

Executive Summary

Purpose of Research

Ramp management has gained acceptance in many area throughout the United States. The Federal Highway Administration (FHWA) and several State DOT's have developed ramp management systems that show positive benefits to reducing congestion on urban freeways. Their years of operational experience can benefit PennDOT in addressing urban freeway congestion throughout the Commonwealth.

Many of the urban freeway congestion and safety problems targeted by ramp management are found on urban freeways throughout Pennsylvania. These characteristics include insufficient ramp acceleration lane length, close spacing of ramps, and deficient mainline capacity during peak periods. Ramp management is a low cost, high benefit solution that can help alleviate localized and corridor congestion, improve safety, and improve travel perception and satisfaction. Ramp management is also a way to improve freeway operations while preserving the existing infrastructure. Communication among different agencies is a consequential benefit of ramp management, as communication plays a key role in effectively implementing ramp management strategies. A large part of the decision making process for ramp management implementation depends on the individual project context. Ramp management strategies are not necessarily right for every situation.

Past research provides little information on the coordination of freeway ramp management systems and arterial traffic signal management systems. One hypothesis of this research is that if these systems can be integrated, ramp management will have less of a negative impact on the operating characteristics on the local roadways resulting in greater acceptance by local municipalities.

FHWA has identified four ramp management strategies for freeway ramps: ramp closures, ramp metering, special use treatments, and ramp terminal treatments. For freeway entry ramps, the most common type of ramp management strategy is ramp metering. In some locations, ramp metering is combined with special use treatments for high occupancy vehicles (HOV) or transit vehicles. Ramp metering practices in various states were reviewed along with installation/operational/maintenance costs associated with ramp metering.

The purpose of this research was to determine the best practices available in ramp management that maybe used in Pennsylvania and to evaluate the feasibility and potentially design the concept of a ramp metering demonstration project in PennDOT District 11-0.

Findings - Defining Freeway Congestion in Pennsylvania

Based upon freeway congestion information provided by local PennDOT Districts and regional planning agencies (RPO's and MPO's), the use of a forecasted v/c ratio is recommended as a screening tool for freeway congestion. For this research, the forecasted v/c ratios were based upon 2030 or 2035 long range projections provided by the regional planning agencies. The forecasted v/c ratio was selected since it is well understood by traffic engineers and transportation planners. Using available information, with some adjustments, this measure of congestion can be applied uniformly statewide. The application of the recommended congestion criteria has identified 275 miles of congested freeways forecasted in Pennsylvania within the next 20-25 years.



With over 275 miles of congested freeway forecasted in Pennsylvania, capacity-adding projects can not be relied upon as the sole method of addressing congestion. As per the current MPO's long-range plans, approximately 62 lane-miles of the freeway are anticipated to be added (31 miles in each direction) by freeway capacity adding projects costing a total of \$1.11 billion. This represents only 11% of the total freeway mileage identified as congested. Using the estimated costs for programmed projects, this approximates the capacity-adding cost to solve recurrent congestion at \$17.9 million per lane mile (or \$35.8 million per mile in both directions). Applying these costs to the remaining 244 miles of congested freeway segments would result in a total cost of \$8.74 billion to solve recurring congestion freeway problems in Pennsylvania.

Recent studies, prepared by the State Transportation Advisory Commission in May 2010, identified numerous needs for funding projects to maintain existing infrastructure rather than capacity adding projects. In order to address freeway congestion issues in Pennsylvania the implementation of ramp management would be strategy that maximizes the use of existing infrastructure.

In addition PennDOT has adopted smart transportation principles which support the need to address freeway congestion through strategies such as ramp management. One principal of smart transportation states that "Choose projects with high value/price ratio". This research identifies the high benefit/cost ratios that can be expected with this type of management strategy.

Findings - Recommended Criteria for Freeway Ramp Management

A two-step approach is recommended to screen for potential freeway segments that could incorporate ramp management. The research of other state's practices indicates that a detailed warrant analysis is the tool typically used; however, because of the large number of congested freeway miles forecasted in Pennsylvania, an initial screening based upon freeway characteristics is recommended that measures the potential for the implementation of ramp management. The following summarizes the criteria used in the preliminary screening of congested freeways to identify candidate locations for ramp management.

