT) jointly operate Scout to improve traffic flow on Metro freeways.

Scout deployed a ramp metering pilot program on I-435 between Metcalf Avenue and the Three Trails Memorial Crossing in early March 2010 with the goal of decreasing congestion and improving merge safety. The meters have been assessed twice since being installed: once six months after installation and again after twelve months.

Both evaluations considered the effectiveness of the I-435 ramp meters according to the following factors:

- Safety and accident reduction
- Speeds and travel times
- Compliance
- Ramp delay
- Traffic Incident Management
- Feedback from the general public, local officials, and law enforcement

The 12-month evaluation indicates that ramp metering has effectively improved I-435 by:

- Decreasing overall accidents on the freeway by 64%.
- Cutting accidents that could possibly be attributed to merging by 81%.
- Helping motorists merge more easily and move at a consistent rate within the corridor.
- Sustaining overall travel times and speeds at reliable levels, despite increased traffic volumes.

What’s more, Scout educated motorist assist, emergency responders, and law enforcement personnel as well as motorists about ramp meter operations and enforcement through the Maximizing the Flow community outreach campaign. As a result, Metro motorists are complying with the meters. Two out of three residents along I-435 who participated in the 2011 Scout survey responded that the ramp meters have improved the freeway; a similar number said other Metro freeways should include ramp metering.

Given the success of the I-435 ramp metering pilot program, Scout may explore ramp metering for other congested freeway segments.
Introduction

KDOT and MoDOT designed Scout to provide drivers in the Kansas City Metropolitan area with less highway congestion, fewer rush hour accidents, improved rush hour speeds, quicker emergency response times, and much more to help them navigate their way along a safer, smoother, and smarter journey. In March 2010 Scout added ramp meters to I-435 between Metcalf Avenue and the Three Trails Memorial Crossing.

The meters are special traffic signals that regulate the rate at which vehicles enter the freeway from the on-ramps. From its Lee’s Summit Traffic Management Center (TMC), Scout uses the I-435 ramp meters, freeway message boards, closed-circuit television (CCTV) cameras, roadway sensors, media partnerships, and the web to manage traffic and provide drivers with helpful information about the freeway system, such as travel times and traffic delays, caused by accidents and lane closures.

Scout is the Metro’s first Intelligent Transportation Systems (ITS) provider. It is one of only a few bi-state ITS providers in the United States and the only one in the region. ITS solutions like ramp metering are an option when communities need to respond to the increasing traffic congestion that results from population growth while also promoting safer, more efficient travel using limited financial resources. With the increasing traffic on the south I-435 corridor, KDOT and MoDOT determined that a ramp metering pilot program should be implemented through Scout at a cost of approximately $30,000 per on ramp in order to:

- Decrease the number of sudden weaving and braking moments that happen as vehicles merge onto the freeway from the on-ramps.
- Allow more cars to smoothly drive along the freeway.
- Reduce accidents.

MoDOT and KDOT conducted a 12-month evaluation of the I-435 ramp metering pilot program. The evaluation began in April 2010 and ended in March 2011.

Evaluation Factors

With an evaluation team consisting of engineering and planning consultants, Scout evaluated the effectiveness of the I-435 ramp meters, looking specifically at the following elements:

- Safety and Accident Reduction
- Speeds and Travel Times on the Freeway
- Compliance with the Meters
- Delay on the Ramps
- Traffic Incident Management
- Community Feedback

Data Collection

To gather information about the I-435 ramp meters, the evaluation team:

- Observed the ramp meters in action on-site at the on-ramps and off-site using the Scout CCTV cameras.
- Collected traffic data for a 12-month period after the meters were in operation spanning from April 2010 to March 2011.
- Compared the “after” findings to traffic conditions on I-435 based on an average of the conditions between April 2008 - 2009 and March 2009 - 2010 — before the meters were installed and turned on.
- Talked with transportation professionals and law enforcement staff to better understand their experiences with the meters after turn-on.
- Conducted a survey to gather feedback from the general public about Scout in general and the I-435 ramp meters specifically.
SAFETY & ACCIDENT REDUCTION

