WISCONSIN TRAFFIC OPERATIONS & SAFETY LABORATORY
UNIVERSITY OF WISCONSIN-MADISON
Department of Civil and Environmental Engineering

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To:	Marie Treazise, WisDOT Bureau of Highway Operations
From:	Peter Rafferty and Amanda Ryadi, Wisconsin TOPS Lab
Subject:	Ramp Metering Evaluation – Technical Memo #1 Introduction and Summary

Introduction

Ramp metering is a critical component of Wisconsin's highway operations and intelligent transportation systems programs, which applies advanced technologies for traffic management and traveler information. Ramp metering has been relied upon in Wisconsin since 1969 and there are now over 120 meters in operation, primarily in the Milwaukee area, with a handful in Madison.

With the objective of improving wise deployment and efficient operations, the Wisconsin Department of Transportation (WisDOT) has undertaken a comprehensive ramp metering evaluation project. WisDOT has funded this ongoing support project in the 2008 to 2010 timeframe with the Wisconsin Traffic Operations and Safety Laboratory (TOPS Lab) to evaluate several aspects of ramp metering in Wisconsin.

A series of technical memoranda serve to document these efforts.

1. Introduction and Overview. This memo, which includes and introduction to the project, a brief synopsis of the different components, as well as some key findings.

2. Background and Related Efforts. This memo provides background context for the current effort, including a description of other metering studies in Wisconsin.

3. Analysis Methodology. The third tech memo documents some background methodology used for the operational analysis. It outlines the economic benefits and costs assessed. The methodology is applied to a related study for illustration and validation.

4. Metering Algorithms. This memo summarizes a survey of a variety of algorithms used around the country and how they may apply in Wisconsin if adopted here.

5. Current Installations – Operations. Here is documented a major component of this project. The operational evaluation looked at metering locations where data are available before and after installations and times of metering window changes.

6. Current Installations – Safety. The crash occurrences in the vicinity of meters before and after installation were compared. This memo summarizes those findings.

7. Metering Warrants. This documents the conditions at existing metering locations and whether warrants are met.

These memos, as well as supporting background documents and resources, are available at http://www.topslab.wisc.edu/workgroups/toip/rampcntrl.html

Overview

Ramp meters are traffic signals on freeway entrance ramps that break up clusters of vehicles entering the freeway. Doing this reduces disruptions that clusters cause to freeway flow and makes merging safer. The benefits of ramp metering are well established. The 2005 TTI Urban Mobility Report estimated that there was 938,000 hours of delay saved in 2003 through the use of ramp meters in Milwaukee. Furthermore, ramp metering evaluations have been completed in Wisconsin for the US 45 corridor in the Milwaukee area and also for the Beltline freeway in Madison.

An initial ramp metering operations effort just prior to the phase document here consisted of an assessment of metering practice in general and application and implementation in Wisconsin specifically. The focus was on implementation guidelines or warrants, and this part concluded with the issuance of a report Ramp Metering and Control Plan in July 2006.

Subsequently, WisDOT undertook the Statewide Freeway Surveillance and Ramp Control sketch planning activity, which is one component of the broader sketch planning project for statewide traffic operations. This effort has culminated in the Wisconsin Traffic Operations Infrastructure Plan (TOIP), an effort that continues to be updated.

The current ramp metering evaluation project focuses on metering operations and warrants. WisDOT currently utilizes a time of day local ramp metering algorithm, and there has never been a comprehensive study of the effectiveness of ramp metering in Wisconsin, and whether or not meters should continue to operate, the algorithm could be improved, and so forth.

Regarding metering algorithms, WisDOT reviewed 33 different ramp metering algorithms used throughout the country. Each algorithm was evaluated against its benefits, relative costs, and concerns related to implementation and operation. Discussions were held with selected states, including Oregon, Colorado, and New York, to aid in understanding other states' experiences with ramp metering algorithms. This effort has resulted in valuable insight into the widely varied practice of ramp metering nationwide.