- The long range (2030/2035) v/c ratio along the corridor
- The total number of interchanges along the corridor
- The spacing between freeway on-ramps
- The amount of coverage provided by PennDOT traffic cameras
- The number of reasonable alternate routes
- The approximate length of the freeway on-ramps

Once congested freeway segments are ranked through the high-level screening criteria, specific freeway segments can then be screened against a set of detailed criteria (called warrants in some states) to determine if specific ramp management strategies are applicable. The following types of localized screening criteria can be used for identified freeway segments:

OPERATIONAL SCREENING CRITERIA

- VOLUME CRITERIA
- DESIGN/SYSTEM CRITERIA



Findings - Ranking Candidate Freeways in Pennsylvania for Ramp Management

This initial screening has been applied to the 289 miles of freeway in Pennsylvania previously identified as congested. For future planning and programming purposes the detailed criteria should then be applied to initiate evaluations for the potential success of this congestion management tool. This recommended planning tool should enable Pennsylvania to identify, rank, and evaluate candidate locations for ramp management prior to expending resources for more detailed studies and construction.

Findings - I-376 Case Study for a Freeway Ramp Management Evaluation

A case study was developed for I-376 in Pittsburgh from Downtown Pittsburgh to Monroeville to evaluate the proposed ramp management criteria. Based upon a review of the ramp management criteria, I-376 in Pittsburgh has the appropriate volume and congestion levels to consider ramp management as an alternative solution to reducing congestion. An area-wide simulation model shows that a combination of ramp metering and ramp closure strategies would provide the most effective congestion reduction. With this congestion reduction, several local street routes will experience an increase in traffic; however, with selective traffic mitigation strategies, this congestion will be alleviated. This evaluation has demonstrated that ramp management techniques along the I-376 corridor can provide significant congestion reduction benefits, while having manageable impacts on the local street network. The PennDOT District 11-0 TMC is capable of expanding its current system to incorporate ramp management operations.

Findings – I-376 Benefit Cost Analysis

Based on the calculations and AASHTO “User and Non-User Benefit Analysis for Highways” methodology, all three ramp management options for I-376 were analyzed to determine the benefit/cost ratios. Three main user benefits were examined for each option: value of time, operating and ownership cost, and crash cost. Option 3 shows the highest benefit/cost ratio (58:1). Although Options 1 and 2 show higher annual benefits than Option 3, the capital and operating costs associated with Option 3 were much lower, making the benefit/cost ratio higher. Option 2 shows the second highest ratio (34:1) because although it has the highest capital cost, this option also shows the highest delay reduction per vehicle on I-376. This delay reduction directly relates to value of time savings, as well as ownership and operating cost savings. Option 1 shows a benefit/cost ratio of 12:1. Although this is not as high as the other options, it still shows the large benefits seen from delay reduction on I-376.

Research Recommendations

The results of this research have determined that Pennsylvania has a need to address freeway congestion. The locations and degree of congestion have been identified and a screening tool developed to identify candidate locations for ramp management strategies. It recommended that PennDOT explore the implementation of ramp management strategies through the programming process at the MPO level and then implement high value projects through the design and construction process. The pilot study of the I-376 congestion had identified a high benefit to cost ration for the investment of a ramp management project.



VIII. Future Research Needs

Based upon the results of this research additional studies are needed to further enhance the benefits of ramp management in the state of Pennsylvania. Specifically in the planning and design phases of implementation of projects additional research is needed in the following areas:

1. What is the optimum planning tools (software) to be used for the travel demand and simulation analysis?
2. What are the best communication and operation systems to jointly control a ramp management and local traffic signal network?
3. Develop a methodology to optimize the operation of both the freeway and the local roadway network for an algorithm that evaluates overall system performance and provides metering rates and traffic signal timing plans that can be varied based upon real time traffic conditions in the network.