One month before the ramp meters were installed, Scout implemented its new Advanced Traffic Management Software to track in greater detail accident characteristics, such as lane blockages, locations, duration of time, and causes of accidents with greater detail and accuracy. Data was collected for the weekday morning (6:45 a.m. – 8:45 a.m.) and afternoon (3:45 p.m. – 5:45 p.m.) rush hours. Scout used the data from the new software plus a review of accident reports for the I-435 corridor to develop a one year summary of safety and accident information for the ramp metering pilot program. Data sets from 2008 and 2009 were averaged together to create the “before” condition while 2010 data provided the “after” condition.

Accidents Per Year that are Likely Attributed to Merging

Of all the accidents that occurred along I-435 prior to ramp meter installation, more than half were possibly attributed to merging. Merging accidents typically result when interchanges are spaced close together or when acceleration and deceleration lanes are short. Rear ends and side swipes are common examples of merging accidents.

Rear ends and side swipes are the most common accidents likely attributed to merging.

Ramp metering improves safety by decreasing accidents.

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Overall decrease of 64%

Overall decrease of 81%

Number of Accidents Per Year

Accidents on I-435 dropped 64% after the ramp meters were installed. The decrease is greater than that found in ramp meter evaluation studies in Milwaukee, Portland, Detroit, and Denver, which have shown that ramp meters can reduce crashes by 26 to 50% when metering is applied throughout the highway systems of these metropolitan communities.

Types of Accidents

Before ramp metering was added to I-435, nearly 75% of the accidents that could be attributed to merging on I-435 were rear ends. After the meters were added, the number of accidents that could be attributed to merging operations dropped to just 19% of the before average.

Accidents not likely attributed to merging

Overall decrease of 64%

Overall decrease of 81%

*Note: Car size depicts number of accidents
SPEEDS AND TRAVEL TIMES ON THE FREEWAY

The speeds and travel times along I-435 were evaluated using a series of travel time surveys. The “before” speeds and travel times were calculated and measured in 2007 during the ramp meter design studies. The “after” speeds and times were calculated and measured in 2010 and 2011 after the ramp meters were installed and in operation for just over one year.

Survey information was collected for both the morning (6:00 a.m. to 8:00 a.m.) and afternoon (4:00 p.m. to 6:00 p.m.) rush hour periods. The evaluation team used the Floating Car Method, which involves driving the survey vehicle as the average vehicle in the traffic stream passing about as many vehicles as pass it, to gather the data.

The information from travel runs in each of the westbound and eastbound directions during the before and after periods was compiled and processed to ensure that the standard deviation of the samples were within the acceptable range of the true averages based on a five percent margin of error. Nearby construction projects located at either end of the corridor, including the Antioch Road and Three Trails Memorial Crossing interchanges, that increased traffic volumes on I-435 were also considered.

Speeds by Freeway Segment:

Speeds during the rush hours increased on several segments of I-435, especially between State Line and Wornall Roads regardless of the direction or rush hour period. Some speeds decreased along the corridor, especially in the eastbound direction during the afternoon rush hour period.

Travel Times by Freeway Segment:

Travel times along south I-435 improved when ramp metering was added. The improvement is the result of a net overall effect of some freeway segments that experienced faster freeway speeds combined with those that did not. Segments with significant increases or decreases in travel time speeds are shown on the maps below. Any decreases that appear on the maps are minimal, consisting of no more than a few seconds within the eight-mile ramp metering corridor.

Traffic from nearby construction projects increased freeway traffic volumes but overall speeds and travel times in the corridor maintained reliable levels.