A major component of this work entailed the evaluation of existing meter installations in terms of operations and safety. By comparing operations at metering locations before and after the meter installation it is possible to assess their impact. In addition, when known timing windows change, the evaluation was also able to assess the conditions during those "shoulder" periods. These aspects of the project are documented in the remaining technical memos.

A previous study developed ramp metering warrants for Wisconsin. As a check of these warrants, all existing metering locations were evaluated to determine whether warrants were currently met. This includes a comparison with recently developed warrants for Texas as well.

Lastly, as part of this study, several meters were turned off, and the results of those changes are documented in the warrants memo.

Key Findings

A broad assessment of meter effectiveness is severely limited by data availability. Most meters were installed before operations and safety data archiving began. Since then, records are often inconsistent, incomplete, or missing. The operations and safety evaluation components of this project are limited to 10% to 15% of current meter installations. Because the warrants analysis uses current operations data, nearly all meters were able to be assessed.

Previous studies both in Wisconsin and elsewhere consistently show that ramp metering demonstrates high benefit to cost ratios. Even in a marginally effective case – as was southbound US 45 toward Milwaukee – the net present values remain positive and benefit-cost ratios greater than one. These ratios increase to 5 or 15 to

one with increasing congestion and well-operated meters. The benefits include increased mainline flow, improved travel time reliability, and reduced crashes.

Background research completed as part of this study generated a sound methodology for assessing the benefits of ramp meters.

The evaluation of meter effectiveness upon initial start up showed little evidence of broad operational benefit. In less than a third of the cases, operational benefit to the mainline roughly exceeds the cost of installation and operations.

For time of operation changes made during shoulder periods of existing metering times, fewer than half showed that the mainline operates better with the meter on.

As part of this study, five meters were turned off in 2009 with a close evaluation of operations, both subjectively and objectively with operations data. In all but one case no detriment to mainline operations was observed – while ramp operations clearly improve – and these five meters remain turned off.

Before and after crash data at ten metering locations revealed that these meter installations have not improved safety. While overall crash frequency remained unchanged (including non-metered times), during the metering periods only three of the ten locations showed an improvement in safety (i.e., a drop in crash frequency) after the installation of a meter. On average across the ten locations the crash frequency increased by 11% during metering times and decreased by 4% otherwise. If meters introduce increased crash risk this is a substantial deterrent to their efficacy.

An assessment of whether current meters meet warrants showed that 12 meters do not currently meet Wisconsin metering warrants. One of these has already been turned off in 2009, and recommendations for others are documented in Tech Memo #7. Texas has also developed metering warrants, but their thresholds are more stringent and no meters in Wisconsin meet those warrants. With consideration of corridor operations and neighboring meters, two of the 12 meters presented themselves as good candidates for turn-off. One was already turned off in 2009 and should remain off. The other (RM-67-123, I-94 WB @ CTH SS) is the next candidate for turn-off and evaluation.

Potential Next Steps

Given the possibility that the time and expense needed to implement an entirely new algorithm in Wisconsin was beyond the resources available, further efforts could include a detailed assessment of whether improvements were possible given the current constraints of the equipment and software.

Additional insight may be gained by utilizing existing microsimulation models developed using Paramics and available at numerous metering locations in the Milwaukee and Madison areas. The existing ramp meter algorithm could be modeled at multiple on-ramps, along with different ramp metering timing schemes to determine whether more optimal plans are achievable for low cost. Simple examples of possible improvements include gradual quickening of the metering rate at the end of the metering time period so that the residual queue does not flood the freeway all at once and also modifying the volume to capacity thresholds currently in use.

A third direction of inquiry may look to the effects of roundabouts at ramp terminals on ramp and meter operations. It is theorized, for example, that the inherent nature of roundabouts to produce less platooning than signals is a benefit to mainline freeway operations and obviates some need for metering.