

# **A TOOLBOX FOR REDUCING QUEUES AT FREEWAY OFF-RAMPS**

## **PROBLEM STATEMENT**

Interstate highways are one of the most important components of the transportation infrastructure in America. The rapid growth of population and economic activities in many states have caused queues on freeway off-ramps to spill back onto the freeway mainline. This problem is present, with varying degrees of severity, at different locations throughout Florida. Spillback creates a potentially hazardous condition where high-speed traffic on the freeway suddenly comes upon traffic stopped and queued from the off-ramp.

To cope with traffic congestion problems, transportation practitioners and researchers have focused their efforts on the development of freeway management and arterial management systems. However, studies of the countermeasures to reduce queues at freeway off-ramps are limited. Currently, more attention and effort are being made to emphasize the integration of both freeway systems and arterial systems. Off-ramps are an important element in this effort because they act as links between the systems. Treatments for reducing queues at freeway off-ramps to minimize potential fatal crashes and major freeway congestion are needed.

## **OBJECTIVES**

The main objective of this project is to study the problem of queues at freeway off-ramps in order to provide transportation practitioners and agencies with a set of potential remedial treatments, presented in the form of a toolbox and organized from different perspectives: freeway operations, arterial operations, and off-ramp operations. Secondary objectives of this project are to understand the main causes of queue congestion at freeway off-ramps, assess the best practices for reducing freeway off-ramp queues in Florida, and address qualitatively the advantages and disadvantages of the different treatments to cope with the queuing problems at congested off-ramps.

## **FINDINGS AND CONCLUSIONS**

Based on interviews with traffic operation engineers and their staff, researchers found that, in general, signal timing and geometric improvements are the most common countermeasures across all FDOT districts and the Florida Turnpike Enterprise. For rural and small urban areas, signal timing adjustments and minor geometric improvements at the congested off-ramp terminal intersections are common successful countermeasures to reduce off-ramp queues. For mid-size urban areas or large urban areas, many different countermeasures, ranging from basic signal timing improvements to major interchange rebuilding, could be used to effectively reduce queues at freeway off-ramps (i.e., depending on specific causes).

For large metropolitan areas, the available right-of-way is very limited and expensive. The added capacity from signal timing and minor geometric improvement can be consumed very quickly due to large traffic demand. Therefore, the countermeasures designed to alleviate traffic congestion focus on shifting some traffic demand to public transit systems, deploying ramp meter systems, providing traveler information such as 511 systems to inform travelers of traffic congestion, implementing transportation

demand management (TDM), effectively monitoring and responding to traffic congestion through traffic management centers, promptly responding to incidents to reduce congestion duration, and providing major geometric improvements along the interstate highway and arterials to create additional capacity

This research showed that, in addition to heavy traffic demand, a variety of factors may be included among the major causes for the spillback of queue from off-ramps to freeway mainlines, including

- inadequate capacity at the off-ramp terminal intersection due to rapid demand growth and/or outdated traffic signal timing plans
- limitation of off-ramp storage capacity
- lane blockages on the arterial, congestion problems along the arterial
- close distance between the off-ramp terminal and its immediate downstream intersections

The most common and effective short-term countermeasures include, but are not limited to

- improving signal timing at the off-ramp terminal intersection
- retiming signals along the arterial near the off-ramp terminal intersection
- reassigning lane usage at the off-ramp terminal intersection or freeway diverge gore area
- adding lanes to the off-ramp, lengthening the off-ramp turning lanes
- lengthening turning lanes at downstream intersections to reduce lane blockage
- adopting access management policies
- applying ramp metering to control freeway volumes
- implementing TDM strategies to reduce freeway demand
- applying ATIS technologies to provide traveler information
- utilizing ATMS to effectively monitor traffic congestion to take immediate actions.

The most common and effective long-term countermeasures include, but are not limited to

- providing major geometric improvements at the off-ramp terminal intersection
- adding lanes on the congested off-ramp to increase departure and storage capacities
- adding lanes on the arterial to reduce arterial congestion
- constructing an additional interchange near the congested one

## **BENEFITS**

This toolbox provides countermeasures to reduce queues at freeway off-ramps based on a comprehensive literature review, surveys of FDOT districts, interviews with FDOT District Traffic Operation Engineers, opinions from transportation experts, and case studies. The countermeasures target the off-ramp queue spillback problem from multiple perspectives: freeway operations, arterial operations, and off-ramp operations. With the growth of traffic demand in many states, the problem on the spillback of off-ramp queues to freeway mainlines is expected become increasingly serious. The toolbox of countermeasures developed in this study will be a valuable asset for identifying and assessing potential countermeasures to alleviate the off-ramp congestion problems. The ultimate benefits of improvements in congestion management are both economic and environmental.

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