Segment Travel Time Changes on I-435

![Travel Times by Freeway Segment](image-url)

Shorter Travel Times
Longer Travel Times
Ramp Metering is a traffic control tool that provides consistency in travel time reliability to the I-435 corridor by metering oncoming ramp traffic. The Travel Time Index is a Federal Highway Administration travel time reliability performance measure. The average travel time indices for 2008 & 2009 on I-435 before ramp metering was installed were 1.10 westbound and 1.05 eastbound for the morning rush hour and 1.20 westbound and 1.33 eastbound for the afternoon rush hour. In 2010 the indices post ramp metering installation were 1.08 westbound and 1.04 eastbound for the morning rush hour and 1.15 westbound and 1.30 eastbound for the afternoon rush hour.

The Travel Time Index (TTI) can be understood by relating the value to a percentage. If the TTI is 1, then the average travel time is the same as the free flow travel time, meaning there is no delay. If the TTI is 1.5, then it takes 1.5 times longer to travel a segment than it would under uncongested conditions. For this analysis, it was assumed that the Travel Time Index cannot be less than 1, which occurs when the average speed is greater than the speed limit.

The Travel Time Index (TTI) is defined as the ratio of the average travel time over the free flow travel time for a section of the freeway. For a specific lane and time period, this is calculated as follows:

$$ TTI = \frac{TT_{Avg}}{TT_{Freeflow}} $$

To calculate the TTI for a station, a weighted average is used with the lane volume as a basis, as follows:

$$ TT_{Station Avg} = \frac{\sum(TT_{1} \times V_{1}) + (TT_{2} \times V_{2}) + (TT_{n} \times V_{n})}{\sum V_{n}} $$

The TTI for a freeway section is then calculated using a weighted average of all Station TTI averages using VMT as a basis, (VMT being defined as the product of the total station volume and the distance that station represents). The TT calculation is shown below:

$$ TT_{Section Avg} = \frac{\sum(TT_{Sta 1} \times VMT_{Sta 1}) + (TT_{Sta 2} \times VMT_{Sta 2}) + (TT_{Sta n} \times VMT_{Sta n})}{\sum VMT_{n}} $$

The Travel Time Index (TTI) for I-435 has decreased since ramp meters were installed causing a more reliable commute.
COMPLIANCE WITH THE METERS

To teach Metro drivers about the new meters before they were turned on, Scout implemented its Maximizing the Flow community outreach campaign. The effort involved:

- Discussing the ramp metering pilot program with local municipalities (Kansas City, Leawood, and Overland Park), and law enforcement agencies.
- Educating and answering questions from the general public through meetings at local schools, community centers, shopping centers and with an on-line public meeting.
- Posting project information on the website.
- Blogging on the Scout blog site.
- Developing an informative, ramp meter video and public service announcement and sharing it with local media outlets which then covered the installation of the meters.
- Providing fact sheets, handouts, and slideshows that responded to the interests of key ramp metering audiences: the general public, local public officials, technical staff and officials, and law enforcement.

During the campaign Scout explained to motorists that compliance with the ramp meters occurs when bringing their car to a full or rolling stop at a ramp meter signal that displays a red light. Partial compliance occurs when a driver does not pull his car close enough to the stop bar to activate the ramp meter. Partial compliance also happens when a motorist at a two-lane meter obeys the directions of the ramp meter signage for the opposite driver rather than the sign for their designated lane. Non-compliance is synonymous with a motorist’s complete disregard for a ramp meter that shows a red light. On-site observations indicate that drivers:

- Appear to be aware of the flashing yellow lights that indicate that a ramp is metered, changes in signal colors, and signage explaining where to stop and how to proceed. A few drivers seem to miss or disregard the same information.
- Comply with the ramp meters in greater proportions since the six month evaluation.

The Maximizing the Flow community outreach campaign informed and educated motorists about the I-435 ramp meters, fostering higher levels of ramp meter compliance.

DELAY ON THE RAMPS

Ramp meter compliance can impact the amount of delay drivers experience on the ramps. The evaluation team measured the delay on the ramps that interviewees believed had compliance issues. The data collected shows that Kansas City motorists experienced less than one minute of additional wait time per vehicle on the ramps after the ramp meters were installed. The added time is less than the minute wait Scout promised when it began educating the public about the meters.
Combining traffic incident management with ramp metering and other Scout tools helped lower incident clearance times from about 22 minutes to approximately 15 minutes overall during rush hours.

TRAFFIC INCIDENT MANAGEMENT

Traffic incidents are lane blockages involving many factors such as, single or multiple cars, vehicular fires, debris, or stalled vehicles in travel lanes. For every minute a freeway lane is blocked during the rush hour, a minimum 10-minute backup will result after the incident is cleared. As a result, it is critical that Scout monitor and track incident times and implement measures that will improve incident clearance times.

Proper traffic incident management is a vital factor in the battle to combat congestion, to improve public safety, and to advance the overall quality of the commute for drivers in the Kansas City Metro. Through its Traffic Incident Management Program, Scout coordinates the resources of a variety of partnering agencies and private sector companies to identify, respond to, and clear traffic incidents as quickly as possible while protecting the safety of on-scene responders and the traveling public.

The Scout Traffic Incident Management Program coordinates the activities of responding agencies in a way that:

- Addresses their needs and priorities while maintaining the safety of all involved.
- Utilizes Scout’s system of message boards, closed-circuit television cameras, roadway sensors, and web resources to reduce the amount of time vehicles involved in accidents sit on Metro freeways.
- Clears incidents quickly and efficiently.

Teamwork Makes Quick Clearance Possible

As the Metro grows, more and more vehicles are using the freeway system. As freeways near capacity, the implementation of ramp metering and other strategies becomes essential. Quick incident clearance is necessary to ensure better traffic flow, congestion prevention, and improved safety. Motorist assist and emergency response operators work together with other on-scene responders to make quick incident clearance happen through Scout’s Traffic Incident Management Program. Partnerships and proper training are essential in making the quick clearance concept work. Scout has helped facilitate an atmosphere of collaboration by having a bi-state ramp metering project, with a regional focus of incident management inside the project boundaries.

Improved Traffic Incident Clearance Times

Several factors have helped improve incident clearance times on I-435:

- Ramp meters helping motorists to merge more easily and move at a consistent rate on the corridor, thereby causing fewer back-ups, secondary accidents and congestion.
- Emergency personnel arriving to the scene faster and clearing incidents at a faster rate.
- Increased collaboration and communication on incidents due to Scout’s Traffic Incident Management Program.

Residents believe traffic incident management is valuable to the region.

Value of Traffic Incident Management (2011 Scout Survey)

Program Partners

Scout dispatches its Motorist Assist Program operators to support law enforcement. Through its Incident Management Program, Scout has partnered with first responders from more than 50 KC Metro organizations including: fire, law enforcement, towing and recovery, media and motorist assist.
COMMUNITY FEEDBACK

Scout issued a 21-question survey to measure the perceived value in the Kansas City Metro of its existing freeway management system, the I-435 ramp meters, and community interest in expansion and future use of Scout tools. The survey was administered by mail and phone to a random sample of residents in the Kansas City five-county metropolitan area consisting of Johnson and Wyandotte Counties in Kansas and Clay, Ray, and Jackson Counties in Missouri. The results were separated into the Regional Area (309 respondents) and the Ramp Meter Area (130 respondents) for a total random sample of 439 respondents. The Ramp Meter Area included those zip codes where a ramp meter was located (66210, 66211, 64114, and 64131). The Regional Area has a 95% level of confidence with a precision of at least +/- 5.5% and the Ramp Meter Area has a 95% level of confidence with a precision of at least +/- 8.7%.

Key survey results include:

- Ramp meter motorists use Metro freeways. Forty-one percent (41%) of respondents drive on a major freeway daily and the same percentage drives on a major freeway several times each week.
- Over half the motorists in the Ramp Meter Area have experience with the I-435 ramp meters. Those surveyed were asked if they had gotten on I-435 when a ramp meter was in use. In the Regional Area, 31% had, and in the Ramp Meter Area, 58% had experienced the ramp meters on I-435.
- Respondents agree that ramp meters have improved I-435. Sixty-two percent (62%) of survey respondents in the Regional Area and 65% in Ramp Meter Area said “yes”, ramp meters have improved I-435. Overall, most respondents who were located within close proximity to the South I-435 Corridor were neutral on the meters’ value. Respondents farther away rated them as either valuable or non valuable. Respondents in northeast Wyandotte County view the meters as very valuable.
- Respondents said there should be more ramp meters. According to survey respondents in the Regional Area and in the Ramp Meter Area, 70% and 62%, respectively, stated “yes” there should be more ramp meters on Metro freeways. The survey did not ask respondents to suggest potential locations for additional ramp metering.

Have Ramp Meters Improved I-435?
by percentage of respondents

Location of Survey Respondents from Zip Codes Where Ramp Meters are Located
(2011 Scout Survey)

According to the 2011 survey, respondents indicated support for ramp meters on Metro freeways.

Should Other Metro Freeways Include Ramp Metering
by percentage of respondents

Scout issued a 21-question survey by mail and phone to a random sample of residents in the Kansas City five-county metropolitan area.
Conclusion

The goal of the I-435 ramp metering pilot program was to help decrease congestion by maximizing the flow of traffic and increasing merge safety on the freeway. The results of the current evaluation study indicate that ramp metering is benefiting traffic flow on I-435 because:

- The number of accidents along the corridor has significantly been reduced. Drivers are more easily able to find gaps in the flow of freeway traffic when entering from the on-ramps than they were before ramp meters were added to the route.
- Freeways travel speeds and times have remained reliable overall. Specifically, freeway speeds have continued to increase within several segments of the corridor and travel times have improved slightly regardless of the increase in overall traffic volumes that resulted when major interchange construction projects, such as the Antioch Road and Three Trails Memorial Crossing Interchanges, were added to both ends of the corridor.
- Motorists have generally accepted the meters, choosing to comply with rather than ignore them, thereby helping to improve the safety of their commutes.
- Motorists have also indicated that meters should be added to other Kansas City Metro freeways.
- Emergency responders are able to achieve faster incident clearance on the freeway with the combination of traffic incident management, ramp metering, and other Scout tools.
- As promised, Kansas City Metro motorists experienced less than one minute of additional wait time per vehicle on the ramps after the ramp meters were installed.

The 2011 Scout survey indicates drivers with ramp meter experience are generally located along the I-435 ramp metering corridor. The vast majority of the region lacks experience with the I-435 meters. Further, transportation professionals and law enforcement officials maintain that additional driver’s education would help strengthen compliance and improve merging skills.

Scout could address the need for further education by organizing a second phase of its Maximizing the Flow outreach campaign that is focused on ramp meter instruction. As part of the instructional phase, a narrative video shot from the driver’s perspective could be produced to provide additional detailed instruction about what motorists should know and do to properly drive through a metered on-ramp and improve compliance. Such a video could be shared with media outlets, area municipalities, driving institutions and instruction agencies, and others.

Greater ramp meter experience and compliance will not keep traffic flowing near the posted speed limit (65 mph), but it will make merging smoother and reduce rear-end and side-swipe accidents. Other transportation improvements may ultimately be necessary to improve congestion issues along I-435 and its cross-streets.

Top 5 Tips for Driving the I-435 Ramp Meters Effectively

1. Notice the flashing beacons on the “Ramp Metered When Flashing” signs that alert motorists that the ramp is being metered and they should be prepared to stop.

2. Pull all the way up to the white stop bar to trigger the ramp meter signal.

3. Follow the signage that indicates the number of cars allowed to proceed per green light. Some ramp meters allow one car per green; others allow two per green.

4. Recognize that ramp meters work and look similar to traffic signals. Drivers must consider and obey them as they would other traffic signals.

5. Understand that ramp metering is an adaptive system that works only when metering is needed on I-435.